DEPARTMENT OF EDUCATION

GRADE 10

SCIENCE

UNIT 4

LIGHT

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GRADE 10

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IN THIS UNIT YOU WILL LEARN ABOUT:

Acknowledgement

We acknowledge the contributions of all secondary teachers who in one way or another have helped to develop this Course.

Our profound gratitude goes to the former Principal of FODE, Mr. Demas Tongogo for leading FODE team towards this great achievement.

Special thanks to the staff of the Science Department of FODE who played active roles in coordinating writing workshops, outsourcing lesson writing and the editing processes involving selected teachers of Central Province and NCD.

We also acknowledge the professional guidance provided by Curriculum and Development Assessment Division throughout the processes of writing and the services given by members of the Science Review and Academic Committees.

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DIANA TEIT AKIS

PRINCIPAL

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SECRETARY'S MESSAGE

Achieving a better future by individual students and their families, communities or the nation as a whole, depends on the kind of curriculum and the way it is delivered.

This course is part of the new Flexible, Open and Distance Education curriculum. The learning outcomes are student-centred and allows for them to be demonstrated and assessed.

It maintains the rationale, goals, aims and principles of the national curriculum and identifies the knowledge, skills, attitudes and values that students should achieve.

This is a provision by Flexible, Open and Distance Education as an alternative pathway of formal education.

The course promotes Papua New Guinea values and beliefs which are found in our Constitution and Government Policies and Reports. It is developed in line with the National Education Plan (2005 – 2014) and addresses an increase in the number of school leavers affected by the lack of access to secondary and higher educational institutions.

Flexible, Open and Distance Education curriculum is guided by the Department of Education's Mission which is fivefold:

- To facilitate and promote the integral development of every individual.
- To develop and encourage an education system that satisfies the requirements of Papua New Guinea and its people.
- To establish, preserve and improve standards of education throughout Papua New Guinea.
- To make the benefits of such education available as widely as possible to all of the people.
- To make the education accessible to the poor and physically, mentally and socially handicapped as well as to those who are educationally disadvantaged.

The college is enhanced through this course to provide alternative and comparable pathways for students and adults to complete their education through a one system, two pathways and same outcomes.

It is our vision that Papua New Guineans' harness all appropriate and affordable technologies to pursue this program.

I commend all the teachers, curriculum writers, university lecturers and many others who have contributed in developing this course.

UKE KOMBRA, PhD
Secretary for Education

UNIT INTRODUCTION

Dear Student,

Welcome to Unit 4 of your Grade 10 Science Course! I hope that you enjoyed studying the earlier Units. I also hope that this Unit on Light will be an interesting and enjoyable unit to study.

In this Unit, there are 20 Lessons on six Topics. The six topics are:

- **Light Energy**
- **Reflection and Refraction of light**
- **Images**
- **The Eye**
- **Dispersion of Light and Colours**
- **Useful Inventions and Applications of Light**

There are four Lessons in the first Topic. The lessons will introduce you to what light is and how it is transmitted through transparent, translucent and opaque substances. You will also learn about shadows and eclipses

The second Topic has two lessons that will discuss the Law of Reflection and Refraction of light.

The third Topic has two lessons that will discuss virtual and real images and how they are produced by plane, concave and convex mirrors.

In the fourth Topic, there are three Lessons that will discuss the structure of the eye and how the eye is able see far as well as nearby objects. You will also learn from this topic the common eye defects.

The fifth topic has two lessons that will discuss about the colours that make up white light and how we are able to see different colours when all objects reflect the same white light.

The last Topic has seven Lessons. It will talk about instruments that were invented which made use of light. You will learn about instruments like the microscope, telescope, camera, fibre optics, satellites, x-rays and the optical smoke detector.

Remember, you have to do all the activities and carry out the Practice Exercises after each lesson. The answers to the activities are at the end of each lesson while answers to the Practice Exercises are at the end of each Topic.

If you have any problems in understanding any of the lessons in this Unit, please do not hesitate to inform the Science Department at FODE Headquarters. This will help the teacher to revise the lessons for the next edition.

You may study this Unit now following the Study Guide on the next page.

All the Best!

STUDY GUIDE

Follow the steps given below and work through the lessons.

Step 1 Start with Topic 1 and work through it in order.

Step 2 When you study lesson 1, do the given Activities. When you complete the Activities, check your work. The answers are given at the end of the Lesson. (Note: Short lessons may not have an Activity.)

Step 3 You will also do a Practice Exercise at the end of each lesson. After you have completed the Practice Exercise, correct your work. The answers are given at the end of each Topic.

Step 4 Then, revise and correct any mistakes.

Step 5 When you have completed all of these steps, tick the check box for Lesson 1, on the Contents page, like this:

☑ Lesson 1: Properties of Light

Then, go on to the next Lesson. Repeat this process until you complete all the Lessons on a Topic. When this is done, revise using the Review Section.

Remember, as you complete each lesson, tick the box for that lesson on the Contents page. This will help you check your progress.

Assignments: Topic Tests and Unit Test

When you have completed all the lessons in a Topic, do the Topic Test for that Topic, in your Assignment Book. The Unit Book tells you when to do this.

When you have completed the entire Topic Tests for the Unit, revise well and do the Unit Test. The Assignment Book tells you when to do the Unit test.

When you have completed the entire Assignment Book, check and revise well before sending it to the Provincial Centre.

If you have any questions, write them on the Student's page. You will receive a response and advice from your teacher when he/she returns your marked assignment.

The Topic Tests and the Unit Test in each Assignment will be marked by your Distance Teacher. The marks you score in each Assignment will count towards the final result. If you score less than 50%, you will repeat that Assignment.

Remember, if you score less than 50% in three consecutive Assignments, your enrolment will be cancelled. So, work carefully and ensure that you pass all the Assignments.

TOPIC 1

LIGHT ENERGY

In this topic you will learn about:

- **properties of light**
- **transmission of light**
- **shadows**
- **eclipses**

INTRODUCTION TO TOPIC 1: LIGHT ENERGY

Light is all around us. It is one form of energy that travels in electromagnetic waves. This energy is both **magnetic** and **electrical**. There are many different types of electromagnetic (EM) waves. Most of them cannot be seen by us. Our eyes see only a small portion of EM waves called **visible light**.

Visible light is the reason we are able to see everything. Light moves as a wave, bouncing off objects so we can see them. Without it, we would be in complete darkness.

The Sun is our main source of light on Earth. Some other sources are stars and fire. Light travels out in all directions from its source and will keep travelling in a straight line until it hits something else.

Shadows are evidence of light travelling in straight lines. When an object blocks light from reaching a surface, we see a shadow of that object.

A cloud blocking light rays from the sun causes shadows

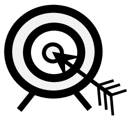
You should know all about light energy as you study this topic. The questions you may be asking yourself now are:

- What are the properties of light?
- How is light transmitted?
- What are shadows?
- How are shadows formed?

In this Topic, you will find the answers to these questions and other questions about light energy.

Lesson 1: Properties of Light

Welcome to Lesson 1. Light is all around us. It is a form of energy which enables not only us but animals as well to see. When no light energy enters our eyes, everything appears black. The more light enters our eyes, things seem to be brighter. In this lesson, you will learn about light energy and its properties.



Your Aims:

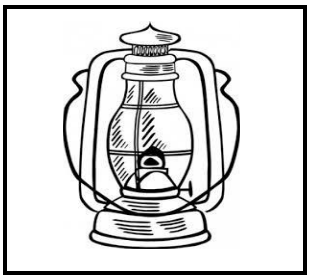
- define light
- describe light as a source of energy
- distinguish luminous from non-luminous objects
- identify artificial and natural sources of light
- identify different ray energies

Luminous Objects

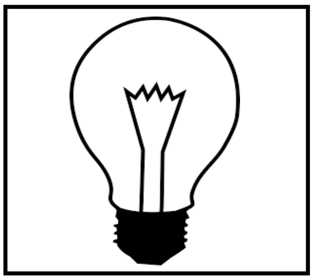
During daytime, we get light from the sun and at night we use light from other sources. Here are some examples.

Light from a fire

Light from a candle



Light from a lamp



Light from an electric bulb

Objects that produce their own light are called **luminous** objects. There are only few objects that give out their own light and are very important because they help us to see. These luminous objects can either be living things or non-living things.

Most of the living things that produce their own lights live in the oceans where the depths are dark. For some animals, the light is to attract prey. Other living things that give out their own light live in the forest. One such animal is an insect called a fire fly. In Papua New Guinea, phosphorescent fungi are used to mark tracks through the bush so that people can walk easily at night.

Natural sources of light

Any luminous object that is not produced in the factory is called a **natural luminous object**. The sun is an example of a natural source of light. During the day the light from the sun reaches the earth. This helps us to see objects very clearly. The other half of the earth experiences total darkness when the sun is not directly facing it. The moon, on the other hand, is an example of a luminous object that allows us to see during the night.

However, the moon does not produce its own light but reflects the light from the sun. The powerful rays of light from the sun make it impossible for us to look at it directly because it can damage our eyes. The stars are also other natural sources of light. They are far from us and that is why we cannot damage our eyes while looking at them directly at night.

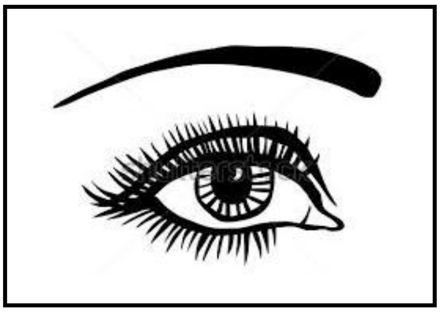
Artificial sources of light

Artificial sources of light are those objects that are manufactured and can produce light. When we heat things they produce light.

In Papua New Guinea, people living in some areas use dried bamboo and coconut leaves to burn and provide light during the night. A piece of firewood gives off light as well as a glowing light globe or candle. A kerosene lamp is an example of an artificial object which can produce its own light.

Light Energy

Light is a form of **energy**. Luminous objects have luminous energy, that is, light energy. It is the energy that causes the sense of sight (seeing things around). Light enables not only us but animals as well to see. When no light enters our eyes, everything appears black. The more light enters our eyes, things seem to be brighter.



The eye

Our eye is a sense organ that is sensitive to light energy and so light energy makes us see things.

Luminous objects produce light energy.

Activity: **Now test yourself by doing this activity.**

Do this: Look around and write down four examples of luminous objects.

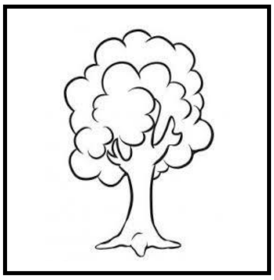
Examples of Luminous objects

1. ____________________________ 2. ____________________________
3. ____________________________ 4. ____________________________

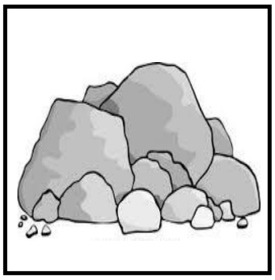
- Luminous objects produce and give out light.
- Luminous objects are sources of light.

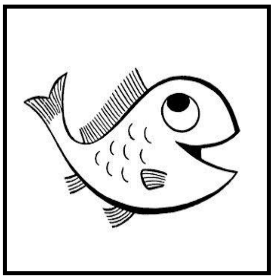
Non-luminous objects

Objects which do not produce light energy are called **non-luminous objects**. We see many non-luminous things around us.

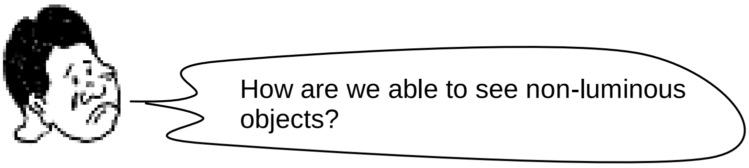

A tree


People


Rocks


A fish

We can list so many other things. Even a candle or a lamp that is not lit is also non-luminous.



Light energy from light sources (luminous bodies) goes out in all directions. Some of this light falls on non-luminous things around us. A part of that light is absorbed and the other part bounces back off after striking those objects. When the light that bounces back reaches our eyes, we see non-luminous objects.

How do we see a tree? How do we see people around us?

Sun's light falls on them and bounces back. We see the objects when light falling on them bounces back and reach our eyes.

We see non-luminous objects when light that falls on them bounce off and reach our eyes.

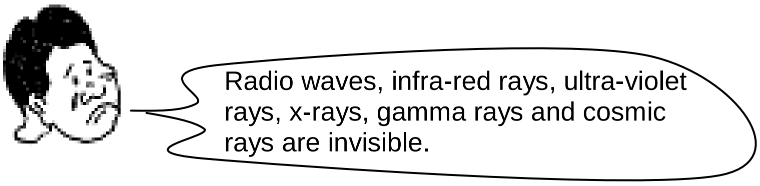
Light energy and ray energies

Light energy is one form of ray energy. It is one of several ray energies. Some of the other ray energies that are in the space around us are:

- radio waves
- infra-red rays
- ultra-violet rays
- X-rays
- gamma rays
- cosmic rays

You know that light energy is ray energy and it travels as waves. In fact, all ray energies travel as waves.

- Light energy is the only ray energy which is visible. It is the only ray energy which we can see. We see light waves because our eyes are sensitive to light.
- The other ray energies are invisible, which means, they cannot be seen by our eyes.



Electromagnetic waves

All ray energies belong to one family of waves called **electromagnetic waves**. They are produced by electromagnetic vibrations. You will learn more about electromagnetic waves in Lesson 12 of this unit and in your next Unit.

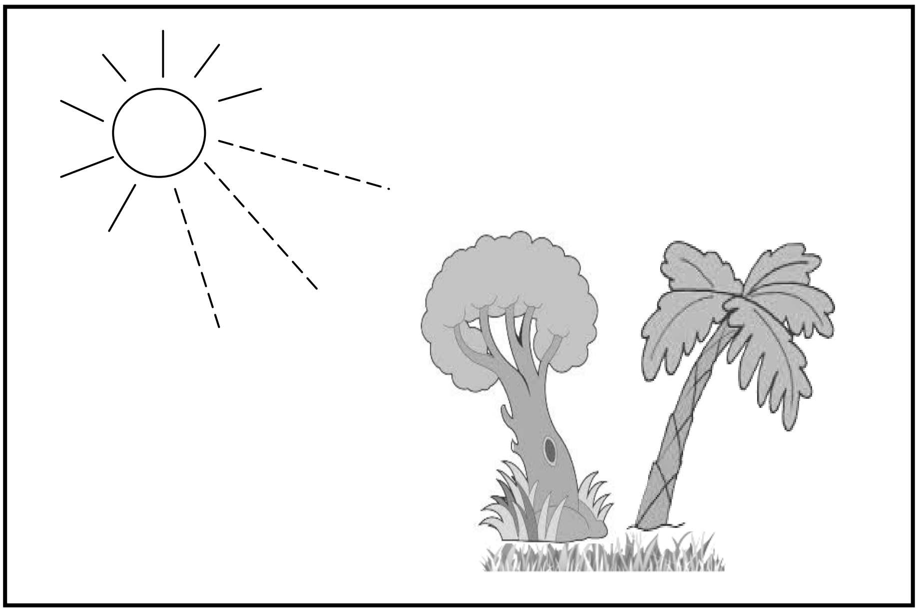
ELECTROMAGNETIC WAVES

Invisible		**Visible**	**Invisible**			
Radio waves	Infra-red rays	Light	Ultra-violet rays	X-rays	Gamma rays	Cosmic rays

Light waves are visible electro-magnetic waves

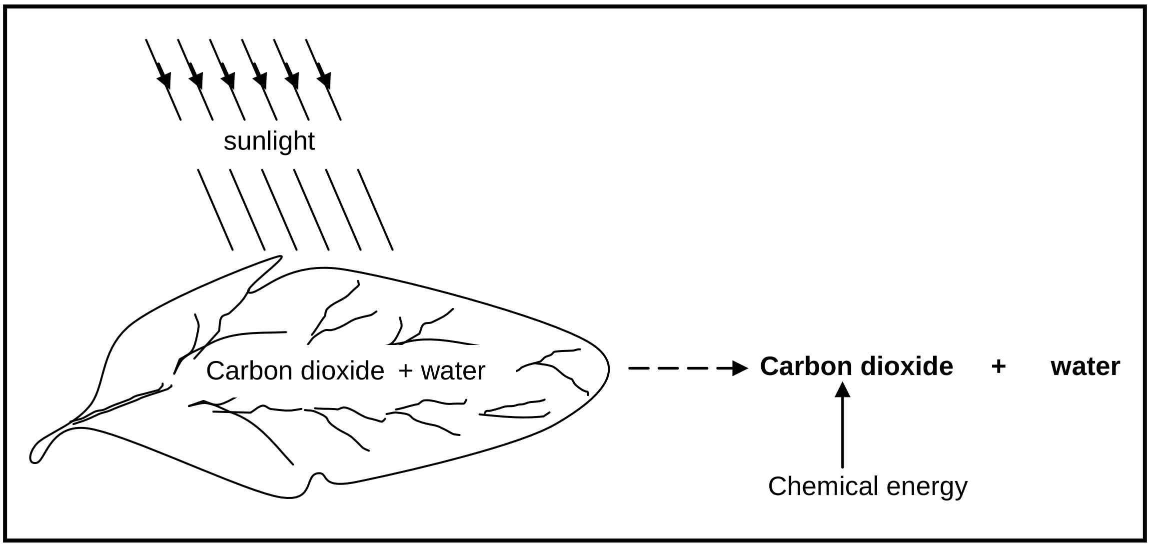
Light energy and life

Light energy from the sun reaches the Earth every day. This energy is trapped by plants. Do you know how?



Sunlight is necessary for photosynthesis in plants

You have learnt in earlier grades that photosynthesis is the process by which plants make food. During photosynthesis, plants change **light** energy into **chemical** energy.



Plants change light energy into chemical energy

Leaves of plants trap light energy from the sun. With light energy, carbon dioxide and water, plants produce food in the form of **glucose** (sugar).

We need energy and we get the energy we need from the food we eat. All our food is from plants or animals that feed on plants.

Plants capture and store energy from sunlight. That is why sunlight is important for life on Earth.

Light energy from the sun is changed into chemical energy by the leaves of plants during photosynthesis.

Summary

You have come to the end of Lesson 1. In this lesson you have learnt that:

- objects that produce their own light are called luminous objects and they can either be living or non-living things.
- any luminous object that is not produced in the factory is called a natural luminous object.
- artificial sources of light are those objects that are manufactured and can produce light.
- light is a form of ray energy and it travels as waves.
- objects which do not produce light energy are called non-luminous objects.
- light energy can only be detected by the eye.
- light energy belongs to a family of waves called electromagnetic waves.
- light energy from the sun is changed into chemical energy by the leaves of plants during photosynthesis.

NOW DO PRACTICE EXERCISE 1 ON THE NEXT PAGE.

Practice Exercise 1

Read and answer all the questions on the spaces provided.

1. (a) What are luminous objects?

____

____

____

____

(b) Write luminous or non-luminous for each of the following.

(i) Stars - ____________________

(ii) Moon - ____________________

(iii) Earth - ____________________

(iv) Page of a book - ____________________

(v) Plastic bag - ____________________

2. (a) What family of waves does light energy belong to?

____

____

(b) Name three other ray energies that belong to the same family as light energy.

____

____

(c) How is light energy trapped on earth for our use?

____

____

3. (a) What part of our body is most sensitive to light energy?

____

(b) Explain how it is possible for us to see non-luminous objects.

____

____

____

____

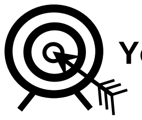
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

(Any object that produces or gives off light, for example, the Sun, stars, moon, light from fire, light from a lamp, light from a candle, light from an electric bulb)

Lesson 2: Transmission of Light

Welcome to Lesson 2. In lesson one, you learnt that light is a form of energy and is produced by luminous objects. It is a ray energy that is visible and travels as waves. In this lesson, you will learn about how light energy is transmitted.



Your Aims:

- describe light as it travels in a straight line
- describe light as it travels through transparent, translucent and opaque objects
- classify given examples of transparent translucent and opaque objects
- observe and make conclusion about a given activity

Light Rays

Light travels in straight lines. You can discover how light travels by carrying out the experiment below. You will use your observations from this experiment to complete the activity that follows.

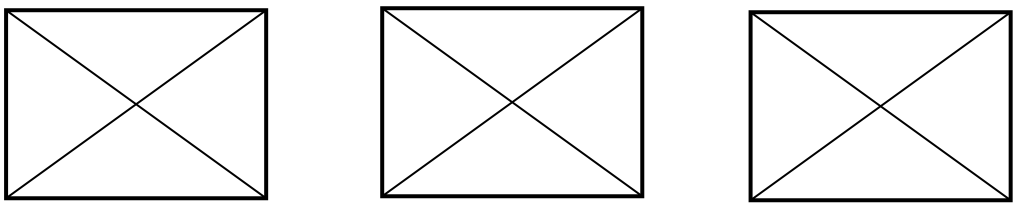
Science Experiment: Light travels in straight lines

Aim:
To discover and describe how light travels.

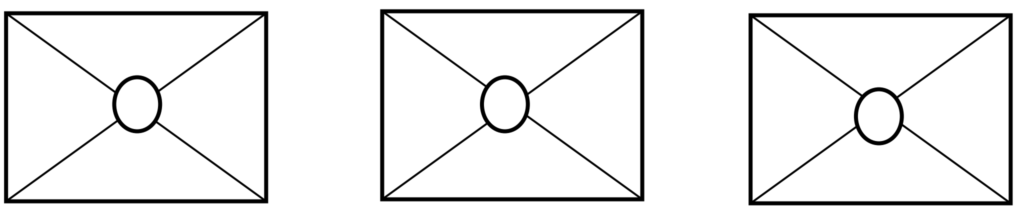
Materials:
3 square or rectangular shaped cardboard of the same size, a small piece of modeling clay or a sticky tack, a candle, a hole puncher, a ruler

Methods:

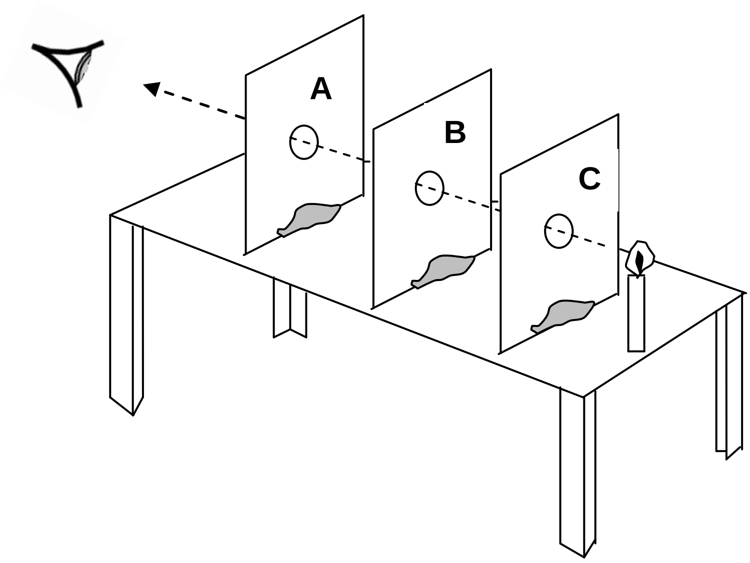
1. For each index card, use a ruler to draw lines connecting opposite corners of the card.



2. At the intersection of the two lines, use a hole puncher to punch a hole in the centre of the cardboards.



3. For each cardboard, use a small piece of modeling clay or sticky tack and place the cardboard into the clay or sticky tack to create a ‘stand’ for the card. Place the cards so that they stand vertically and at an equal distance from each other. See diagram below.



4. Place the candle at one end of the row of cardboard and turn off the light in the room.
5. Arrange the cardboards so that light can be seen through all the holes.
6. Now pull cardboard **B** upwards slightly so that the holes are not in one straight line.

   Do you see the flame now? ______________________________ YES/NO

You do not see the flame because all three holes are not in a straight line with the flame. Adjust the position of cardboard **B** and try to look at the flame through the hole on cardboard **A**.

Conclusion
You will have observed that you see the flame only when all three holes are in the same straight line with the flame.

Activity: Now test yourself by doing this activity.

Use your observations of the experiment to answer the following questions on the spaces provided.

1. How can light be seen through all the cardboards?

   ____

   ____

2. What does the experiment prove about the path that light travels?

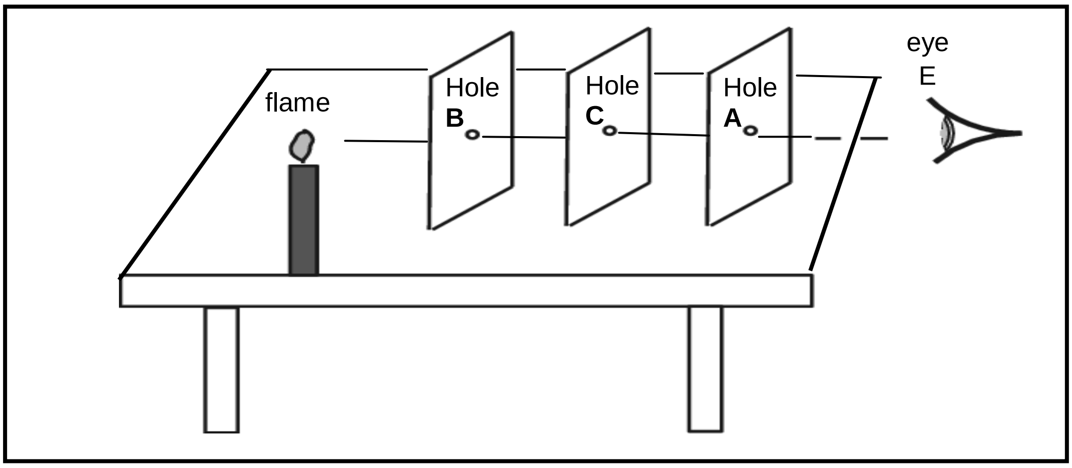
   ____

3. What would happen if the holes were smaller?

   ____

Light Travels in Straight Line

In your experiment, you will see the candle light only when all the three holes and the candle flame are in the same straight line



The holes and the flame must be in one straight line with the eye

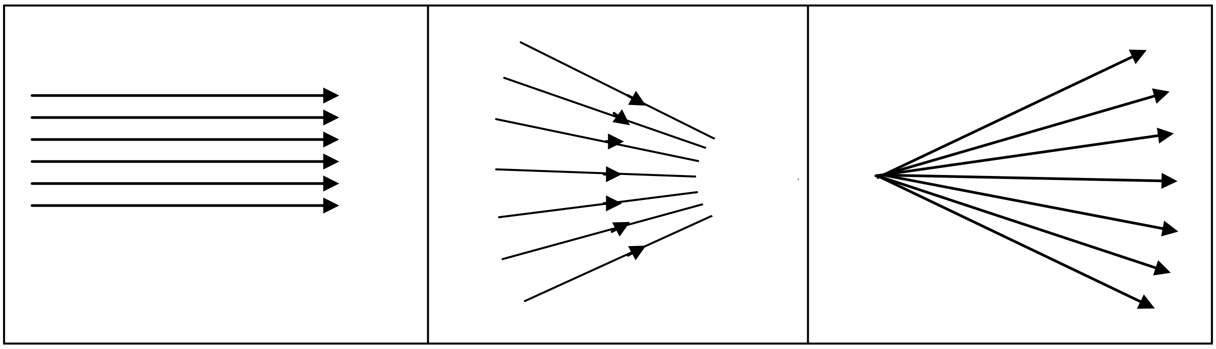
In the diagram, the eye at E sees only that ray which passes through the holes on the cards **A**, **C** and **B.**

Since light travels in straight lines, the holes and the flame must be in a straight line with the eye.

Light rays from the candle flame travel in all directions. If the path is blocked, the light cannot travel further.

Light rays and light beams

When we study about light, we show the path of a light ray by a straight line. The path of several rays is shown by several straight lines and is called a beam of light. Light beams can be of three types.



A parallel beam A converging beam A diverging beam

- Rays that are parallel form a parallel beam of light
- Rays that **converge** (seem to be going towards a point) form a converging beam
- Rays that **diverge** (appear to come from a point) form a diverging beam.

Several light rays form a beam of light. Light beams can be parallel, converging or diverging.

Transmission of Light through Transparent, Translucent and Opaque objects

Transparent substances

Some objects allow light to pass through them while some do not. The substances which allow light to pass through them are called **transparent** substances. Substances like air, water and glass allow light to pass through them. When this happens, they are said to transmit light. This means we can see through them. They are very important and are used in many things like bottles and glass in windows of houses and offices.

Translucent substances

Glass, water and air are transparent only when they are clean and clear. Are they transparent when they are unclear?

- Unclear glass or water allows only a part of the light rays to pass through. We say they are **translucent**.

Translucent substances allow only a part of the light to pass through them. We cannot see through them clearly.

Misty air, misty glass, frosted glass and grease-proof paper are examples of translucent substances.

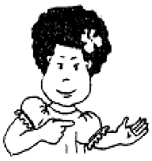
- **Transparent substances allow light rays to pass through them.**
- **Translucent substances allow only a part of light to pass through them**

Opaque substances

You now know what we mean by transparent substances and translucent substances. Transparent substances allow all the light rays to pass through and translucent substances allow only a part of the light to pass through them.

There are substances which do not allow any light to pass through them. They are called **opaque** substances.

For example, trees, steel, wood, brick and mirrors are opaque and they block rays of light from the sun.



Summary

You have come to the end of Lesson 2. In this lesson you have learnt that:

- light travels in straight lines.
- the path of a light ray is shown by a straight line.
- the path of several rays is shown by several straight lines and is called a beam of light.
- light beams can be parallel, divergent or convergent.
- some objects allow light to pass through and are called transparent substances.
- translucent substances allow only a part of the light to pass through them
- substances which do not allow any light to pass through them are called opaque substances.

NOW DO PRACTICE EXERCISE 2 ON THE NEXT PAGE.

Practice Exercise 2

Read and answer the questions on the spaces provided.

1. Complete the blank spaces in the following statements using a word from this list.

opaque **transparent** **translucent**

a) A substance that allows light rays to pass through it is called a __________ substance.

b) Wood and leather are examples of _________ substances.

c) We can see clearly through __________ substances.

d) Substances which allow only a part of the light rays to pass through them are called __________ substances.

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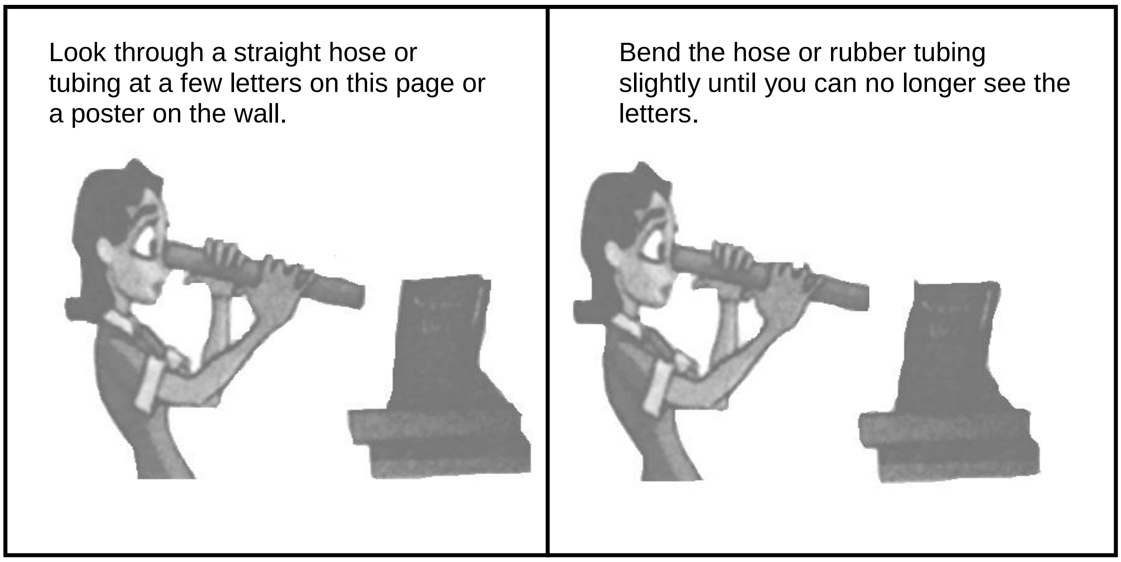
2. Follow the diagram below and do this simple activity and answer the questions on the space provided.



(a) What do you see when you bend the tubing?

____

____

____

(b) Explain your answer to (a) above.

____

____

____

____

3. Does the light reflected from the letters travel in straight lines? Explain.

____

____

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity

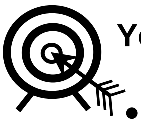
1. The holes are in alignment and the light travels in a straight line.

2. Light travels in a straight line.

3. The light would continue to travel in a straight line but in a more restricted or limited path.

Lesson 3: Shadows

Welcome to Lesson 3. In your last lesson, you learnt that light rays travel in straight lines. The rays are blocked by some objects which do not allow the rays to pass through. This results in the formation of the shadows of those objects. In this lesson, you will learn how shadows are formed.



Your Aims:

- describe shadows
- define umbra and penumbra
- observe and make conclusion about a given activity

How Shadows are Formed

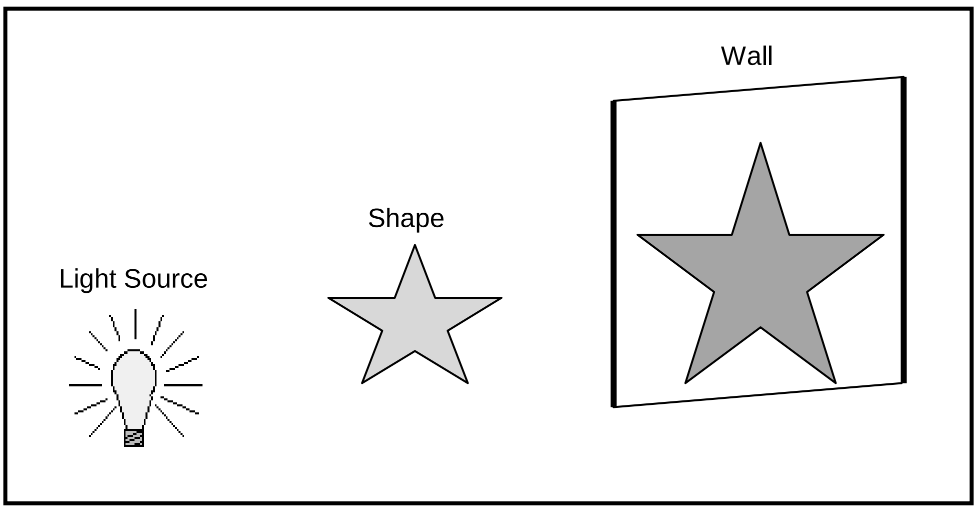
Substances that are opaque completely block light rays from reaching a surface. This results in the formation of **shadows**.

For example, trees are opaque and they block rays of light from the sun. Thus we see shadows of trees. A shadow is an area of darkness that has the same shape as that of the object.

Activity 1: Studying the shape of a shadow

Do this: Place a small bright lamp about a metre from a wall at night. Place different shaped objects about half way between the lamp and the wall.

- Place different shaped objects and observe the shadows formed.



1. Does the shape of the shadow depend on the shape of the different objects? ………………………………………………………… YES/NO

- You can also hold your hand half way between the lamp and the wall and make different shapes with your hand and observe the shadows formed.

Your shadow has your shape. The shadow of a tree has the shape of the tree.

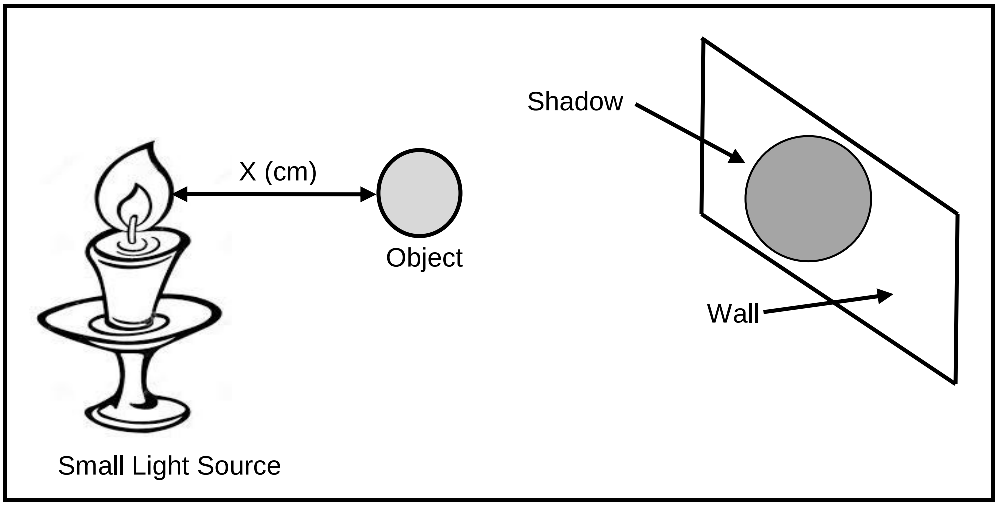
The shadow of any opaque object has the shape of that object.

The Size of a Shadow

You now know that the shape of a shadow depends on the shape of the object. Now, what about the size of a shadow? What does it depend on?

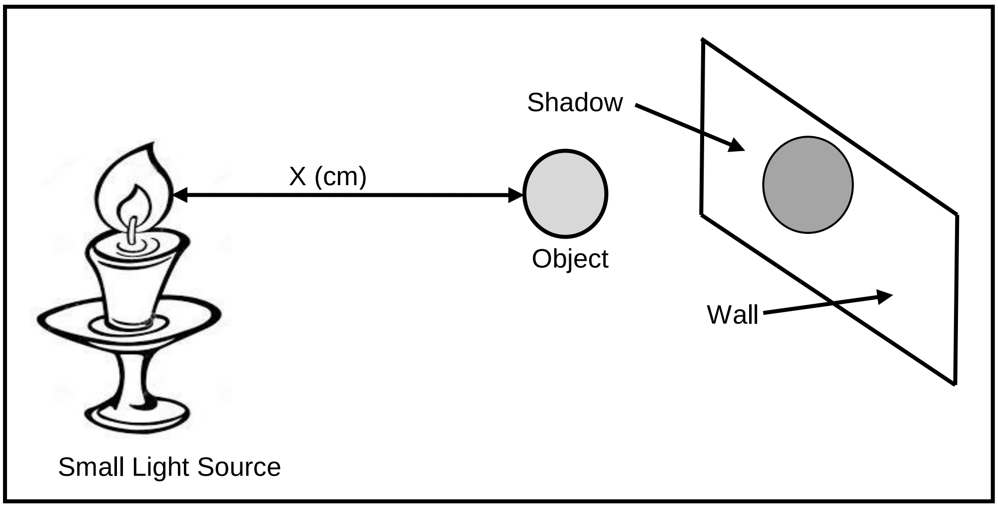
Activity 2: Studying the shape of a shadow

Do this: Place a small bright lamp about a metre from a wall in a dark room. Hold an object, for example, a ball or a book about half way between the lamp and the wall.



1. Do you see the shadow of the object on the wall? ...... YES/NO

- Observe the size of the shadow. Now, move the object towards the wall. Observe the size of the shadow, as you keep moving the object.



2. Does the shadow become bigger or smaller? ………………..…… YES/NO

This activity will have shown that the size of the shadow of an object depends on the following factors:

- The size of the object.
- The distance between the light source and the object.
- The distance between the shadow and the object.

A shadow gets bigger as the object moves closer to the source of light. It gets smaller as the object moves away from the source of light.

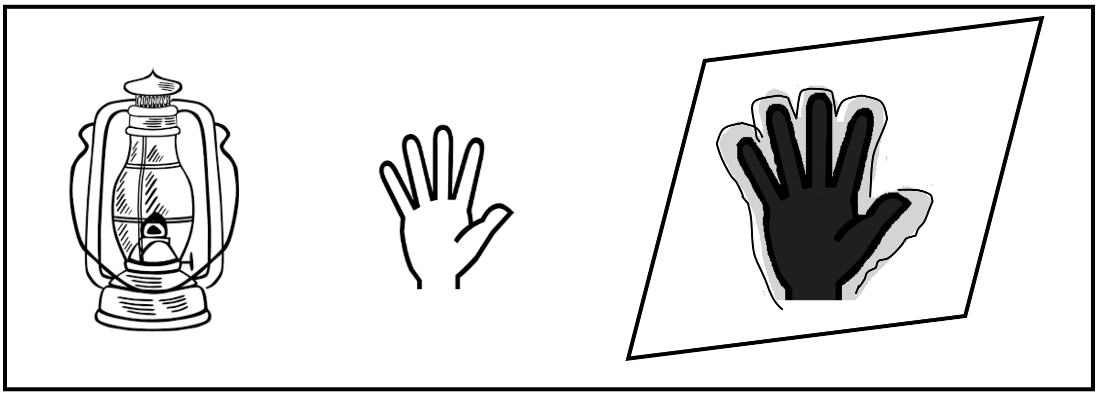
Inner and outer shadows

Have you ever seen a shadow within a shadow? You will now do an activity to see for yourself how the shadow of an object is formed within its shadow.

Activity 3: A shadow within a shadow

Do this: In a dark room, light a lamp. Place the lamp about two metres from a wall.

- Hold your hand between the lamp and the wall.

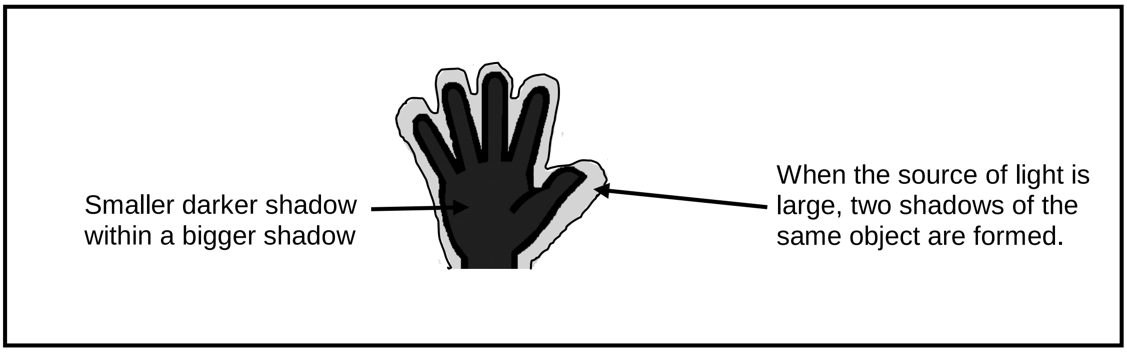


1. Do you see the shadow of your hand on the wall? .... YES/NO

Move your hand closer to the wall and look carefully at the shadow.

2. Do you see the shadow of your hand on the wall? .... YES/NO
3. Is the shadow evenly dark all over? ……………………………..……. YES/NO
4. Do you see a darker shadow within a lighter one? ……………….… YES/NO

In your activity, you will have seen that the shadow is not evenly dark all over. You will have seen two shadows- one smaller but darker surrounded by a bigger but lighter shadow.



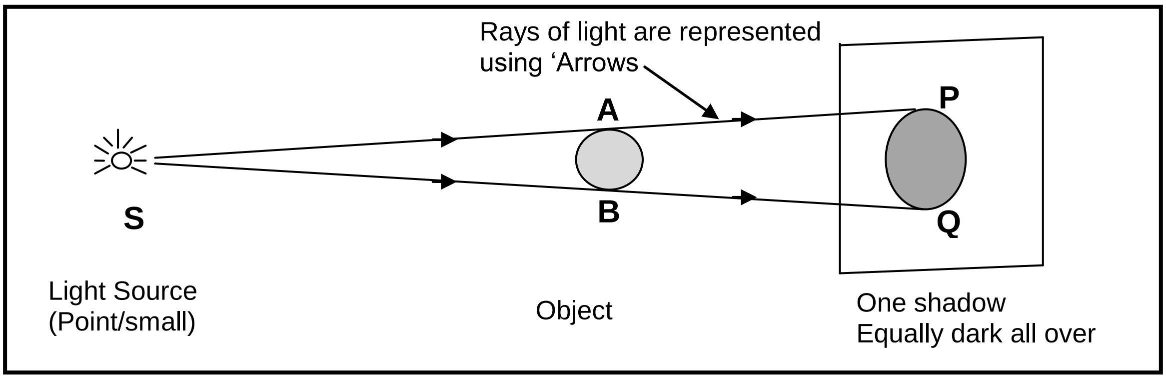
A smaller but darker shadow is seen within a bigger but lighter shadow.

A large source of light produces an inner and an outer shadow of the same object.

Double shadow – how?

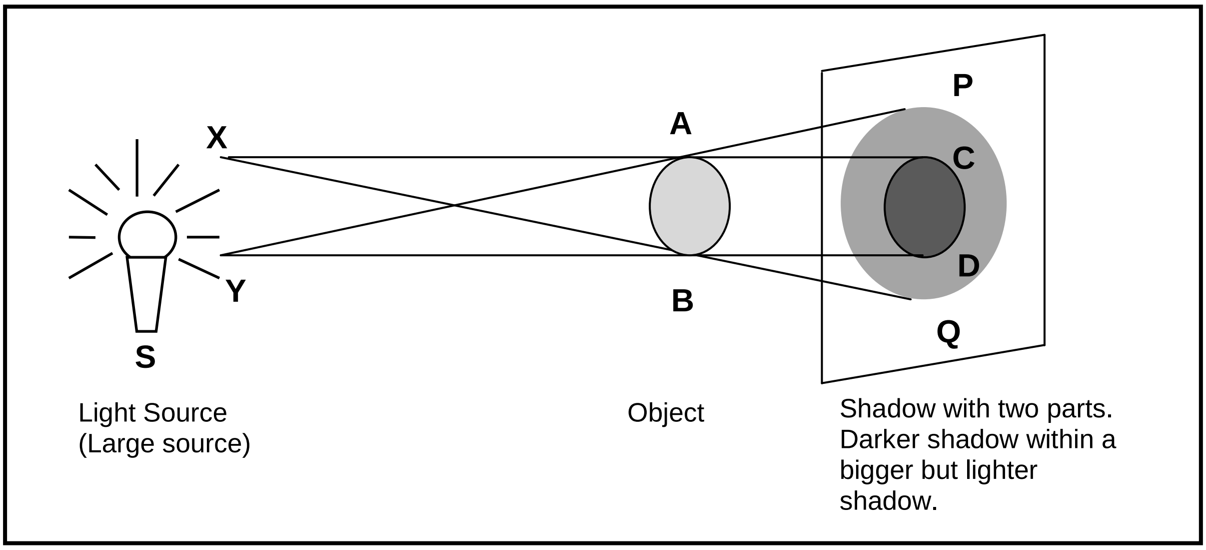
You have seen that a point source of light or a small source of light produces shadows which are equally dark all over. You have also seen that shadows produced by larger light sources have two parts, a small darker shadow within a bigger darker shadow. We shall now study how this happens.

Look at this diagram. It shows that the shadow is produced by a small source of light.



Shadow produced by a small source of light

The rays of light **SAP** and **SBQ** travel from one point **S**. The rays of light between **SA** and **SB** do not reach the screen. So, we see one shadow **PQ** on the screen and the shadow is equally dark all over.



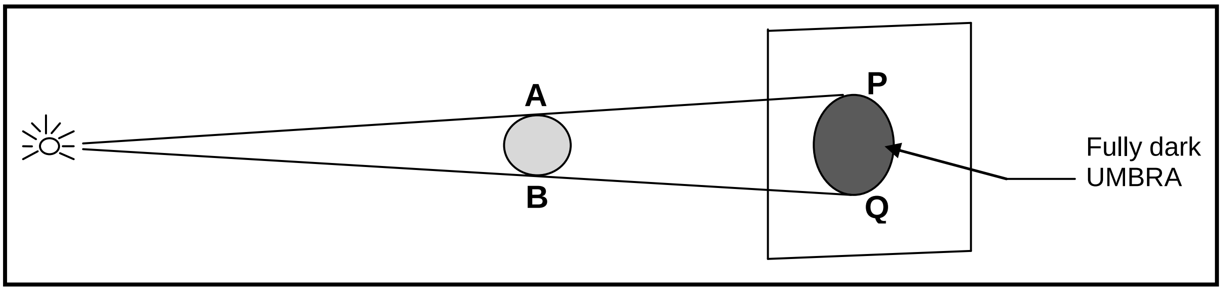
Shadow produced by a large source of light

- No light rays reach the inner area and so the shadow in that area looks darker. Rays below **XAC** and above **YBD** are completely blocked.
- Some rays of light reach the outer shadow area but not all the rays; so that area is not fully dark but only partly dark.

The inner shadow is darker because no light rays reach that area.
The outer shadow is lighter because some rays reach that area.

Umbra and penumbra

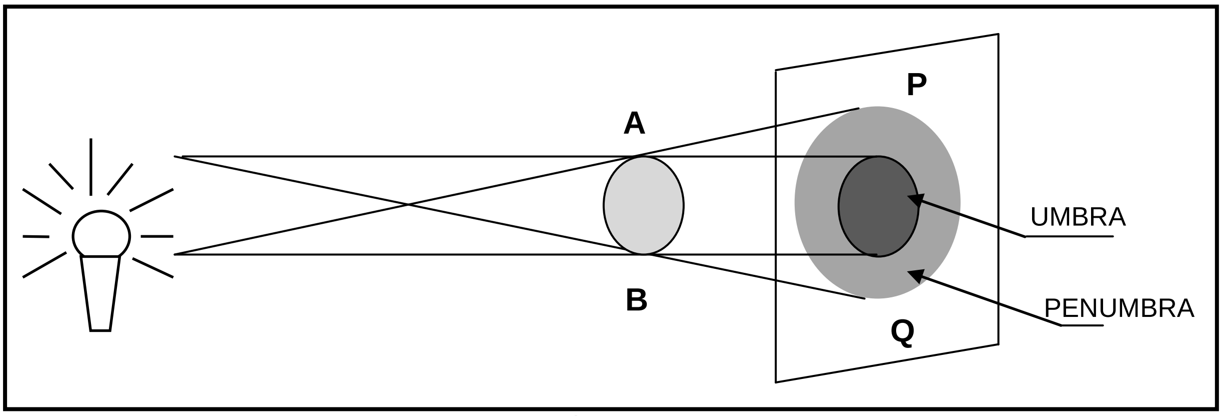
You have learnt that when the light comes from a very small source, we get one dark shadow. No light rays reach that area of the shadow. Therefore, it is fully dark.



Umbra

A dark shadow has a special name called **umbra**. It is an area from which all light rays are cut off. All parts of the shadow appear equally dark.

You also learnt that when the source of light is a large source, we get two shadows. One is a small darker shadow within a bigger, less dark shadow.



Penumbra

The outer shadow is called the **penumbra**. Light rays from some parts of the light source are blocked from reaching the penumbra but rays from some other parts, reach that area. The diagram shows four rays of light that go out in straight lines.

Thus, a larger source of light produces shadows with two parts, the umbra and the penumbra.

The fully dark area of a shadow is called the umbra.
The partly dark area of a shadow is called the penumbra.

You have now learnt that shadows are of two types. One type has clearly defined or sharp edges. This is produced when a small source of light is used or when the object is close to its own shadow.

The other type of shadow is by far the more common. It has fuzzy edges. These shadows are produced by a large source of light or when the object is far away from its own shadow. A translucent light bulb, a fluorescent tube and the sun will produce this kind of shadow.

Shadows can be magnified or diminished depending on where the object is to the surface. If the object is closer to the surface then it will become smaller. If it is further away from the surface, it will be enlarged.

Summary

You have come to the end of Lesson 3. In this lesson you have learnt that:

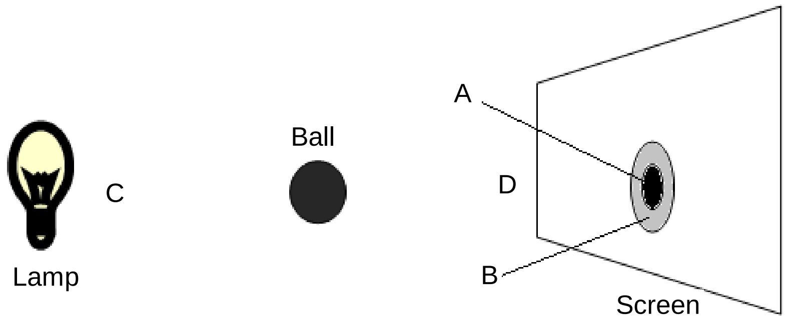
- when an opaque object blocks light from reaching a surface, a shadow is formed.
- the region formed on a shadow where all the light is blocked is called umbra (Full shadow).
- the region on a shadow where part of the light is blocked is often known as penumbra (Partial shadow).
- a small source of light produces a sharp edged shadow or when the object is closer to its shadow.
- a large source of light usually produces a fuzzy edged shadow.
- a shadow of an object has a similar shape of that object.

NOW DO PRACTICE EXERCISE 3 ON THE NEXT PAGE.

Practice Exercise 3

Answer the following questions.

1. Look at the diagram below and answer the questions.



a) Name the part labeled A.

____

b) Name the part labeled B.

____

c) If the ball was placed at position **C**, and if the source of light is large, what kind of shadow will be formed?

____

d) If the ball was placed at **D,** and if the source of light is small, what kind of shadow will be formed?

____

e) Describe the shadow that will be formed if the ball is moved closer to the screen.

____

f) Describe the shadow that will be formed if the ball is moved away from the screen.

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to Activity 1

1. Yes

Answers Activity 2

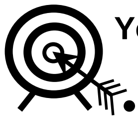
1. Yes 2. smaller

Answers Activity 3

1. Yes. 2. Yes 3. No 4. Yes

Lesson 4: Eclipses

Welcome to Lesson 4. In the previous lessons, you learnt about shadows (inner and outer shadows). This knowledge will help you understand the content of this lesson. In this lesson, you will learn about the eclipse of the Sun and the Moon.

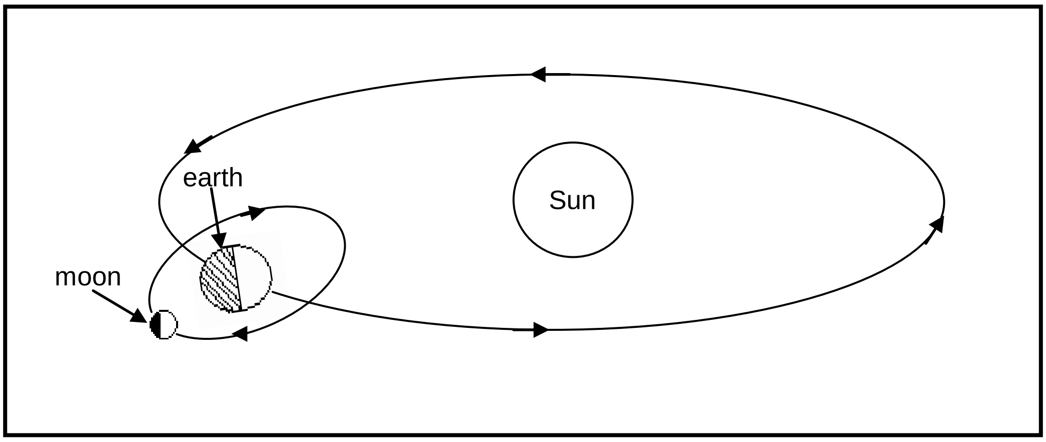


Your Aims:

- define solar and lunar eclipse
- distinguish total eclipse from partial eclipse
- describe the eclipse of the Sun and the Moon

Eclipse of the Sun

You know that the earth orbits the sun and the moon orbits the earth.



The earth orbits the sun and the moon orbits the earth.

Remember that the earth and the moon are relatively close together and a long way from the Sun, so if the three of them line up, the sun can never be between the other two.

The sun is luminous. The earth and the moon are both non-luminous, they are opaque. During daytime, we on Earth see the sun and get light from the sun.

At night, light from the sun falls on the moon's surface, bounces off and reaches us. Thus, we see the moon and also enjoy the moonlight.

While orbiting the Earth, sometimes the moon comes directly between the sun and the Earth. When this happens, the moon's shadow falls on the Earth.

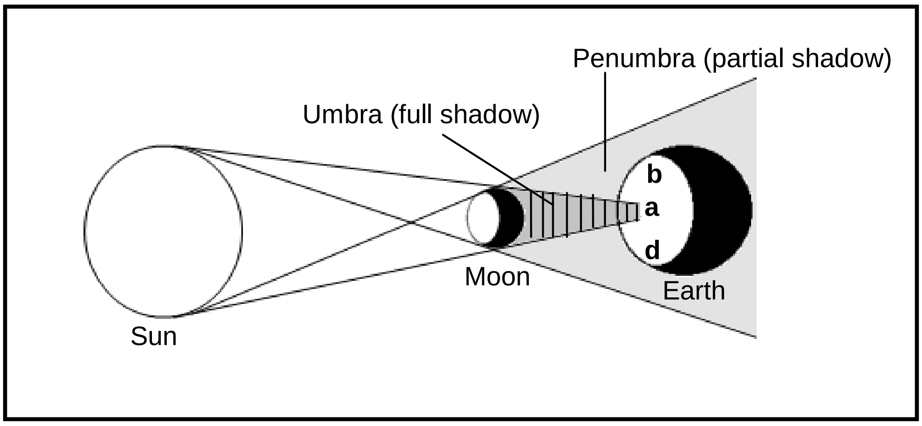
If the moon's shadow falls on the earth during daytime, that part of the earth on which the shadow falls loses Sunlight. Light from the Sun does not reach that part of the earth for a short time.

This is an eclipse of the sun. It is called the **solar eclipse**.

A solar eclipse occurs when the Moon comes directly between the Earth and the Sun during daytime.

Total Eclipse and Partial Eclipse

The moon's shadow has a fully dark inner shadow known as **umbra** and a partially dark outer shadow which is the **penumbra**. Hence, during a solar eclipse, some parts of the earth lie in the penumbra and some parts lie in the umbra.

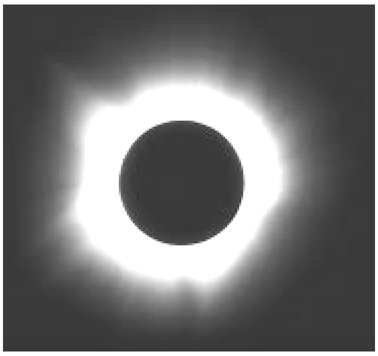


A solar eclipse occurs when the Moon comes directly between the Sun and the Earth

As you can see from the above diagram, some parts of the earth are in the umbra and some parts in the penumbra. The parts of the Earth which lie in the **umbra** (marked **a** in the above diagram) will experience complete darkness. This is called **total** eclipse of the sun.

The parts which lie in the penumbra (marked b and d in the above diagram) will experience) partial darkness. This is called **partial** eclipse of the Sun.

Look at the two photographs given below:



Total eclipse of the Sun

Partial eclipse of the Sun

These photos were taken during a total eclipse and a partial eclipse of the Sun.

- During a total solar eclipse, the sky is dark and we do not see the Sun. But we see a beautiful bright circle of light around the Sun. This circle is called the **corona**. We can look directly at the corona.

- During a partial solar eclipse, the sky is fairly dark but we see a part of the sun. It is dangerous to look at the Sun directly during a partial solar eclipse. Harmful rays from the sun can damage the eyesight.

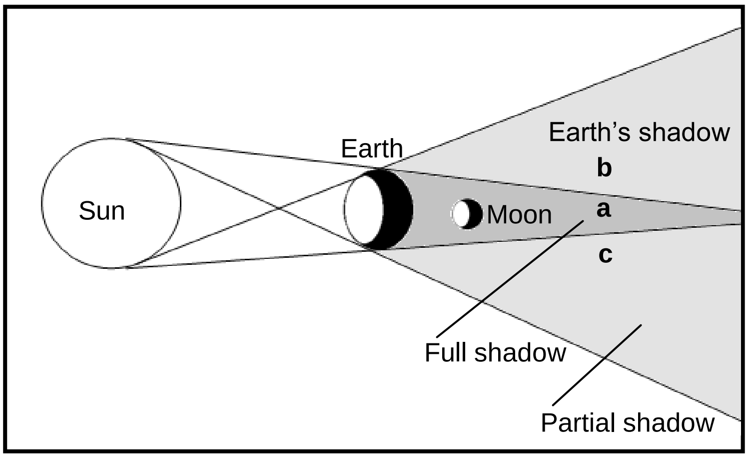
A solar eclipse can be a total eclipse or a partial eclipse.

Eclipse of the moon

You know that the Moon is non-luminous. Rays of sunlight fall on the Moon and bounce back to us. That is how we are able to see the moon.

The Earth is opaque. When the Earth comes between the Sun and the Moon, sunlight produces the shadow of the Earth.

You know that a solar eclipse occurs when the moon comes between the Sun and the Earth. There are also times when the Earth comes between the Sun and the moon. When this happens, it is called a lunar eclipse. The diagram below shows a lunar eclipse.

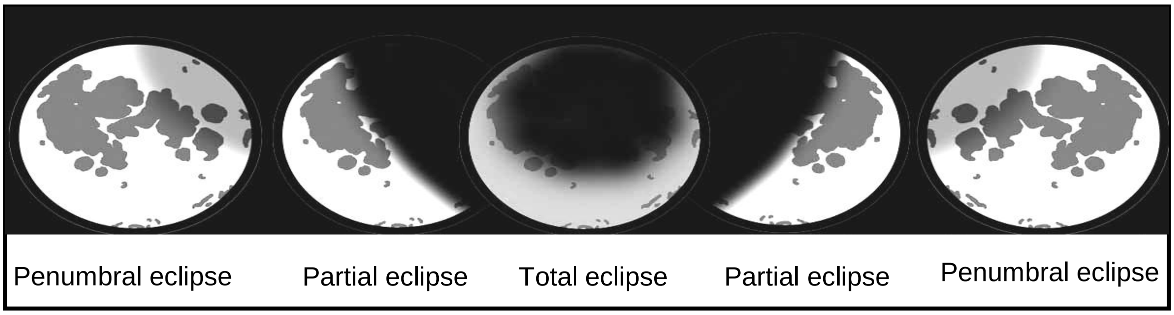


A Lunar eclipse occurs when the Earth comes between the Sun and the Moon

When the Moon passes through the shadow of the Earth, an eclipse of the Moon occurs which is called a **lunar** eclipse.

The Earth's shadow has an umbra(marked **a** in the above diagram) and a penumbra (marked **b** and **c** in the diagram).

The lunar eclipse occurs in stages when the moon passes through the penumbra, the umbra and the penumbra again.



Phases of the lunar eclipse

The photograph above shows the different stages of a lunar eclipse. It shows what the moon looks like as it passes through the different stages of a lunar eclipse. During a lunar eclipse, the moon looks reddish gold.

Lunar eclipse is the term for the eclipse of the moon.

Activity: Now test yourself by doing this activity.

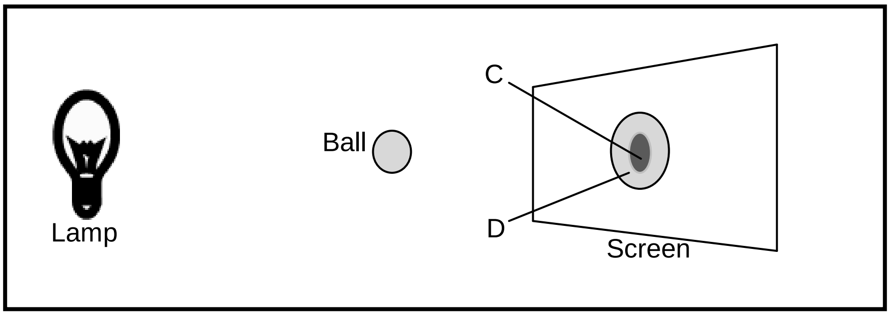
Read the questions carefully and write your answers on the spaces provided.

1. Differentiate between the umbra and penumbra.

2. Why is it dangerous to look directly at a solar eclipse?

3. What can be seen from Earth during a total eclipse of the sun?

4. The equipment shown below can be used to represent an eclipse of the Sun.



(i) Which object represents the

a) Sun? __________

b) Earth? __________

c) Moon? __________

(ii) Which letter represents a

a) full shadow? __________

b) partial shadow? __________

Summary

You have come to the end of Lesson 4. In this lesson you have learnt that:

- an eclipse of the Sun occurs when the moon comes directly between the Earth and the Sun during daytime and moon’s shadow falls on the Earth.
- an eclipse of the Moon occurs when the Earth comes between the sun and the moon and the Earth’s shadow falls on the moon.
- total solar eclipse occurs when parts of the earth which lie in the umbra experience complete darkness. This happens because the Moon blocks almost all the Sun’s light from reaching the Earth.
- a partial solar eclipse will occur when parts of the Earth which lie in the penumbra will experience partial darkness.
- lunar eclipse occurs in stages as the moon passes through the penumbra, the umbra and the penumbra again.

NOW DO PRACTICE EXERCISE 4 ON THE NEXT PAGE.

Practice Exercise 4

Read and answer the following questions on the spaces provided.

1. What is a:

   (a) solar eclipse?

   (b) lunar eclipse?

2. The Sun, the Earth and the Moon must be in a line for an eclipse of the Moon to occur. Using diagrams, describe the occurrence of the following:

   (a) A solar eclipse

   (b) A lunar eclipse

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 1.

Answers to activity

1. The region formed on a shadow where all the light is blocked is called umbra (Full shadow) and the region on a shadow where part of the light is blocked is often known as penumbra (Partial shadow).

2. The Suns light is too bright and you may damage your eyes if you look directly**.**

3. The Sun’s corona

4. (i) (a) Lamp (b) Screen (c) Ball

   (ii) (a) C (b) D

Answers to Practice Exercises 1 – 4

Practice Exercise 1

1. (a) Luminous objects are objects that produce their own light.

   (b) (i) Luminous
   (ii) Luminous
   (iii) Non-luminous
   (iv) Non-luminous
   (v) Non-luminous

2. (a) Light energy is a ray energy and belongs to a family of waves called electromagnetic waves.

   (b) Radio waves, infra-red rays and gamma rays, cosmic rays, microwaves, x-rays, ultra violet, radio waves (**accept any 3 answers**)

   (c) Leaves of plants trap light energy from the sun through the process of photosynthesis for our use.

3. (a) Our eye is sensitive to light.

   (b) We see non-luminous objects when light that falls on them bounce off and reach our eyes.

Practice Exercise 2

1. (a) transparent

   (b) opaque

   (c) transparent

   (d) translucent

2. (a) You cannot see the letters when you bend the tubing.

   (b) Light travels in straight lines which allow us to see objects. When the tubing is bent, the path of light is blocked so we cannot see the letters.

3. Yes, the light reflected from the letters travel in straight lines to reach our eyes in order for us to see them.

Practice Exercise 3

1 a) Umbra (full shadow)

  b) Penumbra (partial shadow)

c) Fuzzy edged shadow

d) Clearly defined or sharp edged shadow

e) It will become smaller.

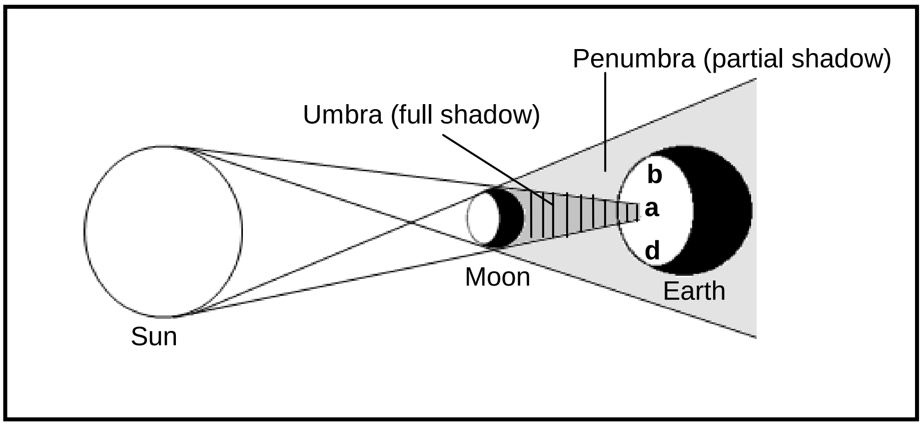
f) It will be enlarged.

Practice Exercise 4

1. (a) A solar eclipse is an eclipse of the Sun and occurs when the Moon comes between the Sun and the Earth and the shadow of the Moon falls on the Earth.

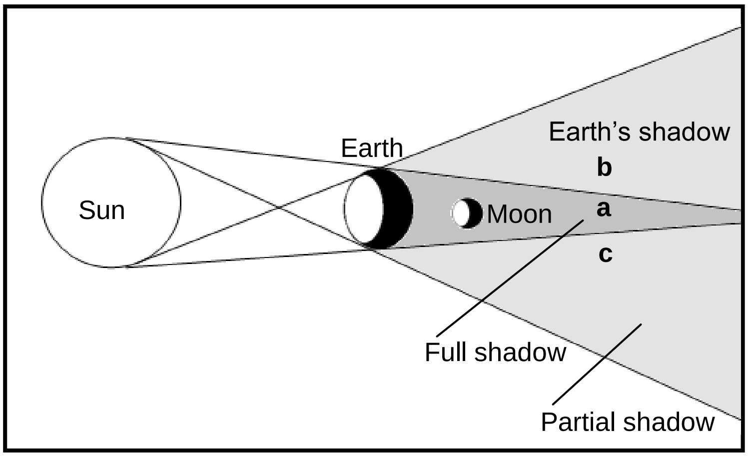
   (b) A lunar eclipse is an eclipse of the Moon and occurs when the Earth comes between the Sun and the Moon and the Earth's shadow falls on the Moon.

2. (a)



A solar eclipse occurs when the Moon comes between the Sun and the Earth

(b)



A Lunar eclipse occurs when the Earth comes between the Sun and the Moon

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REVISE TOPIC 1 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 1: Light Energy

Now, revise all lessons in this Topic and then do **ASSIGNMENT 4**.
Here are the main points to help you revise.

Lesson 1: Properties of Light

- Objects that produce their own light are called luminous objects and they can either be living or non-living things.
- Any luminous object that is not produced in the factory is called natural a luminous object.
- Artificial sources of light are those objects that are manufactured and can produce light.
- Light is a form of ray energy and it travels as waves.
- Objects which do not produce light energy are called non-luminous objects.
- Light energy can only be detected by the eye.
- Light energy belongs to a family of waves called electromagnetic waves.
- Light energy from the sun is changed into chemical energy by leaves of plants during photosynthesis.

Lesson 2: Transmission of Light

- Light travels in straight lines.
- The path of a light ray is shown by a straight line.
- The path of several rays is shown by several straight lines and is called a beam of light.
- Light beams can be parallel, divergent or convergent.
- Some objects allow light to pass through and are called transparent substances.
- Translucent substances allow only a part of the light to pass through them
- Substances which do not allow any light to pass through them are called opaque substances.

Lesson 3: Shadows

- When opaque object block light from reaching a surface a shadow is formed.
- The region formed on a shadow where all the light is blocked is called umbra (Full shadow).
- The region on a shadow where part of the light is blocked is often known as penumbra (Partial shadow).
- A small source of light produces a sharp edged shadow or when the object is closer to its shadow.
- A large source of light usually produces a fuzzy edged shadow.
- A shadow of an object has a similar shape of that object.

Lesson 4: Eclipses

- An eclipse of the Sun occurs when the moon comes directly between the Earth and the Sun during daytime and moon’s shadow falls on the Earth.
- An eclipse of the Moon occurs when the Earth comes between the sun and the moon and the Earth’s shadow falls on the moon.
- Total solar eclipse occurs when parts of the earth which lie in the umbra experience complete darkness. This happens because the Moon blocks almost all the Sun’s light from reaching the Earth.

- A partial solar eclipse will occur when parts of the Earth which lie in the penumbra will experience partial darkness.
- Lunar eclipse occurs in stages as the moon passes through the penumbra, the umbra and the penumbra again.

REVISE WELL AND THEN DO TOPIC TEST 1 IN YOUR ASSIGNMENT 4.

TOPIC 2

REFLECTION AND REFRACTION OF LIGHT

In this topic you will learn about:

- **reflection of light**
- **refraction of light**

INTRODUCTION TO TOPIC 2: REFLECTION AND REFRACTION OF LIGHT

You cannot see through some things because light rays bounce off them. We see objects that do not produce their own light like houses, chairs, our friends, and other objects because light bounces off them. This is called **reflection**. When light rays hit the smooth surface of a mirror, they bounce off in a straight line. That is why you can see a reflection of your face in a mirror. Light rays bounce off in different directions when they hit bumpy surfaces. That is why you cannot see your face in your friend's hair but you can see the hair.

Light bends when it enters materials. You can see light bend when it goes from air to water. Light bends because it changes speed when it enters the water. Put a pencil at a slant in a glass of water. The pencil looks like it is broken in two at the surface of the water. The surface is where the light rays slow down and bend as they go from air to water. This bending of light is called **refraction**.

When light rays hit the smooth surface of a mirror, they bounce off in a straight line. That is why you can see a reflection of your face in a mirror.

The pencil looks like it is broken in two at the surface of the water. The surface is where the light rays slow down and bend as they go from air to water.

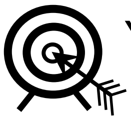
You should know all about the reflection and refraction of light. Some of the questions you may be asking yourself now are:

- When does reflection occur?
- When are clear and unclear images formed?
- When does refraction occur?
- How does a light ray bend in different mediums?

In this topic, you will find the answers to these questions and all other questions relating to reflection and refraction of light.

Lesson 5: Reflection of Light

Welcome to Lesson 5. In this lesson, you will learn about the reflection of light. When light strikes a surface, some light is reflected. How it is reflected depends on the colour and smoothness of the surface.



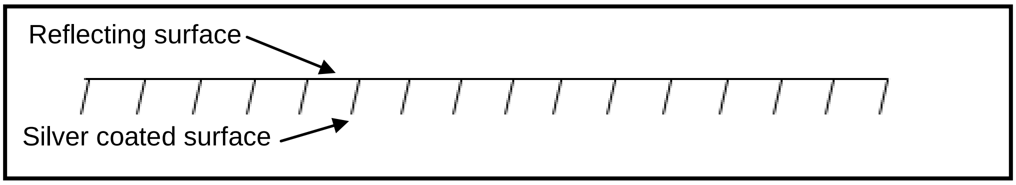
Your Aims:

- define reflection
- state the Laws of Reflection
- describe the reflection of light in plane and curve surfaces
- observe and make conclusion about a given activity

What is Reflection?

Reflection is the bouncing back of light on a smooth and shiny surface.

Any smooth surface which reflects light is said to be a **mirror**. The mirrors we use have flat (plane) surfaces that are smooth and shiny with silver coating on one flat side. We call them **plane mirrors**. It is the silver coating that reflects and not the glass.



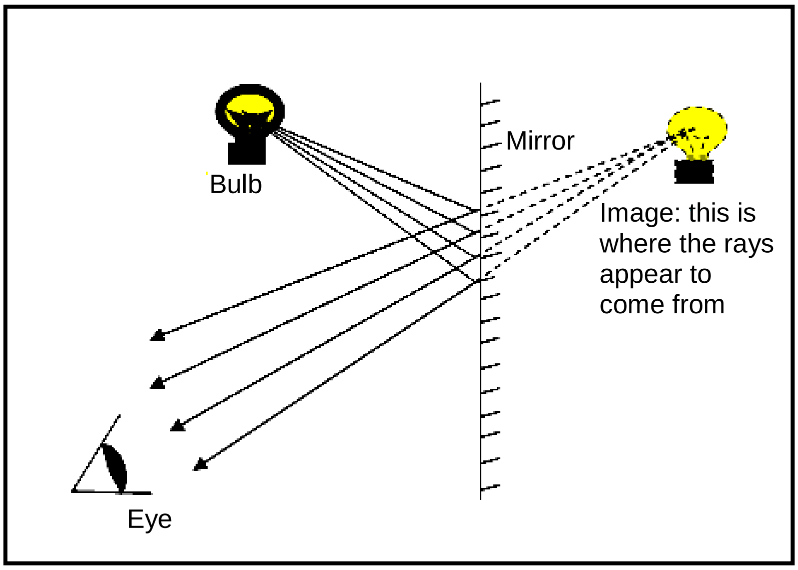
A symbol used to represent a plane mirror

We now know that a plane mirror is normally shown by a straight line, shaded on one side. The shaded side represents the side with the silver coating which is also the back of the mirror.

While shiny, polished surfaces are useful as mirrors, they are not wanted in other situation. The wall of the room is more restful to our eyes if they are not shiny. The paint used to give a non-shiny surface is called a **matt or flat paint**. Unglazed or non-shiny paper in books is more restful to our eyes than glazed or shiny paper. When people see their faces in the mirror, light coming from the faces is reflected regularly without distortion by the mirror. This kind of reflection is called a **regular reflection**.

Regular reflection occurs when light strikes a smooth shiny surface, such as a polished piece of metal.

When you look into a mirror, you see a clear, reflected image of yourself. Have you ever wondered how your image is formed? An image of yourself is formed because the light from the sun or other luminous objects bounce off from your body and is reflected regularly without distortion by the mirror. Rays from the mirror enter the eyes so that your image seems to be somewhere behind the mirror like shown in the diagram below.



Flat mirrors are also known as **plane mirrors**. When you look at yourself in a mirror you see an image. The images in the picture below are formed because light coming from the jar is reflected from a smooth and shiny surface behind this sheet of glass.

The image of the jar is behind the mirror

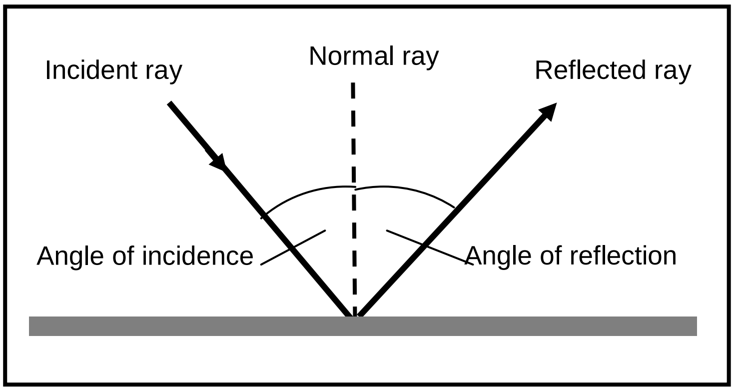
Laws of Reflection

Reflection always involves two rays: an incoming or an incident and an outgoing or reflected ray. The law of Reflection states that;

1. The angle of incident is equal to the angle of reflection

2. The incident ray and the reflected ray are found on the same plane but are on opposite sides of the normal.

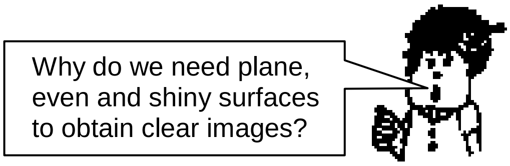
3. The normal is an imaginary line passing at 90 degrees between the point where the two rays meet.



Reflection of a light ray

Activity: Now try this activity.

Activity: Reflection on plane smooth surfaces.



Do this: Stand in front of a mirror and look at your image.

1. Do you see a clear image of yourself? ……………………………YES/NO

2. Is the surface of the mirror smooth, shiny and flat? …………….YES/NO

- Stand in front of a shiny piece of aluminium foil or tin sheet which is corrugated that is, not plane but bent like waves.

3. Do you see a clear image of yourself in it? ……………………YES/NO

- Take a bucket of water. Look at the image of your face in it when the water is still.
- Now, disturb the water and look at your image in it again.

4. Do you see a clear image in it when the water is disturbed? ……YES/NO

Clear images are formed when the reflected light rays are undisturbed.

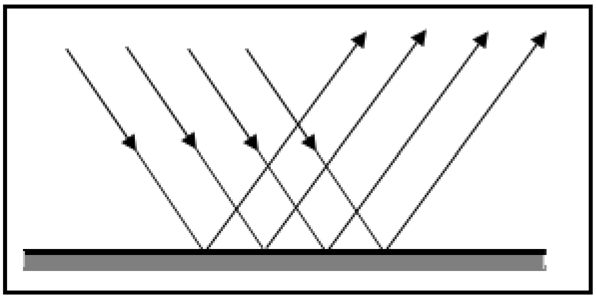
The activity you have done has shown you that reflected images are clear in plane, smooth, shiny surfaces and in still water. This is because the reflected rays bounce off undisturbed surfaces without being scattered.

Undisturbed reflection

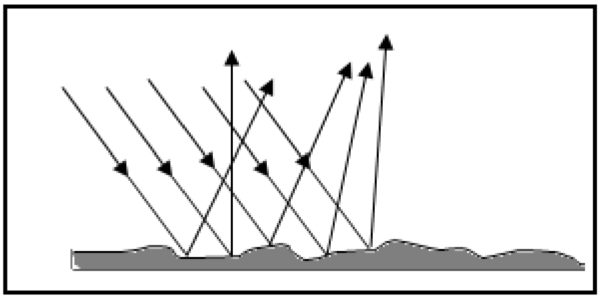
In the activity you performed as well as in your day to day observations, you must have found an important fact about reflection and reflected images.

- Reflection on plane, even and smooth surfaces produce clear images.
- Reflections on uneven and rough surfaces do not produce clear images.

You know that the reflection of light means the bouncing back of light from a surface. How a ray of light bounces off a surface depends on the nature of the reflecting surface.



Reflected rays undisturbed on plane, even surfaces



Reflected rays disturbed on uneven plane surfaces

- Rays of light reflected by plane and even surfaces are undisturbed, so they all bounce off in the same direction.
- Rays of light reflected by uneven reflecting surfaces are disturbed, so they bounce off in different directions.
- A plane mirror reflects light rays undisturbed.

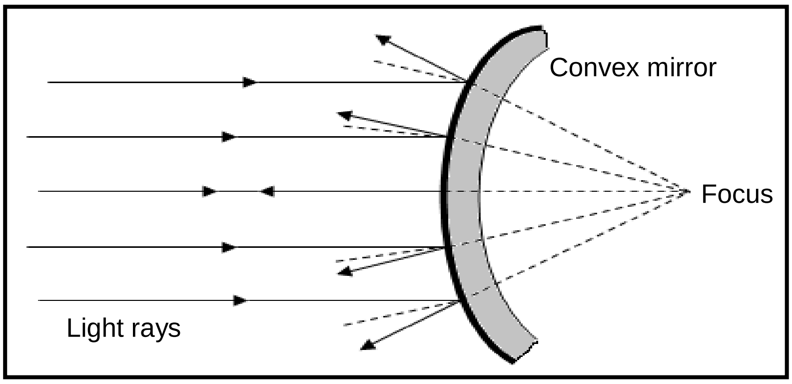
Undisturbed reflected rays produce clear reflected images.

Rough surfaces scatter or diffuse light. This is known an **irregular or diffuse reflection**. That is where light spreads out in different directions. Rough surfaces include things like sand paper but there are other non-shiny things that have rough surfaces. The rough surfaces can only be seen with a lens or a microscope. Flat paint and unglazed paper actually appear to have rough surface when examined under a microscope.

Rays of light striking the rough surfaces still follow the Laws of reflection but because the surface is rough the rays are scattered. This diffuses the light and prevents the glaring reflections which shiny surfaces give.

Convex mirrors

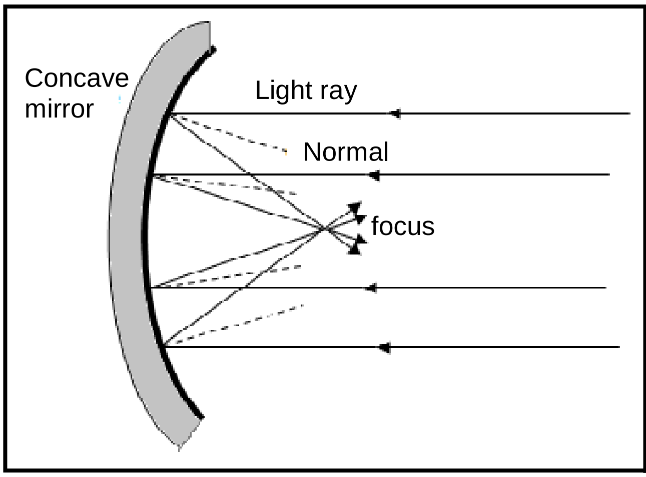
Convex mirrors are curved outwards at the front. Instead of concentrating the light at a focus, a convex mirror spreads light out. The light rays are said to diverge. A focus is the point on the axis of a mirror to which parallel rays of light converge or from which they appear to diverge after reflection. Convex mirrors have a wide field of vision when viewed from in front. Because of this they are used in cars where they give a smaller image of a wider field of view. Because of their wide coverage, convex mirrors are also used in self-service shops to detect stealing.



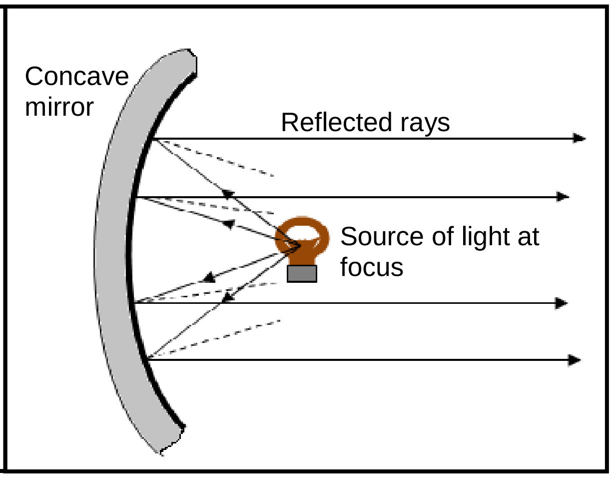
Parallel rays reflected by a convex mirror

Concave Mirrors

Concave mirrors are curved inwards at the front. When the rays of light parallel to each other, such as a beam of light, strikes a concave reflector directly in front, the rays of light are reflected so that they meet at the focus. The rays of light are said to converge. Curved mirrors of this shape are used in astronomical reflecting telescopes.



Parallel rays reflected by a concave mirror



A concave mirror producing parallel rays of light

Summary

You have come to the end of Lesson 5. In this lesson you have learnt that:

- reflection is the bouncing back of light on a smooth and shiny surface.
- any smooth surface which reflects light is said to be a mirror.
- regular reflection occurs with a smooth and shiny surface and produces a clear image.
- an irregular reflection occurs with a rough surface and produces an unclear image.
- when light is reflected it is found that :
  1. The angle of incidence is equal to the angle of reflection.
  2. The incident ray and the reflected ray are on the same plane but opposite the normal.
  3. The normal is the imaginary line that is at 90^0 to the incident and the reflected ray.

  This is known as the law of reflection.
- a plane mirror gives an image that is far behind the mirror as the object is in front .
- a concave mirror gives and makes rays converge. It can be used to focus light or to make parallel rays of light.
- a convex mirror makes rays diverge. It produces an image with a wide field of view.

NOW DO PRACTICE EXERCISE 5 ON THE NEXT PAGE.

Practice Exercise 5

Answer the following questions on the spaces provided.

1. Define reflection.

2. What is the name given to any smooth surface that reflects light?

3. Describe in your own words where a/an

   a) irregular reflection occurs and the type of image produced.

   b) regular reflection occurs and the type of image produced.

4. State the law of reflection.

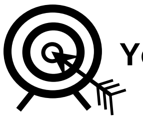
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

1. Yes
2. Yes
3. No
4. No

Lesson 6: Refraction of Light

Welcome to Lesson 6. You now know that light travels in straight lines, but when it travels from one substance to another, it bends and its direction is changed. In this lesson, you will learn what is meant by the bending of light rays.



Your Aims:

- define refraction
- state the Law of Refraction
- describe the refraction of light in different mediums
- explain the causes of refraction
- observe and make conclusions about a given activity

Medium

You have learnt that light rays travel in straight lines. This is true only when light rays travel in the same substance, for example, air.

Air is a substance in which light travels. Glass and water are also other examples.

In Science, a substance in which light travels is referred to as a **medium** (plural- media or mediums). Air, glass and water are different media.

What is refraction?

Light waves travel in straight lines through empty space (a vacuum), but more interesting things happen to them when they travel through other materials, especially when they move from one material to another.

If you shine a beam of light (a bundle of parallel rays) through air, it will travel in a straight line. Rays of light usually travel in straight lines until they hit something.

If a ray of light hits the surface of a glass, some light will be reflected by its surface. However, much of the light will pass through because glass is transparent.

Water affects light rays in a similar way. Some light will be reflected off the surface of the water, but much of the light will pass through the transparent water.

When a light ray passes from air into water a similar thing occurs: the light ray is bent as it strikes the surface of the water. This 'bending of a ray of light' when it passes from one substance into another substance is called **refraction**.

The bending of a light ray occurs when the ray comes out of a glass or water and passes into air.

Refraction is the bending of light as it passes from one medium to another. It occurs when a ray passes from one medium to another.

What Causes Refraction?

Glass and water are thicker and heavier than air. They are said to be 'denser' than air. What happens is that light slows down when it passes from the less dense air into the more dense glass or water.

The slowing down of the ray of light also causes the ray of light to change direction. It is the change in the speed of light that causes refraction.

This is a bit like when a car goes partly off the road and some of the wheels go into softer edge of the road. The softer surface drags on the wheels and slows them down. This can cause the car to pull to the left, slightly changing its direction.

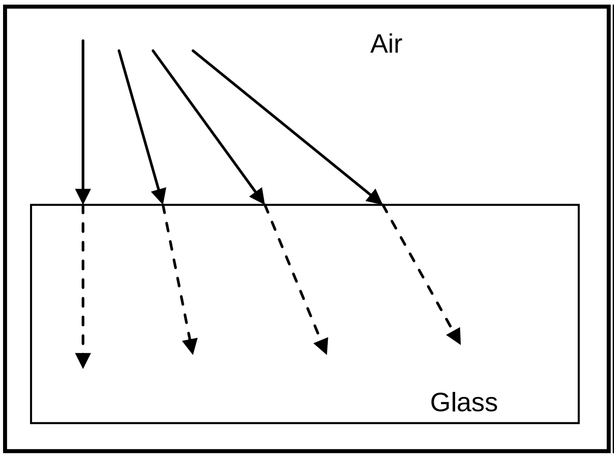
It is the change in the speed of light that causes refraction.

Direction of bending

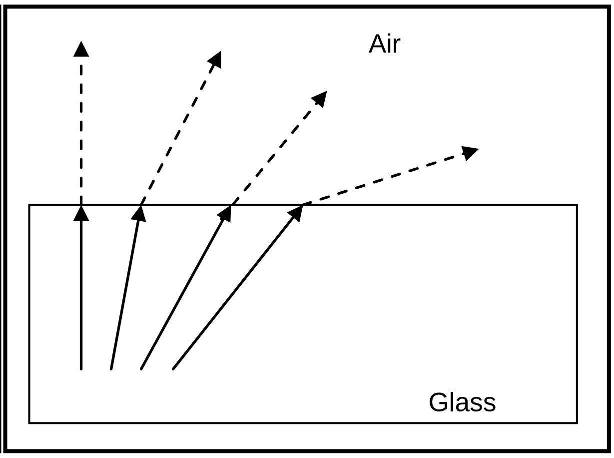
When a ray of light passes from a less dense material, example, air, into a more dense material, example, glass or water, it is bent away from the surface between the two materials. This means that in this situation, the angle of refraction is always less than the angle of incidence.

However, if the ray of light hits the surface at right angles, that is, at 90^0 to the surface, the ray is not bent.

When a ray of light passes from a more dense material, example, water or glass into a less dense material, example, air, it is bent towards the surface between the two materials. This means that in this situation, the angle of refraction is always greater than the angle of incidence.

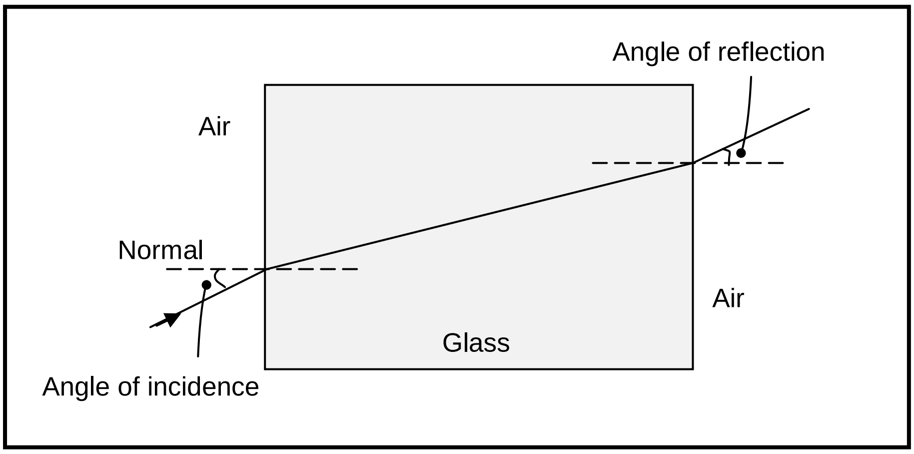


Light ray passing from air into glass



Light ray passing from glass into air

The diagram below shows light passing from air into glass. You will now see that the incident ray is bending towards the normal when it enters the glass and bending away from the normal as soon as it comes out from the glass into the air. The ray of light that comes out from the glass is known as the **emergent ray** which is now refracted away from the normal.



Refraction occurs when light passes through a block of glass

A ray of light that passes from one medium into another refracts at the surface that separates the two media.

We now know that air is less dense then water or glass. Light slows down when it passes from the less dense air into the more dense glass or water.

Comparing density, water is more dense than air. So, we state a rule using the ***density*** of the two media, to give the direction of refraction.

RULE: A ray that passes from a more dense medium into a **less dense** medium refracts **away** from the **normal** to the surface of separation.

Using the above rule and common sense, we can state another rule to give the direction of refraction of a ray that passes from a less dense medium into a more dense medium.

RULE: A ray that passes from a less dense medium into a more **dense** medium refracts ***towards*** the **normal** to the surface of separation.

The two rules just learnt will now help us to easily remember a law called the law of refraction.

The law of refraction states that;

Rays of light travelling from air to glass are bent or refracted toward the normal. Rays of light travelling from glass to air are bent or refracted away from the normal.

Effects of Refraction

The effects of refraction can be seen in a number of everyday situations. For example, refraction can cause a straight stick appear bent when it is dipped into the water. Water in a clear pool also appears shallower than it really is because the light rays bent as they pass from the water into the air above.

Activity: **Now try this activity of a pencil dipped in water.**

Do the activity below and answer the questions that follow.

Do this: Take a pencil (or a straight stick, example a ruler) and some water in a glass cup.

Dip the pencil in the water (see the picture below) and observe the pencil's shape.

1. Does the pencil appear straight or bent? ______________________________

   Hold the pencil at different angles and observe.

2. Does the pencil appear straight or bent? ______________________________

Now, dip the pencil in water and hold it vertically.

3. In the box below, write what you observe using the words **straight, bent, longer or shorter.**

In your activity, you have seen that a pencil or a straight stick which is partly dipped in water appears bent. It looks bent but it is not really bent.

You will also have seen that the length of a pencil or rod which is dipped vertically in water appears shorter than the real length.

These are both effects of refraction.

Summary

You have come to the end of Lesson 6. In this lesson you have learnt that:

- refraction is the bending of light as it passes from one medium to another.
- refraction of light rays is due to a change in the speed of light as it passes from one medium to another at an angle of less than 90^0.
- when light enters a medium at right angles the light is not refracted, but its speed changes.
- when light moves into water or glass from air, it is bent towards the normal and when it moves from water or glass into air, it is bent away from the normal.
- when light passes from one medium to another, the amount of refraction depends on the type of medium through which the light is passing.

NOW DO PRACTICE EXERCISE 6 ON THE NEXT PAGE.

Practice Exercise 6

Answer the following questions on the spaces provided.

1. Fill in the missing words.

   i) A ray of light travelling from air into glass is __________ or bent __________ the normal.

   ii) A ray of light travelling from water to air is __________ or bent __________ from the normal.

   iii) The speed of light in water is __________ than the speed of light in air.

   iv) A swimming pool looks __________ than it really is, because light from the bottom is refracted __________ from the normal on passing into air.

2. What is meant by refraction?

   ____

   ____

3. What causes light to be refracted?

   ____

   ____

4. State the law of refraction.

   ____

   ____

   ____

   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 2.

Answers to Activity

1. bent

2. bent

3. The pencil or a straight stick which is partly dipped in water appears bent. Also the length of a pencil or rod which is dipped vertically in water appears shorter than the real length.

Answers to Practice Exercises 5 – 6

Practice Exercise 5

1. Reflection is the bouncing off light on a smooth and shiny surface.

2. Any smooth surface which reflects light is said to be a mirror.

3. a) An irregular reflection occurs with a rough surface and the image produced will not be clear.

   b) A regular reflection occurs with a smooth and shiny surface and produces a clear image.

4. The law of Reflection states that;

   1. The angle of incident is equal to the angle of reflection

   2. The incident ray and the reflected ray are found on the same plane but are on opposite sides of the normal.

   3. The normal is an imaginary line passing at 90 degrees between the point where the two rays meet.

Practice Exercise 6

1. i) refracted, towards

   ii) refracted away

   iii) less

   iv) shallower, away

2. Refraction is the bending of light as it passes from one medium to another.

3. The change in speed of light causes it to be refracted.

4. Rays of light travelling from air to glass are bent or refracted toward the normal. Rays of light travelling from glass to air are bent or refracted away from the normal.

REVISE TOPIC 2 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 2: Reflection and Refraction of Light

Now, revise all lessons in this Topic and then do **ASSIGNMENT 4**.
Here are the main points to help you revise.

Lesson 5: Reflection of Light

- Reflection is the bouncing back of light on a smooth and shiny surface.
- Any smooth surface which reflects light is said to be a mirror.
- Regular reflection occurs with a smooth and shiny surface and produces a clear image.
- An irregular reflection occurs with a rough surface and produces an unclear image.
- When light is reflected it is found that :
  1. The angle of incidence is equal to the angle of reflection.
  2. The incident ray and the reflected ray are on the same plane but opposite the normal.
  3. The normal is the imaginary line that is at 90^0 to the incident and the reflected ray.

  This is known as the law of reflection.
- A plane mirror gives an image that is far behind the mirror as the object is in front.
- A concave mirror gives and makes rays converge. It can be used to focus light or to make parallel rays of light.
- A convex mirror makes rays diverge. It produces an image with a wide field of view.

Lesson 6: Refraction of Light

- Refraction is the bending of light as it passes from one medium to another.
- Refraction of light rays is due to a change in the speed of light as it passes from one medium to another at an angle of less than 90^0.
- When light enters a medium at right angles, the light is not refracted, but its speed changes.
- When light moves into water or glass from air, it is bent towards the normal and when it moves from water or glass into air, it is bent away from the normal.
- When light passes from one medium to another, the amount of refraction depends on the type of medium through which the light is passing.

NOW DO TOPIC TEST 2 IN YOUR ASSIGNMENT 4.

TOPIC 3

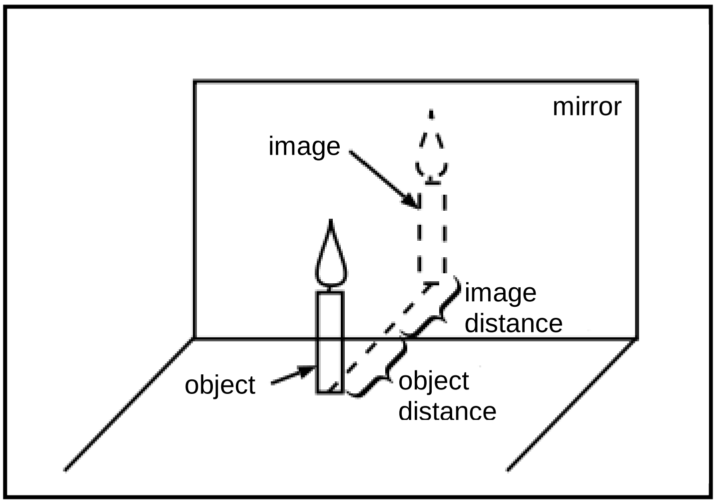
IMAGES

In this topic you will learn about

- **virtual images**
- **real images**

INTRODUCTION TO TOPIC 3: IMAGES

An image is a representation of an object formed by a mirror or lens. Light from the image is seen.



An object formed by a mirror is real and upright.

If you place a candle in front of a mirror, you now see two candles. The actual, physical candle is called the **object** and the picture you see in the mirror is called the **image**. The object is the source of the incident rays. The image is the picture that is formed by the reflected rays.

The object could be an actual source that emits light, such as a light bulb or a candle. More commonly, the object reflects light from another source. When you look at your face in the mirror, your face does not emit light. Instead, light from a light bulb or from the sun reflects off your face and then hits the mirror. However, in working with light rays, it is easy to pretend the light is coming from the object.

An image formed by reflection may be real or virtual. A **real** image occurs when light rays actually intersect at the image. A real image is inverted, or upside down. A **virtual** image occurs when light rays do not actually meet at the image. Instead, you "see" the image because your eye projects light rays backward. You are fooled into seeing an image. A virtual image is erect or upright.

You can tell the two types apart by putting a screen at the location of the image. A real image can be formed on the screen because the light rays actually meet there. A virtual image cannot be seen on a screen, since it is not really there.

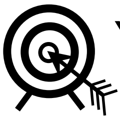
You should know all about images. The questions you should ask yourself are:

- How are images produced in plane and curved mirrors?
- What type of image is produced by a plane, convex and concave mirror?
- What type of image is produced by a concave and convex lens?

In this topic, you will find the answers to these questions and all other questions relating to images.

Lesson 7: Virtual images

Welcome to Lesson 7. You have learnt that the reflection of light on a smooth plane surface produces clear images. A common example is our image, which we see in plane mirrors. The image we see in a plane mirror is called a plane mirror image. In this lesson, you will learn about virtual images.



Your Aims:

- describe virtual images produced in a plane mirror, convex and concave mirror and lens
- identify the uses of plane, convex and concave mirror and concave lens
- observe and make conclusion about given activities

Studying Plane Mirror Images

You will have to perform the activity below to help you discover the main properties of plane mirror images.

Activity 1: Studying Plane Mirror Images

Do this: Look at yourself in a plane mirror.

Study the image carefully, and then use a word or phrase from each of the word-lists **A** and **B** given below, to describe the image.

List A	**List B**
enlarged (made bigger than the original)	upright
diminished (made smaller)	inverted (upside down)
the same size as the object	

1. The image is ………………………………………………….. (choose from list **A**)

2. The image is ………………………………………………….. (choose from list **B**)

- Now, move towards the mirror and observe what happens:

3. Does your image move towards the mirror? …………………………….. Yes/No

- Raise your right hand and look at its image in the mirror.

4. Which hand (right or left) appears raised in the image? ………………………….

If you studied the plane mirror image carefully, you must have discovered the main properties of plane mirror images.

Properties of plane mirror images

In the last Activity, did you see that the **size** of the object and the **size** of the image were equal? Was the image upright or inverted?

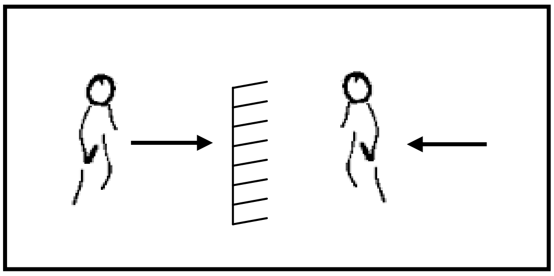
Plane mirror images are the same size as the objects. They are also upright, that is they are erect.

For example, in the picture opposite you can see that the plane mirror image (right) is the same size as the baby's face and is upright too.

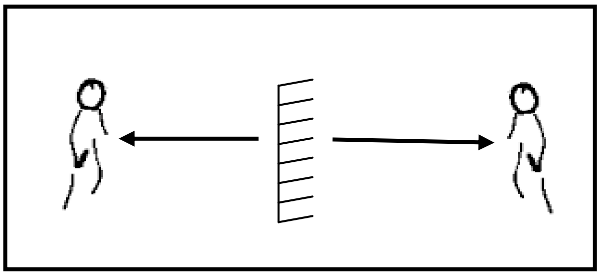
Plane mirror image

Plane mirror images are upright and have the same sizes as the objects.

In your activity, you have also observed what happens when you move towards the mirror or away from the mirror.



When we move towards the mirror, the image moves towards the mirror.



When we move away from the mirror, the image also moves away from the mirror.

This is because of another property of plane mirror images. The property is about image distance and object distance from the mirror.

Object O----------//----------|----------//----------I image

Distance of object **O** in front of the mirror **M** = Distance of the image **I** behind the mirror **M.**

- The distance of the object from the mirror and the distance of the image from the mirror are equal.

There is another important property of plane mirror images. You know that we see plane mirror images only when we look through the mirror. The image produced by a plane or flat mirror appears to be behind the mirror. We cannot produce plane mirror images on screens.

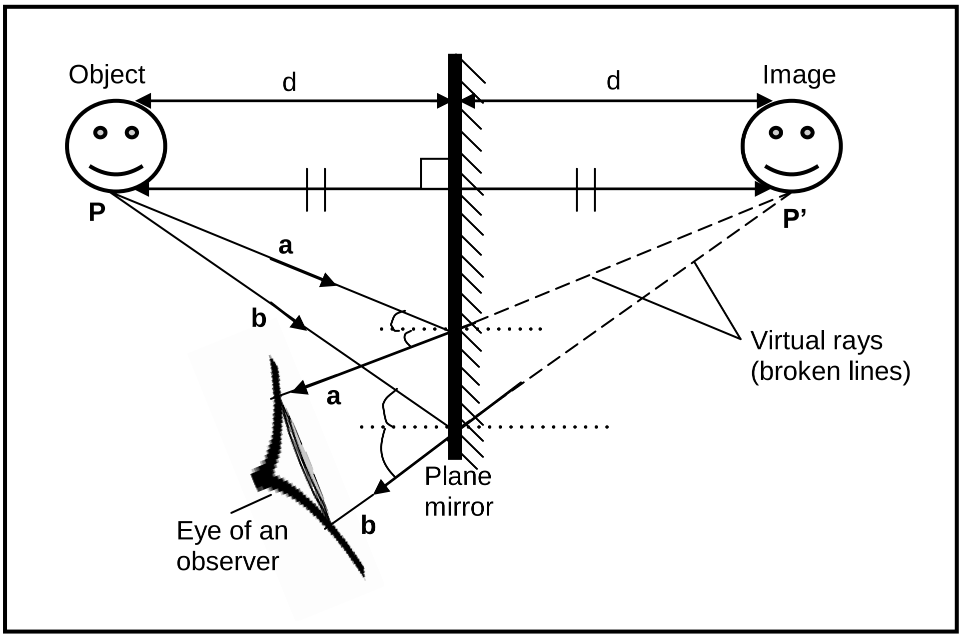
No matter where the screen is placed, the image will never appear on it. This includes placing a screen behind the mirror. This type of image is called a **virtual** image. Virtual images are not real and cannot be projected onto a screen.

Plane mirror images are unreal. Their distance behind the mirror is equal to the distance of the objects in front of it.

Virtual Images

In our earlier discussions, we looked at plane mirror images which led us to their properties. One of these properties is that, plane mirror images are always virtual. These are images that cannot be projected or captured on a screen. They are usually produced by light rays which seem to come from the image but do not actually pass through it. A virtual image is produced at the place where the reflected rays appear to intersect behind the mirror. Whenever a mirror creates an image that is virtual, it will be located behind the mirror where light does not really come from.

The diagram below shows how a plane mirror forms a virtual image of an object.



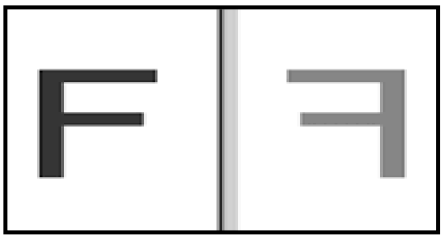
The object seemed to have originated just behind the mirror from the observer's position.

1. Rays of light **a** and **b** from point **P** of the object are reflected by the plane mirror before entering the observer's eyes.
2. The reflected rays, when extended backwards behind the mirror appear to intersect at **P'** which forms the corresponding image of **P**. This happens to all the points of the object and a complete virtual image is then formed.

Lateral inversion

In the activity earlier on where you looked at yourself in the plane mirror, you would have quickly noticed that there is an apparent left-right reversal of the image. When you looked at your image with your right hand raised, which hand appeared raised in your image? You would have noticed that the image raises what would seem to be its left hand. If you raise your left hand, the image raises what would seem to be the right hand. That is, we see a side-to-side change. We say that plane mirror images are inverted **sideways**. This right-left change or side-to-side change is called **lateral inversion**. We say that plane mirror images are **laterally inverted**.

Look at the letter **F** opposite which is on the left-hand side of the picture. Now look at its image in the mirror on the right-hand side of the picture. The image of letter F has been laterally inverted when reflected in the mirror.



Letter F and its laterally inverted image

Here is another example.

If you write **REFLECTION OF LIGHT ON A MIRROR** and hold it in front of a mirror, then the writing will look like the one shown below.

Study and compare the shape of each image with that of the original letter. The mirror images are laterally inverted.

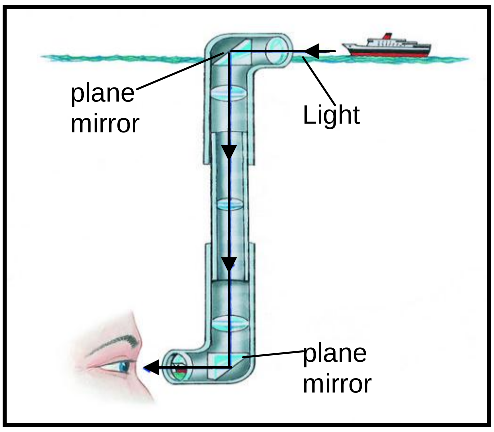
Lateral inversion means right-left or side to side change.

The uses of plane mirrors

The following are some applications of plane mirrors.

1. The plane mirror periscope.

   This is an optical device that is used to view objects in an elevated position behind an obstruction or a wall. It is mostly used in a submarine to view objects above the sea.



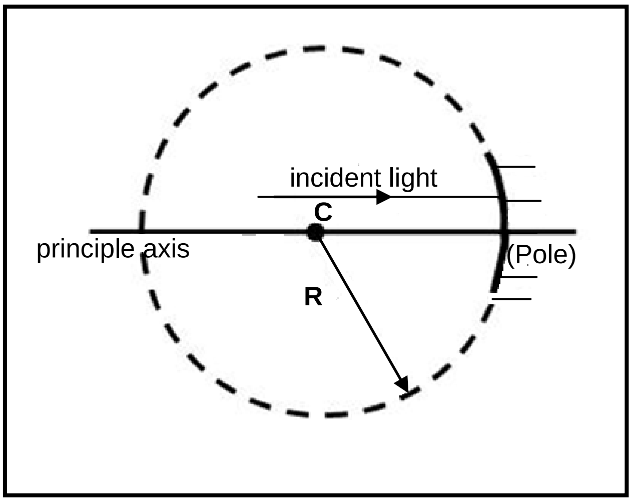
A periscope

2. Optical eye testing.

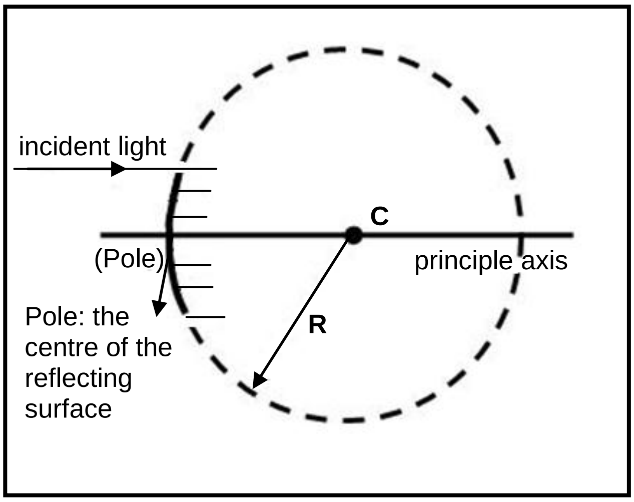
   A plane mirror is used in optical testing because the objects can be laterally inverted.

Curved surface mirrors
Many mirrors used today are curved surface mirrors. The most common curved mirrors are spherical mirrors. The reflecting surface of such mirrors forms part of a spherical surface. Spherical mirrors may be concave or convex.

A concave mirror curves inwards like a cave, whereas a convex mirror curves outwards. The radius of the spherical surface is called the **radius of curvature**, **R**, while the centre is called the **centre of curvature**, **C**. The centre of the mirror is called the **pole**. The straight line joining the pole and centre of curvature is called the **principle axis**.



A concave mirror

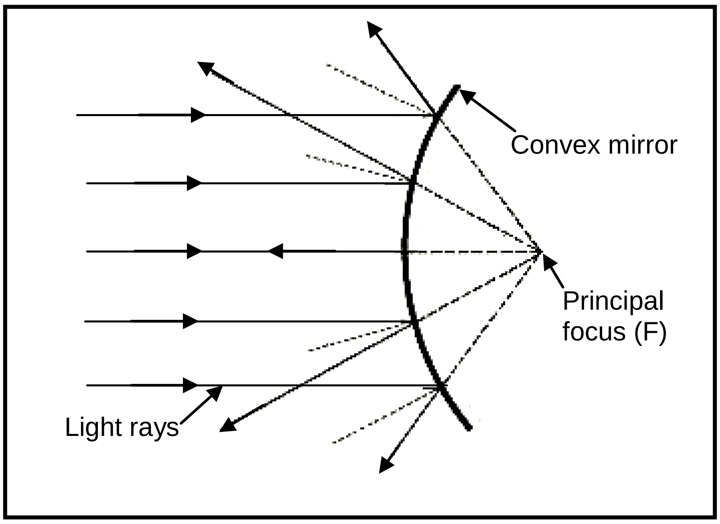


A convex mirror

When light strikes a curved mirror it still obeys the laws of reflection. For each ray, the angle of incidence still equals the angle of reflection (with $i = r$).

There are two types of curved mirrors: concave and convex mirrors.

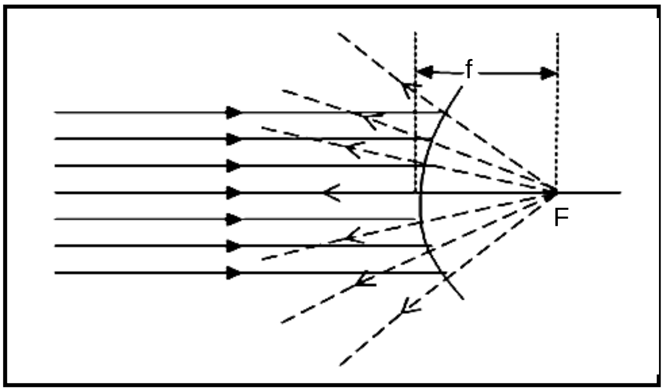
Convex mirrors
Convex mirrors are curved outwards at the front. Instead of concentrating the light, at the **focus**, a convex mirror spreads light out. The reflected light rays are said to diverge. The focus is also called the **principal focus** and is the point on the axis of a lens or mirror to which parallel rays of light converge or from which they appear to diverge after reflection. It is represented by the letter F.



Parallel rays reflected by a convex mirror

When parallel rays of light strike a convex mirror the rays are reflected, each obeying the law of reflection, so that they diverge (spread apart). If the reflected rays are extended backwards or behind the mirror, they cross at the principal focus. If a screen is placed at this point, no light is seen and an image is not formed on it. Convex mirrors are often called **diverging mirrors**.

The distance between the pole of the mirror and the focus is called the **focal length**, *f*.

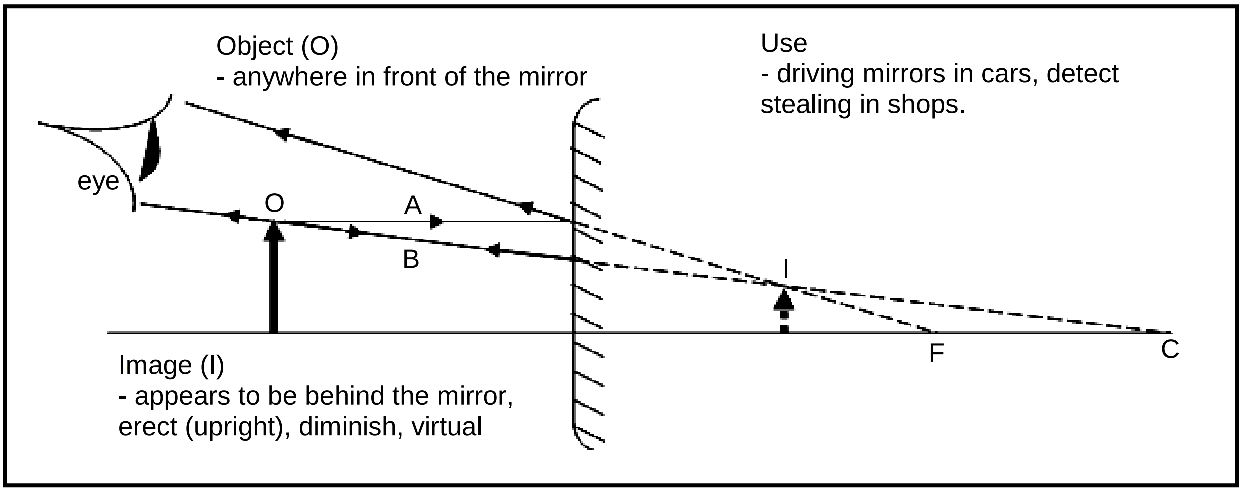


Focal length and focus of a convex mirror.

For all the positions of an object, the positions of its images are behind the mirror. The images are always virtual, upright and diminished (made smaller). The images are formed where the extended rays behind the mirror intersect.

Convex mirrors only form virtual images.

The diagram below shows how the image will be formed on a convex mirror.



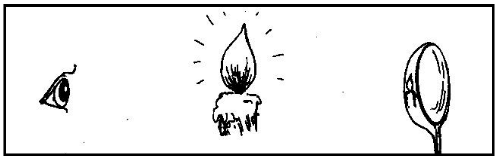
Images formed by a convex mirror are always smaller.

A convex mirror is a curved mirror with the reflecting surface bending outwards.

Activity 2: Convex mirror images.

You need: A shiny metal spoon and a candle.

Do this: Light the candle and stand it firmly on its stand.



- Hold the spoon so that its convex surface faces the candle. Look for the **image** of the candle flame, in the convex surface and answer the following questions.

  1. Do you see an upright image? YES/NO..............................
  2. Is the image size smaller than that of the flame? YES/NO.

- Move the spoon away from the candle. Observe what happens to the *size* of the image:

  3. Does the image get smaller in size? YES/NO......................
  4. Does the image get bigger in size? YES/NO.......................

- Now, move the spoon towards the candle. Observe what happens to the size of the image as you change the distance and answer the following:

  5. Does the size of the image get bigger than the actual flame for any position of the spoon? YES/NO.........................
  6. Does the image get inverted anytime? YES/NO..................

This activity would have shown that the image in a convex mirror is always upright (erect) and diminished (smaller in size than the object).

Convex mirror images

You now know that images formed by convex mirrors are always **upright** and **diminished** (smaller than the object). As in plane mirrors, the images are also **virtual** that is not real. They are always formed behind the mirror. This is true for all images at whatever distance from the mirror the object is.

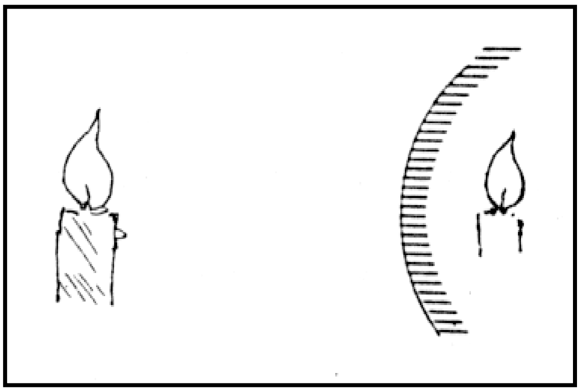


Image of a candle in a convex mirror

Field of view
When we look at any mirror, we see reflected images of things, places and areas behind us too. All that we see come into our **field of view**.

Convex mirror images are always **diminished**. This is true for all objects, at whatever distance from the mirror the object is. Since convex mirror images are diminished, images of things and areas we see in them are smaller than the actual sizes of the things and areas.

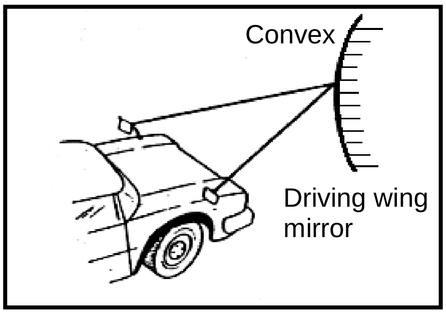
So, using convex mirrors we can see things within a wider angle round the mirror, than we can by using plane mirrors. We say that convex mirrors have a wider **field of view** than plane mirrors.

Convex mirrors have a wide field of view than plane mirrors

Use of convex mirrors
Convex mirrors have a wider field of view when viewed from in front than plane mirrors. So, they are more useful than plane mirrors, in some day-to-day practical situations.

Side view mirrors
Convex mirrors are usually fixed on motor vehicles. The drivers use them to look at the traffic from behind and also traffic overtaking them.

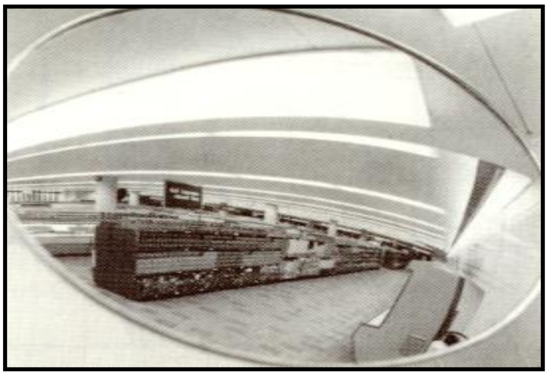
Using plane mirrors, drivers can see only traffic that is behind. Convex mirrors used by motor vehicles for viewing behind are called side view mirrors. Convex mirrors have a field of view



Side view mirrors of a car.

Security mirrors
In big supermarkets, convex mirrors are fixed in some corners at the top of the wall.

Security guards and management personnel can observe several parts of the stores, from one place. Shop lifters and shop assistants can be observed.


View of a shop in the security mirror

Convex mirrors are better for use as side view mirrors and security mirrors because they have a wider field of view.

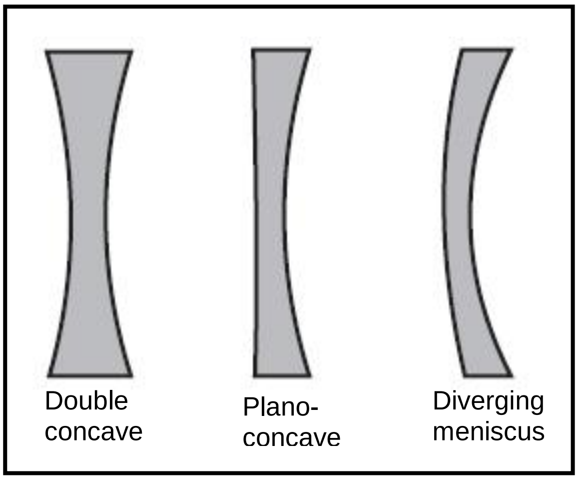
What is a Lens?

A lens is usually a piece of glass or transparent plastic with curved (spherical) surfaces. It is shaped so that it refracts light passing through it. There are two main types of lenses: the convex and concave lenses. You will learn how images are formed using a concave lens.

Concave lens

Concave lenses are also known as **diverging lenses** or **negative lenses**. They are thinner in the centre than at the edge.

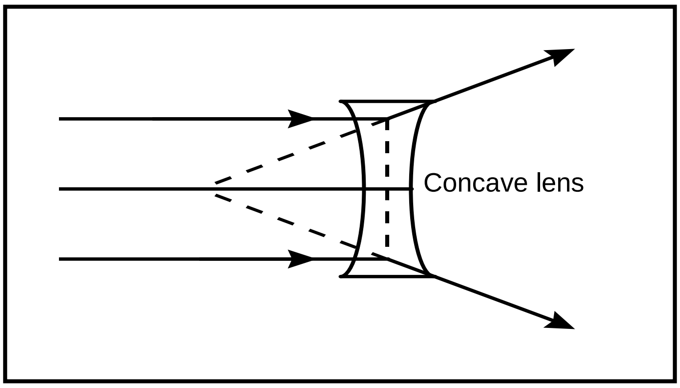
Below are cross-sectional views of common types of concave lenses.



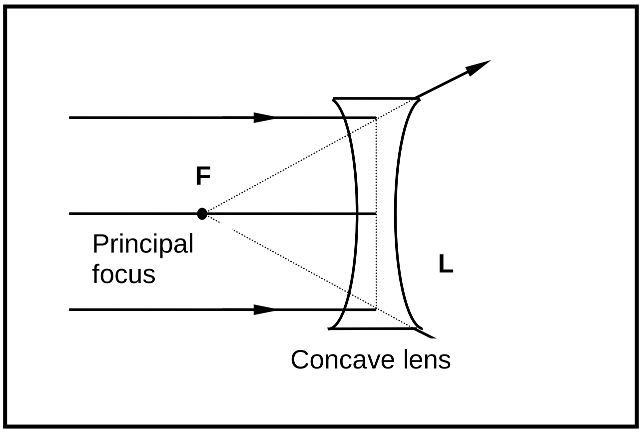
Shapes of common diverging lenses

Principal focus of a concave lens

What happens when rays parallel to the principal axis of a concave lens are refracted by the lens?



A concave lens diverges (spreads out) parallel rays of light that fall on it. The refracted rays appear to diverge from a point on the principal axis. That point is called the **principal focus** of the lens. Principal focus is also known as the **focal point**.

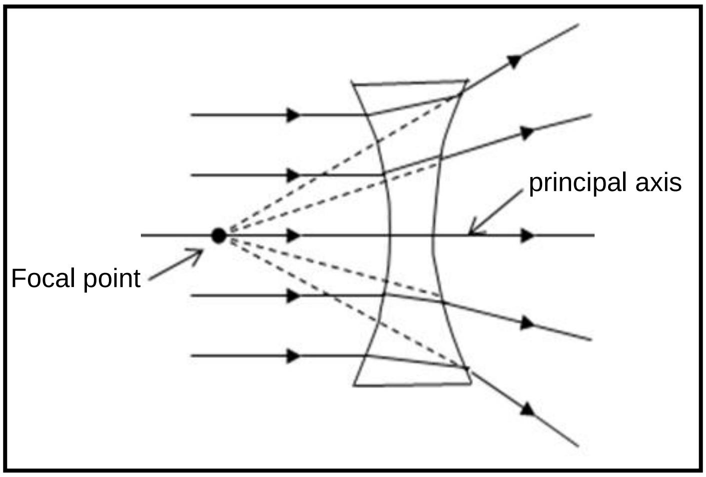


In the diagram, the point **F** is the principal focus of the concave lens **L**.

The distance between the concave lens (L) and the principal focus (F) is called the **focal length** of the lens.

In a concave lens, the refracted rays appear to diverge from the principal focus of the lens.

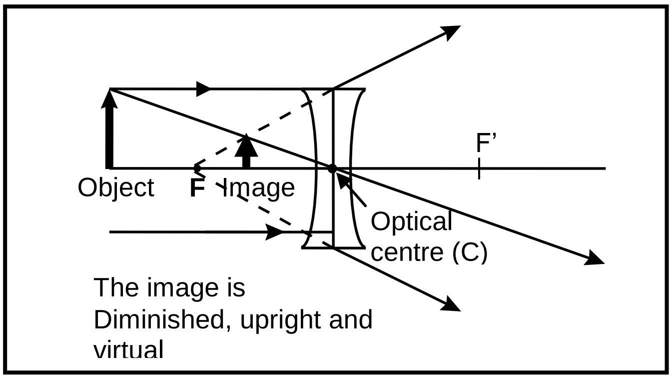
Concave lenses refract incident rays of light, which are parallel to the principal axis, so that they appear to **diverge** from the focal point of principal focus located on the incident side of the principal axis.



Parallel rays refracted to pass through a principal focus of a concave lens

A concave lens image

We shall now look at an image formed of an object on the principle axis by a concave lens. Look at the diagram below:



The **object** is on the principle axis. The image is obtained by drawing rays of light from the object using the two rules:

- Rays parallel to the principal axis, after refraction by the concave lens, appear to *diverge* from **F** - the principal focus.
- Rays through the **optical centre (c)** passes without refraction.

The optical centre is the point on the principle axis of a lens through which light passes without undergoing any deviation. In other words, a ray of light passing through the optical centre will not change its direction.

Drawing the rays, we see that the image is formed at the point at which the two refracted rays meet. Now, study the image. It is

- **upright**
- **on the same side of the lens as the object.**
- **diminished (smaller than the object).**

The image is on the same side of the lens as the object or between the lens and the object and so, it cannot be caught on a screen. It is therefore **virtual**.

In the previous diagram, the object is beyond **F** - the principal focus of the lens.
Now look at the image when the object is between the lens and **F**.

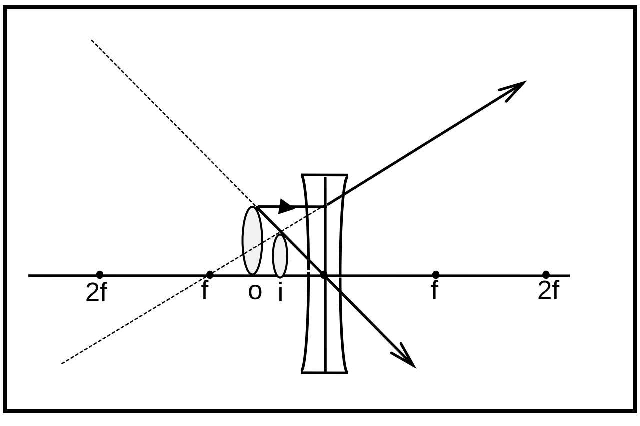


Image formed when the object is between the lens and **F**.

Now we see that the concave lens image is upright, diminished and virtual

Concave lens images are always upright, diminished and virtual.

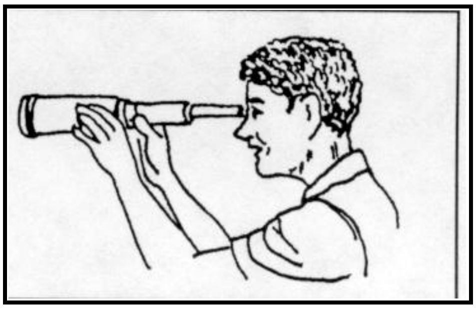
Use of concave lenses

You have learnt that a concave lens always produces an upright, diminished and virtual image. It has three main uses.

1) The Galilean telescope

Astronomical telescopes are made by using two convex lenses. Another type of telescope is the **Galilean** telescope. This is made using a **convex** lens and a **concave** lens.

In a Galilean telescope, the object lens (lens at the wide end) is the convex lens. This convex lens has a long focal length. It produces a real, diminished image of a distant object.



A boy using an astronomical telescope

We look through the eye lens. The eye lens is a concave lens with short focal length.

The image we see through a Galilean telescope is upright and diminished. The Galilean telescope was first built in 1609 by the great scientist Galileo.

2) The spy glass

The spy glass is a concave lens in the door of a house. When someone knocks or calls, we can look to see who is outside it before we open the door. This is a safety device.

3) Spectacles

A pair of spectacles is what people wear to overcome their eye defects. Concave lenses are used to make spectacles for people with short-sightedness.

You will learn more about this in Lesson 11 of this unit.

The Galilean telescope is made using a convex lens and a concave lens. It was built in 1609 by the great scientist Galileo.

Activity 3: Now test yourself by doing this activity.

Answer the following questions on the spaces provided.

1. What is a virtual image?

   ____

2. What is meant by the focus of a plane mirror?

   ____

3. (a) What is a concave lens?

   ____

   (b) What type of image does a concave lens produce?

   ____

4. On a diagram, show what happens when parallel rays of light strike a convex mirror.

   Space for drawing:

CHECK YOUR WORK. ANSWERS ARE AT THE END OF THE LESSON 7.

Summary

You have come to the end of Lesson 7. In this lesson you have learnt that:

- a plane mirror gives an image as far behind the mirror as the object is in front. The image is also laterally inverted and virtual.
- plane mirror images are upright and have the same size as the objects.
- virtual images such as those produced by plane mirrors cannot be produced on a screen.
- a convex mirror makes rays diverge. They produce images with a wide field of view.
- a lens is a piece of curved transparent material which controls the direction of light by refraction.
- concave lenses are thinner at the centre than the edge and bend rays of light so that they only appear to come from a focus.
- the focus in a curve is the point where the incident and the reflected ray meet. It is given the symbol “F”. The focal length is the distance between the mirror and the focus. It is given the symbol “f”
- concave lens images are always upright, diminished and virtual
- concave lenses are also used as spy glasses and to make spectacles for people with short-sightedness.

NOW DO PRACTICE EXERCISE 7 ON THE NEXT PAGE.

Practice Exercise 7

Answer the following questions on the spaces provided.

1. Draw a diagram to show what happens when a ray of light is reflected by a smooth surface.

2. a) When you stand in front of a plane mirror, where does your image appear to be?

   ____

   b) Is the image bigger or smaller than you?

   ____

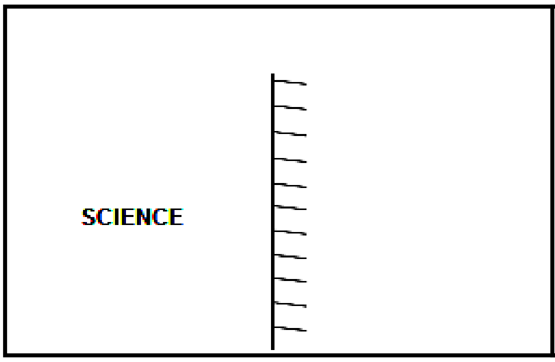
3. What is the difference between a real image and an image produced by a plane mirror?

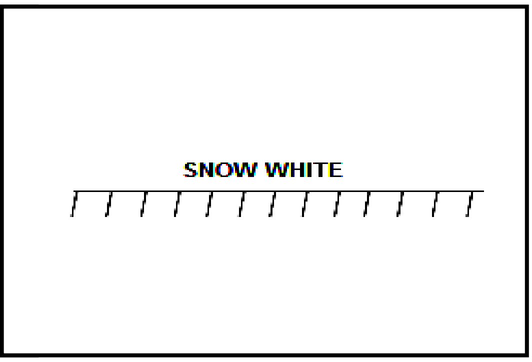
   ____
   ____

4. Explain why a convex mirror can be used to detect stealing in shops where people serve themselves.

   ____
   ____

5. Copy and complete the two diagrams. Write how the image would appear at the back of the mirror.





CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

Answers to Activity

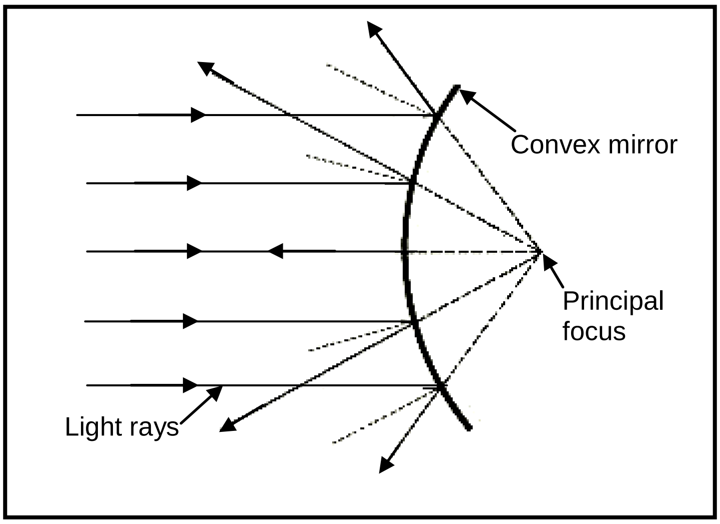
1. A virtual image is an image in which the outgoing rays from a point on the object always diverge.

2. Is the point where the image is formed.

3. a) A concave lens is a piece of glass or transparent plastic which is thinner at the centre than at the edge. It has both surfaces concave.

   b) Concave lens images are always upright, diminished and virtual.

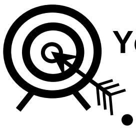
4.



Parallel rays reflected by a convex mirror

Lesson 8: Real Images

Welcome to Lesson 8. You have learnt that reflection of light on a smooth surface produces a clear image while reflection on a rough surface produces an unclear image. An image produced by reflection may be real or virtual. In this lesson, you will learn about real images.

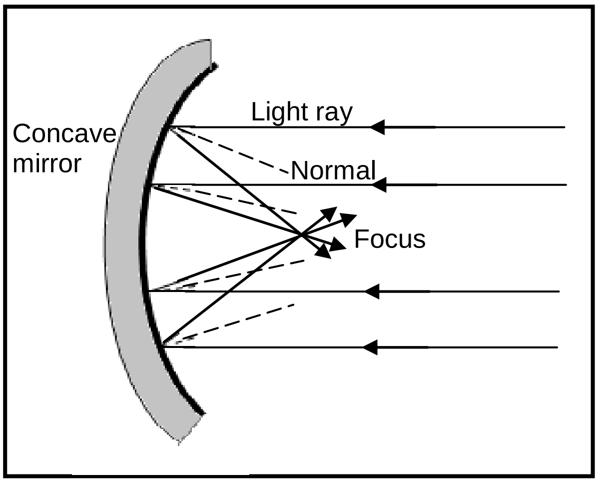


Your Aims:

- describe real images in a concave mirror and a convex lens
- identify the uses of a concave mirror and a convex lens
- observe and make conclusion about the given activities

Concave Mirrors

Concave mirrors are curved inwards at the front. They bring parallel rays of light together. Each ray obeys the law of reflection. When the rays of light parallel to each other, such as a beam of light, strikes a concave reflector directly in front, the rays of light are reflected so that they meet at a point called the **focus**. The rays of light are said to converge. Curved mirrors of this shape are used in astronomical reflecting telescopes.



Parallel rays reflected by a concave

Concave mirrors can produce real images. A common example is when this type of mirror is used to burn a piece of paper. Rays of light from the Sun come from such a great distance, that they appear to be parallel. When you point the principle axis of a concave mirror toward the Sun, all the rays are reflected through the focus. When a piece of paper is placed at the focus of the mirror then an image of the sun is formed. This real image is bright that it can cause the paper to burn.

You can locate the focus by moving a sheet of paper toward and away from the mirror until the smallest and sharpest spot of sunlight is focused on the paper. This spot is called the focus.

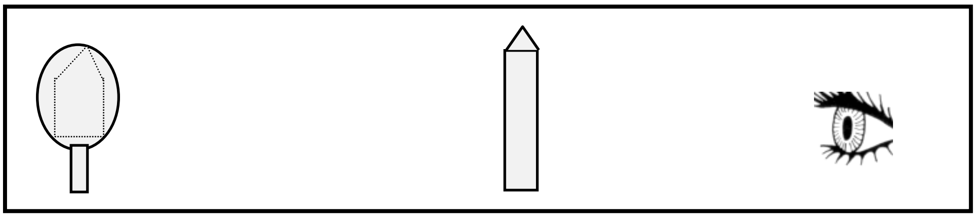
Concave mirror images

Mirrors produce reflected images. What type of images do concave mirrors produce? Here is an activity that helps you discover the answer.

Activity: Concave mirror images

You need: A polished metal spoon and a pencil.

Do this: Hold the pencil very close to the concave surface of the spoon, as shown in the diagram below.



Place your eye on level with the pencil top and the spoon and look for the reflected image of the pencil in the spoon. Move the pencil sideways or backwards and forwards in front of the spoon until you see a clear image. Then look with one eye and study the image closely.

1. Do you see an upright image? .... Yes/No
2. Is the image bigger than the pencil?... Yes/No

Now, slowly move the pencil away from the spoon, towards your eye.

3. Do you now see an inverted image (upside down)?........................ Yes/No

Keep changing the distance of the pencil from the spoon and observe how the image changes.

4. Does the size of the image keep changing?.................................... Yes/No
5. Do you see the image always inverted?.. Yes/No

Repeat the activity at night, in a dark room, using a lighted candle instead of a pencil. You will see the images more clearly.

Activity and observations

In the last activity, you would have observed that a concave mirror produces two types of images, upright images as well as inverted images.

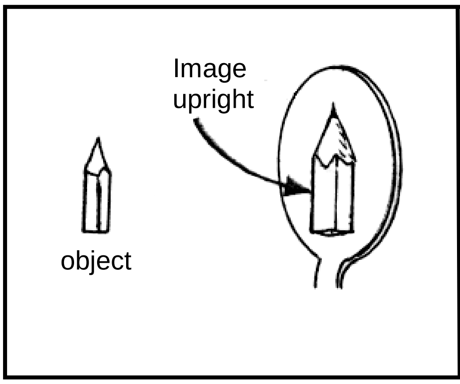


Figure 1

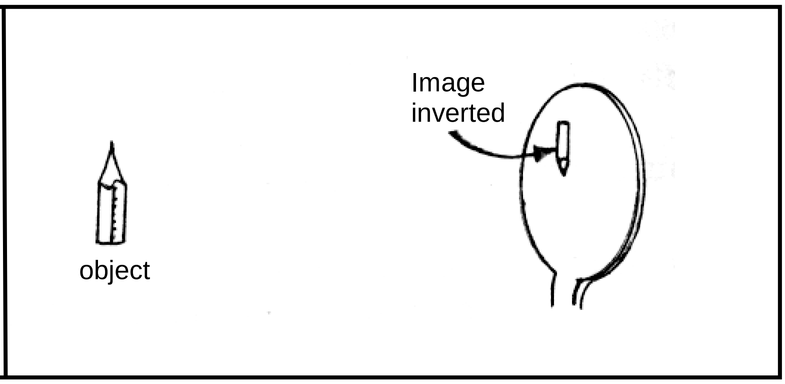


Figure 2

The concave mirror image is **upright** when the object is **very close** to the mirror. The upright image is always **enlarged**, that is, bigger than the object. (Figure 1 above).

> **A concave mirror image is upright and enlarged when the object is very close to the mirror.**

Distance of object and nature of image

You would also have observed that when the object is not close to the mirror the image is inverted (See Figure 2 above). The size of the inverted image changes depending on the distance of the object from the mirror.

As we go on increasing the distance of the object from the mirror, we observe that the size of the image becomes smaller and smaller (Figure 3 and 4 below).

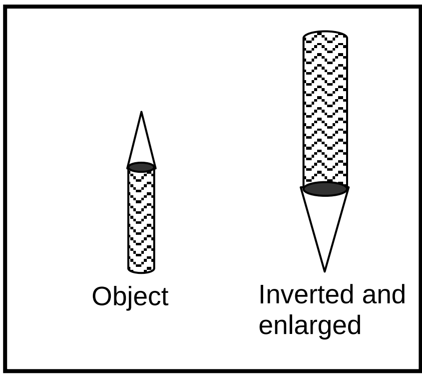


Figure 3

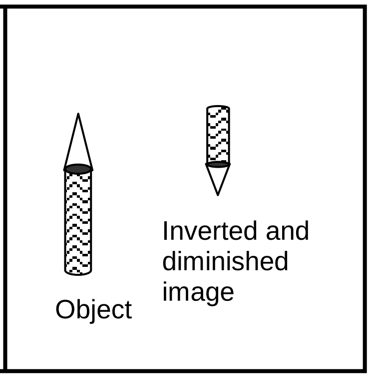


Figure 4

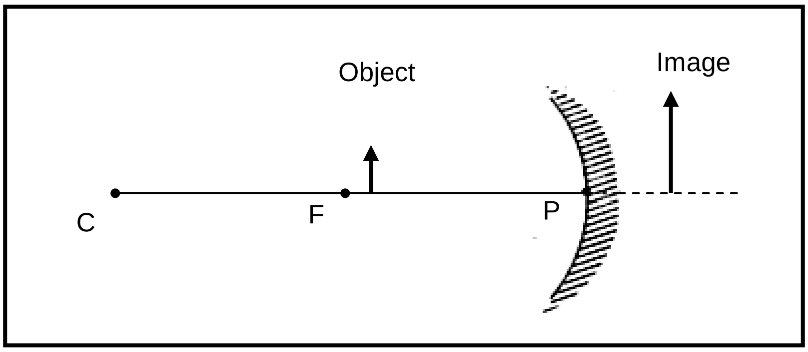
Generally, in the activity, you have observed how the nature of a concave mirror image changes, as the distance of the object from the mirror changes.

Observations about concave mirror images

- The image is **inverted** when the object is not close to the mirror.
- The **size** of the image becomes smaller and smaller, as the distance of the object from the mirror increases.

Upright, enlarged image

You now know that a concave mirror image is upright and enlarged when the object is **close to** the mirror. Now, we can say **how close** to the mirror the object should be, for a concave mirror image to be upright and enlarged.



Object between a mirror and its focus: image is upright and enlarged.

A concave mirror image is upright and enlarged, when the object is between the mirror and the focus of the mirror.

A concave mirror image is upright and enlarged when the object is between the mirror and its focal point.

Practical uses

You learnt that a concave mirror produces an upright enlarged image. This happens only when the object is between the mirror and the focus.

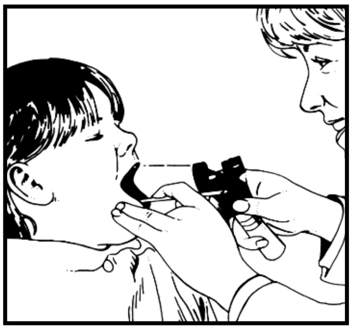
When our face is between a concave mirror and its focus, we see an enlarged upright image.

Hence, we use concave mirrors as shaving mirrors or make-up mirrors. In the make-up mirror shown opposite you can see that the image of the girl's face is larger than the normal size of her face.

A make-up mirror

Small concave mirrors are sometimes used by dentists too. They use them to examine the back part of our teeth, which they cannot examine easily. By doing this, an enlarged image of the teeth is seen.

The picture opposite shows a dentist shining a light onto a small concave mirror with a long handle which she has inserted in her patient's mouth so that she can see a magnified image of the back of her patient's teeth.

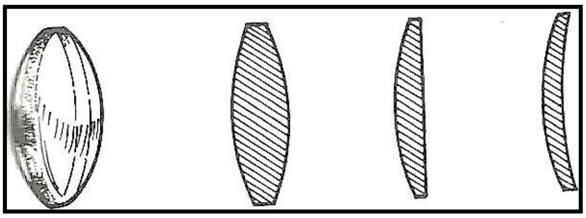


A dentist examines the back of a patient's teeth

Concave mirrors are used as shaving, make up and dental mirrors.

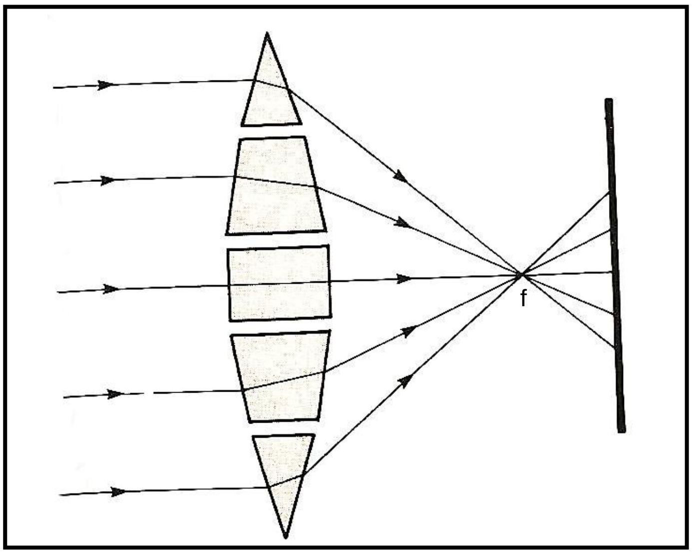
Convex lenses

Convex lenses are thicker at the centre than at the edges.



Convex lenses are thicker at the centre

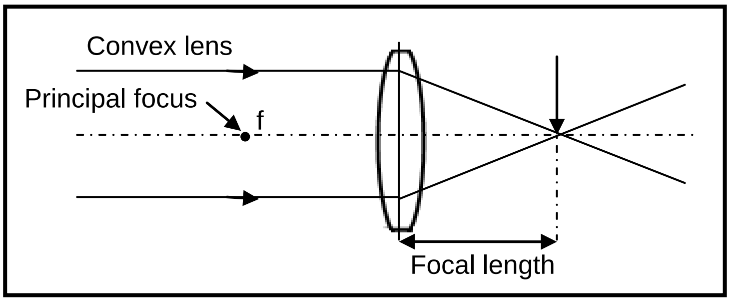
When parallel rays of light pass through a convex lens, they come together or focus to a point.



Five prisms bending a ray of light so that they converge

In a convex lens, parallel rays are refracted to pass through a point which is called a principal focus.

When a convex lens causes rays of light to converge to a point, the rays are said to be focused.



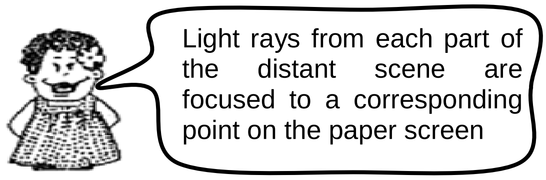
Parallel rays refracted to pass through a principal focus of a convex lens

This is the principle behind the use of a magnifying glass as a burning glass. The rays of the Sun are focused by the lens to a point. When a convex lens is used to focus the rays of the Sun onto paper or dry leaves and grass then they will burn. It is possible for grass fires to start accidentally in this way by bottles carelessly thrown into the grass.

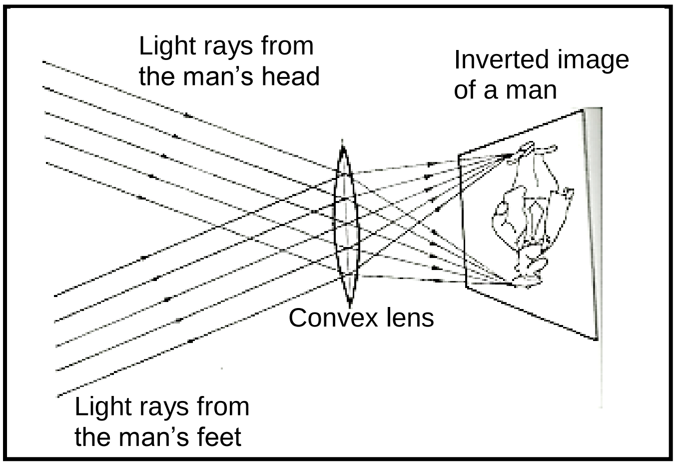
Images produced by lenses

When a convex lens is held with a piece of paper near its principal focus, an image of a distant scene can be formed on the paper. This is because the light rays from each part of the distant scene are focused to a corresponding point on the paper screen.

Using a convex lens to focus an image of a distant scene

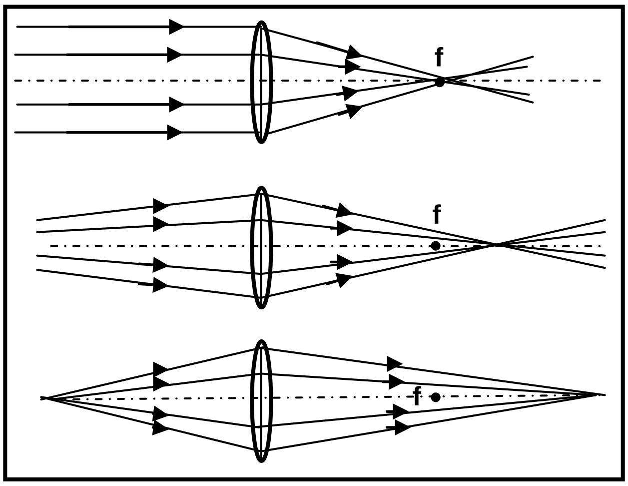


The image produced is upside down or inverted. For distant objects whose light rays are almost parallel, the image is formed near the principal focus. The image is a real image because it can be focused on a screen.



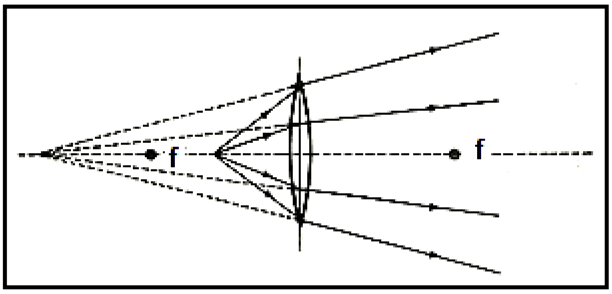
An inverted diminished image from a convex lens.

When a distant object is moved closer to the lens its image moves away from the lens. It also gets bigger. This idea is used in a projector. A brightly lit piece of film is placed close to a convex lens. The result is a large real image on the screen many metres away. For an upright image, the film must be upside down. This is because the light rays from near objects are not parallel when they meet the lens, but are spreading out. These light rays are focused at a point further away from the lens than the principal focus.



As the source of light comes closer to the lens, the light is focused further away

When the object is placed closer to the lens than the principal focus, the light rays striking the lens are diverging so widely that the lens is unable to converge it to a point. No real image can be formed on the screen in this case.



When the source of light is closer to the lens than the principal focus, no real image can be formed on the screen

In contrast, a real image is an image in which the outgoing rays from a point on the object pass through a single point. It is easy to observe real images when projected on an opaque screen (although the screen is not necessary for the image to form). If you observe a focused image on a screen inside or behind a converging lens (at least one convex side) or in front of a concave mirror, what we see on the screen is a real image.

Uses of convex lenses

Convex lenses are used in several optical instruments like the microscope, telescope, binoculars and the camera. They are also used in spectacles to correct some eye defects.

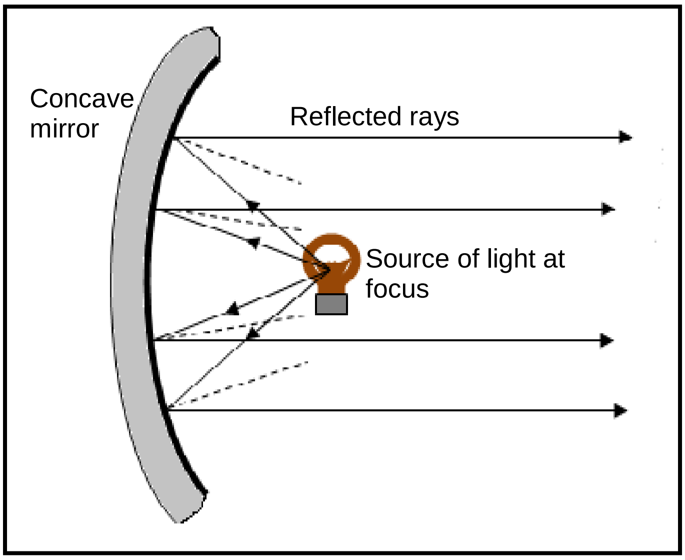
You will learn about them in the lessons in TOPIC 6.

A convex lens is called a magnifying glass because it gives an upright, magnified and virtual image of an object behind the original object, if the object is close to the lens.

Parallel beams

You have learnt that rays of light parallel and close to the principal axis are reflected through the focal point (focus). Now, what happens to the rays of light from a source of light that is at the focus of a concave mirror?

Rays of light which strike the mirror close to the principal axis are reflected parallel to the principal axis.

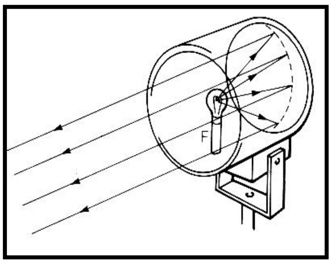


Rays from the focus are reflected parallel to the principal axis.

Lights and search lights

Have you seen car headlights? They reflect parallel beams. In such lights, a special type of concave mirror called a **parabolic** mirror is used to reflect parallel beams. Parabolic mirrors reflect parallel beams over a long distance. Opposite is a drawing showing a light source at the focus of a parabolic mirror. You can see that the light rays after reflection in the mirror travel in parallel lines.

We have mentioned that parabolic mirrors are used in car headlights. A photograph of a parabolic mirror used in a car headlight is shown below.



A search light parabolic mirror

As well as being used in car headlights, police cars, defence force boats and aviation towers use parabolic mirrors, called searchlights, to reflect parallel beams of light.

In torch lights, we turn the head of the torch to focus the light or produce parallel beams.

Parabolic mirrors are used as reflectors in headlights of cars, torch and search lights.

Summary

You have come to the end of Lesson 8. In this lesson you have learnt that:

- a concave mirror is a curved mirror with the reflecting surface bent inwards.
- when parallel rays of light strike a concave mirror, the rays are reflected so that they meet at a point called the focus.
- concave mirrors can produce real images.
- real images are images that can be formed on a screen.
- a concave mirror image is upright and enlarged when the object is very close to the mirror.
- a concave mirror sends out parallel beams of light when the light source is at the focus of the mirror, and its rays strike the mirror close to the principal axis.
- a concave mirror is used as a shaving mirror and make-up mirror.
- parabolic mirrors are used as reflectors to send out parallel beams of light.
- convex lenses are thicker at the centre than at the edges.
- in a convex lens, parallel rays are refracted to pass through a point called the principal focus.
- real images are formed on a convex or converging lens if the objects are outside the focal length of the lens.
- in concave mirrors, the images appear in front of the mirror while in a convex lens the image will be on the opposite side of the lens.

- convex lenses are used in several optical instruments like the microscope, telescope, binoculars and camera. They are also used in spectacles to correct some eye defects.

NOW DO PRACTICE EXERCISE 8 ON THE NEXT PAGE.

Practice Exercise 8

Answer the following questions on the spaces provided.

1. Complete the following statements using a word from the list.

enlarged	focal	upright	convex
diminished	parallel	inverted	concave
principal			

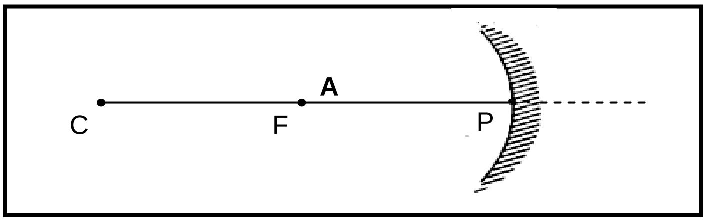
(a) A mirror in which the reflecting surface bends inwards is called a ________________________ mirror.

(b) All parallel rays, close to the principal axis, after reflection in a concave mirror, pass through its ________________________ point.

(c) When the object is between the focus and the mirror, a concave mirror image is ____________________ and ________________in size.

(d) A concave mirror is used as a shaving mirror because it shows an ________________________ image.

2. Look at this diagram and answer the questions below.



(a) What does **F** stand for? ________________________

(b) Describe the nature of the image we see when the object is at the position marked **A** in the diagram?

____

3. Write down some uses of convex lenses.

____

____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 3.

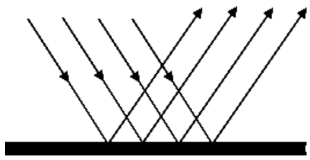
Answers to Activity

All the answers will be ‘Yes’.

Answers to Practice Exercises 7 - 8

Practice Exercise 7

1

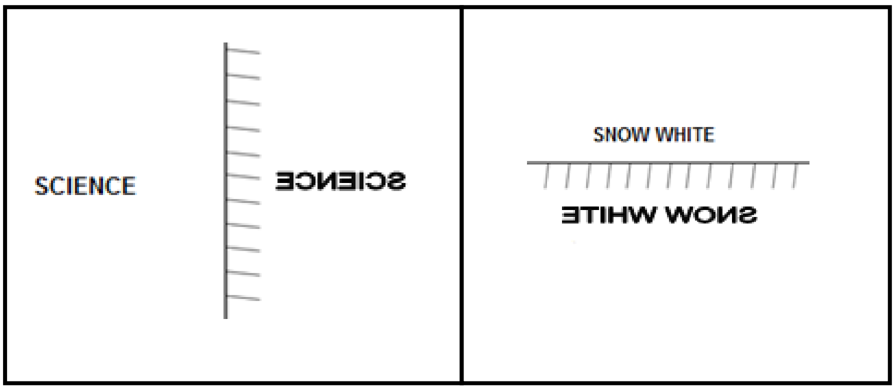


2. a) Behind the mirror
   b) Same size as you and laterally inverted

3. A real image can be placed on the screen. A virtual or unreal image cannot be placed on the screen.

4. Because it has a wide field of view.

5.



Practice Exercise 8

1. (a) concave
   (b) focal
   (c) upright and enlarged
   (d) enlarged

2. (a) focus (or focal point)
   (b) upright and enlarged

3. Convex lenses are used in several optical instruments like the microscope, telescope, binoculars and the camera. They are also used in spectacles to correct some eye defects.

REVISE TOPIC 3 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 3: Images

Now, revise all lessons in this Topic and then do **ASSIGNMENT 4**.
Here are the main points to help you revise.

Lesson 7: Virtual Images

- A plane mirror gives an image as far behind the mirror as the object is in front. The image is also laterally inverted and virtual.
- Plane mirror images are upright and have the same size as the objects.
- Virtual images such as those produced by plane mirrors cannot be produced on a screen.
- A convex mirror makes rays diverge. They produce images with a wide field of view.
- A lens is a piece of curved transparent material which controls the direction of light by refraction.
- Concave lenses are thinner at the centre than the edge and bend rays of light so that they only appear to come from a focus.
- The focus in a curve is the point where the incident and the reflected ray meet. It is given the symbol “F”. The focal length is the distance between the mirror and the focus. It is given the symbol “f”.
- Concave lens images are always upright, diminished and virtual
- Concave lenses are also used as spy glasses and to make spectacles for people with shortsightedness.

Lesson 8: Real Images

- A concave mirror is a curved mirror with the reflecting surface bent inwards.
- When parallel rays of light strike a concave mirror, the rays are reflected so that they meet at a point called the focus.
- Concave mirrors can produce real images.
- Real images are images that can be formed on a screen.
- A concave mirror image is upright and enlarged when the object is very close to the mirror.
- A concave mirror sends out parallel beams of light when the light source is at the focus of the mirror, and its rays strike the mirror close to the principal axis.
- A concave mirror is used as a shaving mirror and make-up mirror.
- Parabolic mirrors are used as reflectors to send out parallel beams of light.
- Convex lenses are thicker at the centre than at the edges.
- In a convex lens, parallel rays are refracted to pass through a point called the principal focus.
- Real images are formed on a convex or converging lens if the objects are outside the focal length of the lens.
- In concave mirrors, the images appear in front of the mirror while in a convex lens the image will be on the opposite side of the lens.
- Convex lenses are used in several optical instruments like the microscope, telescope, binoculars and camera. They are also used in spectacles to correct some eye defects.

NOW DO TOPIC TEST 2 IN YOUR ASSIGNMENT 4.

TOPIC 4

THE EYE

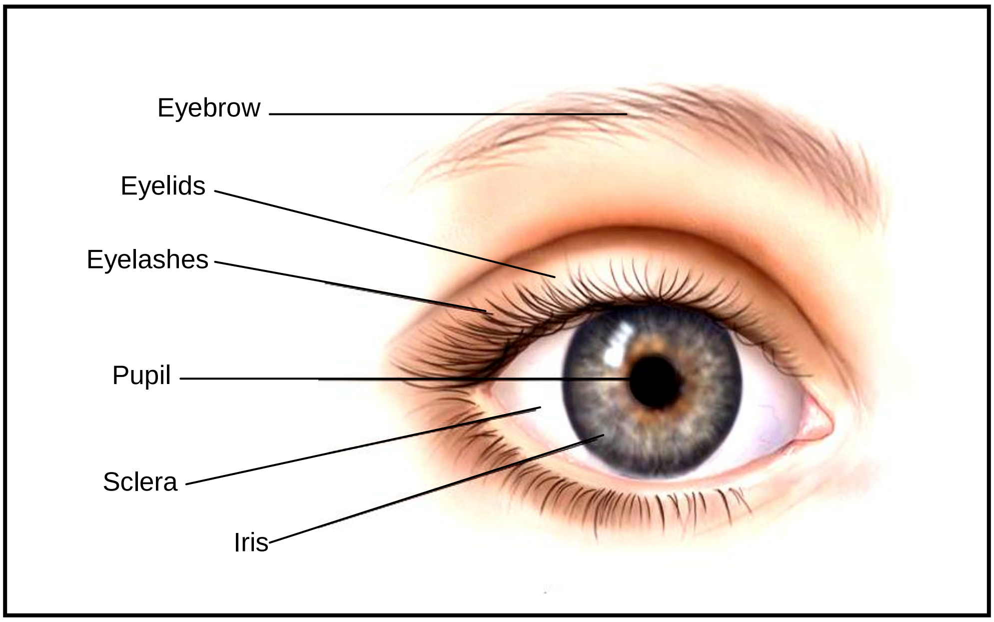
In this topic you will learn about:

- **structure and parts of the eye**
- **power of accommodation and persistence of vision**
- **common eye defects**

INTRODUCTION TO TOPIC 4: THE EYE

Think about all the things you do with your eyes. You watch TV and read books. You surf the Internet. You keep your eye on the ball when you play sports. You see your family and friends. Your eyes are your windows to the world.

Your eyes are like cameras that focus on what is in front of you. Your eyes work together with your brain to create a picture of the world. The process of creating the picture starts when light rays enter your eyeball.



The outer parts of the eye

You should know about the eye. Some of the questions you may be asking yourself now are:

- What is the function of each part of the eye?
- How does the eye work?
- How am I able to see objects that are far as well as nearby?
- What are some common eye defects?

In this topic, you will find the answers to these questions and all other questions relating to the eye.

Lesson 9: Structure and Parts of the Eye

Welcome to Lesson 9. You have learnt that we have parts of our body which we call sense organs. Our eyes detect light energy. They allow us to recognise and be familiar with places. We watch where we are going and look for clues to possible dangers. We learn through our eyes by reading, watching experts at work or by noticing what happens around us. The human eye is similar to a camera in many ways. It is a natural optical instrument which uses a natural lens.The eye is spherical in shape and about the size of a betelnut.

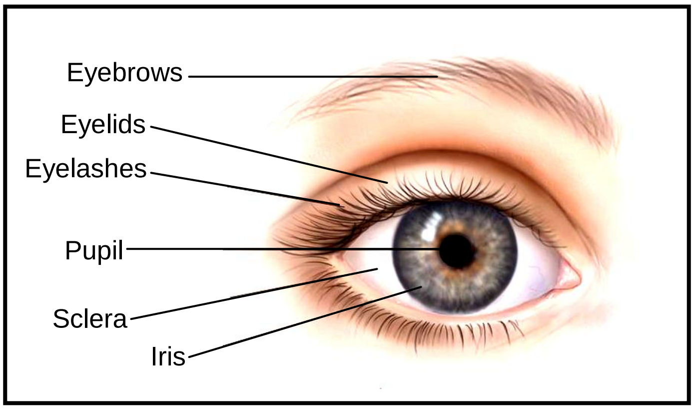
Your Aims:

- identify and describe the external and internal parts of the eye
- describe how the eye works
- describe the function of each part of the eye

We will now learn about the eye by examining it externally.

Activity: Studying the outer parts of an eye.

Do this: Look carefully and study your friend's eye.



The outer parts of the eye

Try to identify the eyebrow, eyelids and eyelashes.

1. What is the function of the eyebrows, eyelids and eyelashes?

   Write your answer here: ____
   ____

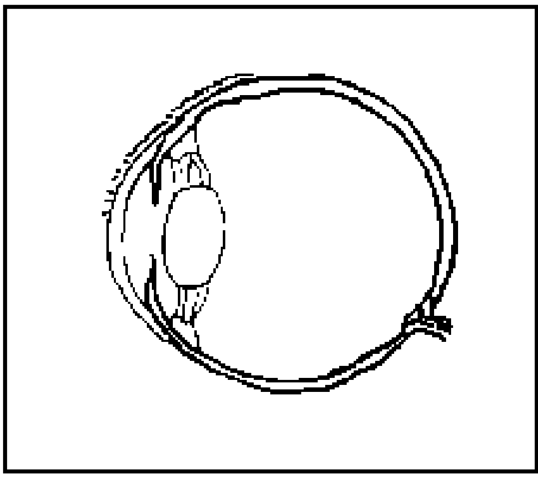
2. Observe the colour of the iris and write it here: ______________________

Observe the size of the pupil in bright light; and then observe its *size* in dim light. Does the size of the pupil change?

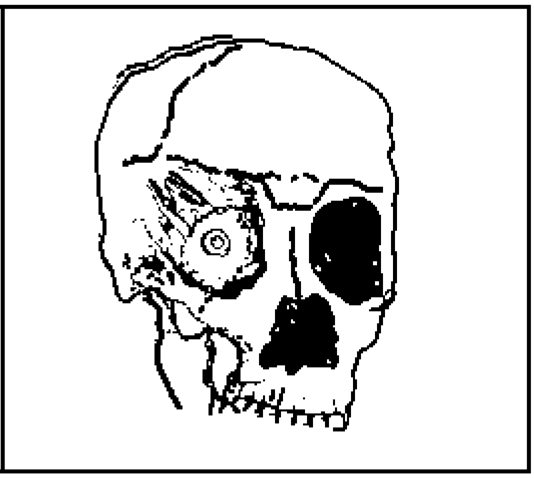
3. Write your observations here: ______________________________________
   ____

The eyeball

An eye is spherical in shape. It is like a ball. It is referred to as the eyeball. The eyeball is set into deep depressions in the skull, below the forehead, as shown in the diagram.



The eye is spherical in shape

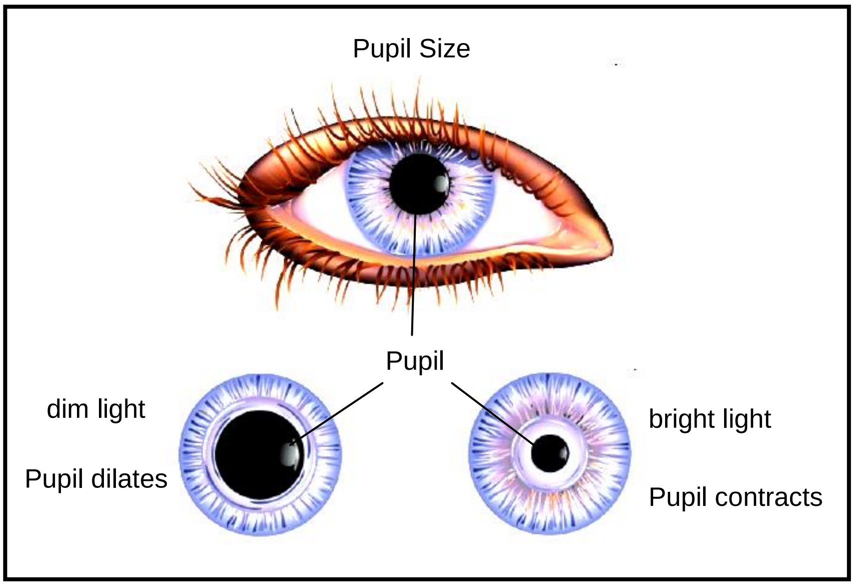


It is set into deep depressions

The eyeball is attached to the skull by muscles. These muscles keep it in position and also help to move the eyeball.

Looking at an eye from outside, we see the iris and the pupil. In your activity, you have seen that the colour of the iris differs from people to people. Some have blue iris, and some have black and others have brown.

In dim light, the pupil of an eye will look bigger in size. In bright light, the same pupil will look smaller in size.



Pupil size in bright and dim light

In dim light, the pupil widens to allow more light to enter the eye. This helps a person to see better in the dark. In bright light, the pupil narrows and less light enters the eye. This protects the retina of the eye from damage.

The colour of the iris differs from people to people.
The pupil is bigger in dim light than in bright light.

Functions of the External Parts of the Eye

The outside of the eyes are covered by the eyelids. These are skin flaps that act as shutters to protect the delicate eyeball from dust, smoke, bright light or physical injury. The eyelids are very sensitive to touch, especially around the hairs of the eyelashes.

Our eyebrows, eyelids and eyelashes prevent dirt or dust entering our eyes. They protect the eyes. But sometimes dust or dirt enters our eyes.

What happens if dirt enters our eye?

You know that the eye produces tears.

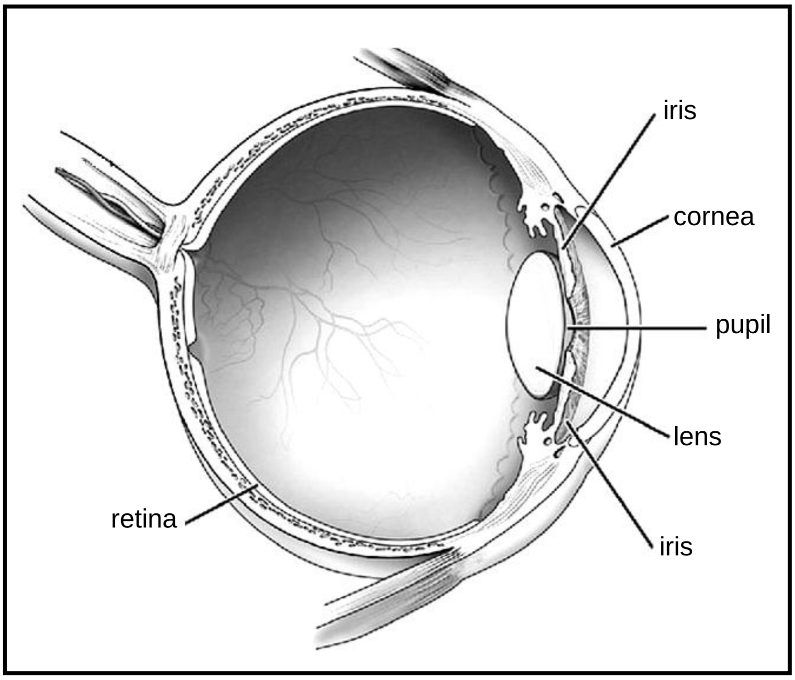
There is a liquid called **tears** in our eyes. Tears from the eyes wash the dust out. That is one of the functions of tears. Tears protect the eyes by killing germs too.

Tears protect the eyes by washing out dirt and killing germs.

Structure and Internal Parts of the Eye

You have learnt about the eye and the eyeball and examined some of the external parts of the eye. The eyeballs are in the bony cavity in the face. To learn about the function of the eye, we have to look at its main parts.

Look at the picture below.



Main parts of an eye

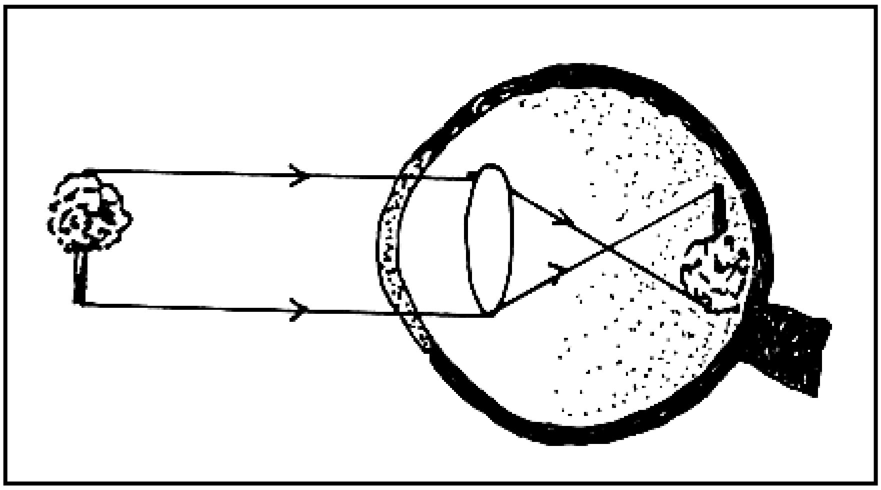
It shows an eyeball that has been cut in half to show the internal parts. There are five parts and they are the **cornea,** the **pupil,** the **iris,** the **lens** and the **retina**.

The **cornea** is the front part of the tough outer coat, the **sclera**. It is curved (convex) and transparent. We see things when light falls on the cornea, enters the eye and passes inside and to the brain through optic nerves.

The **pupil** is the opening in the middle of the iris through which light enters the eye and passes to the back. Its size changes when the iris opens and closes.

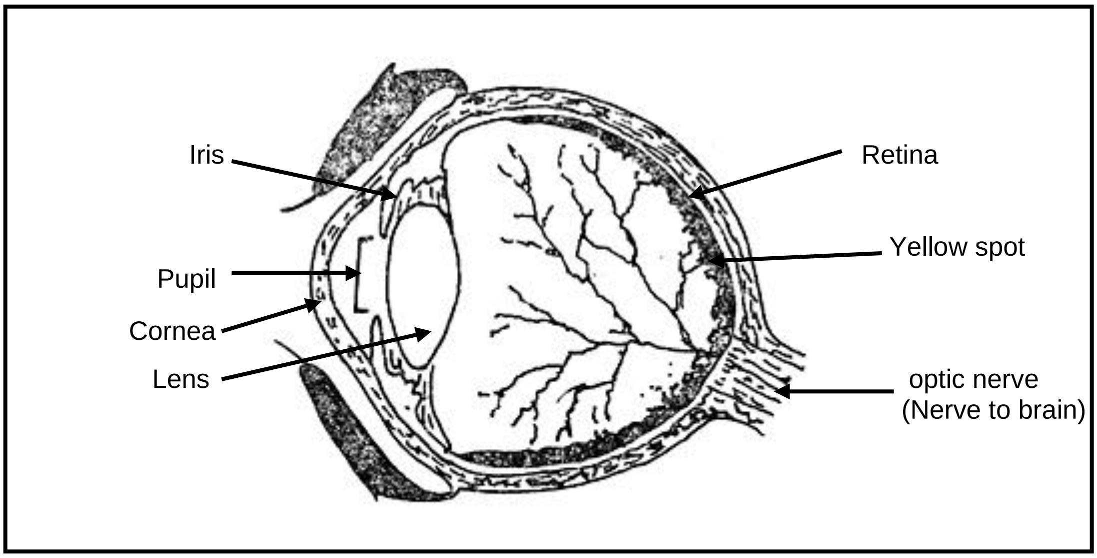
The amount of light entering the eye has to be controlled. The **iris** performs this controlling function. Its muscles contract and relax to change the size of the pupil.

The light rays that enter the eye are bent to form an inverted image by the **eye lens.**



Light rays that enter the eye are bent to form an inverted image

The image produced by the lens falls on the inside wall of the eyeball called the **retina**. It contains millions of nerve cells sensitive to light. The cells are of two types, one is called rods and the other called cones (because of their shape). Rods are sensitive to dim light and black and white while cones are sensitive to coloured lights.



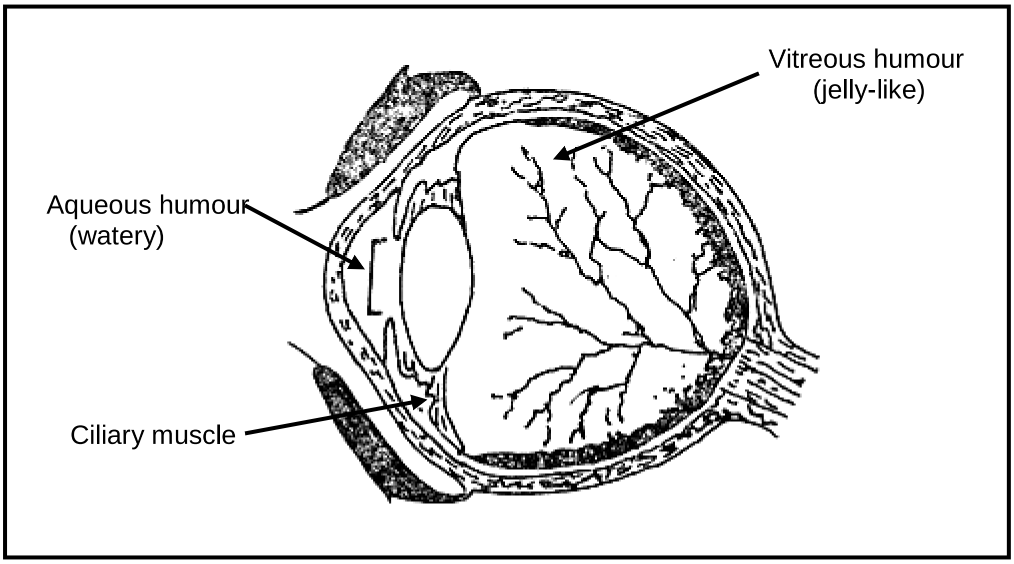
Other internal parts of a human eye

The cornea, pupil, iris, lens and retina are some important parts of the eye.

Other important parts

You have learnt about the cornea, the pupil, the iris, the lens and the retina. These are some important parts of the eye, but not all of them.

Now look at this picture:



Other important parts of the human eye

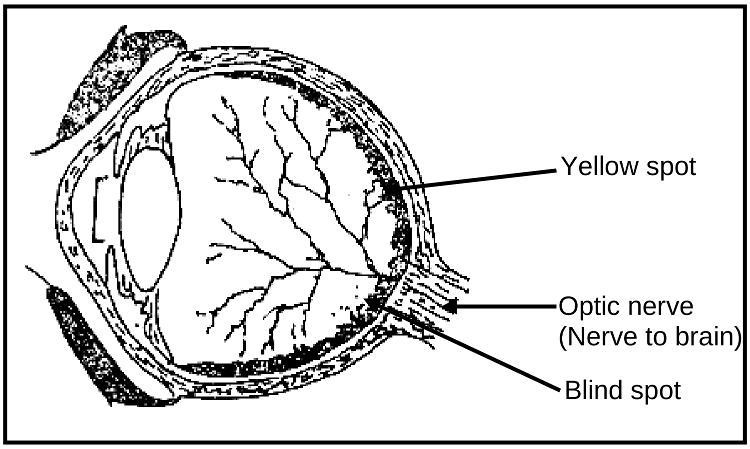
It shows other important parts of the eye. There is a space between the cornea and the lens. This space is filled with a clear watery fluid. It is called **aqueous humour**. It helps the eyeball keep its shape.

You see a bigger space between the lens and the retina. This space is filled with a clear, jelly-like substance called **vitreous humour**. This also helps the eyeball keep its shape.

Look at the parts above and below the eye lens. You see the muscle called the **ciliary muscle**. The ciliary muscle can contract and relax and thus change the thickness of the lens.

Now, look at the part named **yellow spot** in the retina.

The yellow spot is the spot which is most sensitive to light.

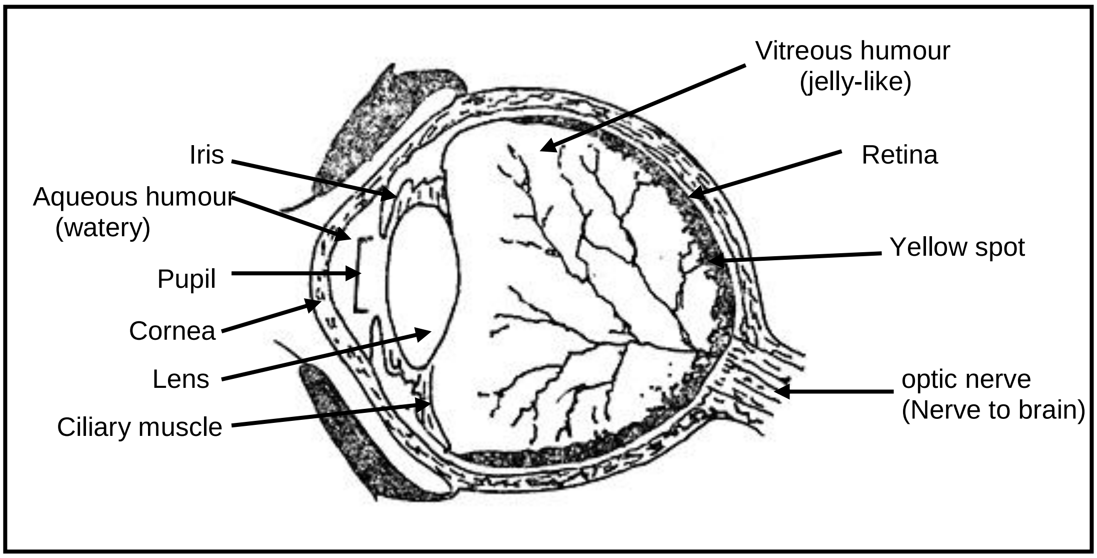


The retina is connected to the brain by the **optic nerve**. This nerve carries the message about the image to the brain. Light falling directly on the optic nerve is not carried to the brain. This part is called the **blind spot**.

The ciliary muscles can contract and relax and therefore can change the thickness of the lens.

How the Eye Works

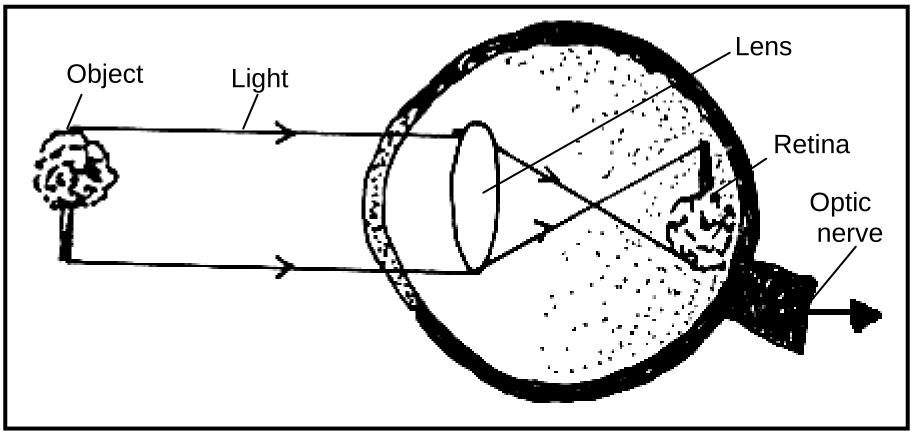
You now know the important parts of the eye. They are all shown in the same picture given below:



The parts of a human eye

How does the eye work with all these parts? This is how it works.

When we look at an object, light from that object falls on the eye and enters through the pupil. It then passes through the lens and the image of the object falls on the retina of the eye.



How an image is formed on the retina of the eye

The optic nerves carry the message about the image formed on the retina to the brain.

The image formed on the retina is always **inverted.** Cells in the retina convert the light into nerve impulses that are sent to the brain. The brain processes the nerve impulse from both eyes and interprets the image. Even though the image on the retina is upside down, the brain interprets it as being upright and so we see the image of the object as it is.

When we look at an object, the image of the object falls on the retina. The optic nerves carry the message to the brain

Summary

You have come to the end of Lesson 9. In this lesson you have learnt that:

- the eye is an organ in our body that can detect light. It is about the size of a betel nut.
- an eye is spherical in shape and is referred to as the eyeball.
- the eyeball is set into deep depressions in the skull and is attached to the skull by muscles. These muscles keep it in position and also help to move the eyeball.
- externally, we see the iris and the pupil. In dim light, the pupil looks bigger in size and in bright light the same pupil will look smaller.
- our eyebrows, eyelids and eyelashes prevent dirt or dust entering our eyes.
- tears from the eyes wash the dust out.
- the cornea is the curved outer part of the eye. It is a transparent covering.
- light enters the eye through a small area called the pupil.
- the iris controls the amount of light entering the eye.
- the lens performs the function of image focusing.
- the image produced by the lens falls on the retina.
- the retina is a layer of two types of nerve cells which are called rods and cones.
- the space between the pupil and the lens is filled with a liquid called aqueous humour.
- the space behind the lens is filled by the fluid called vitreous humour.
- the ciliary muscles contract and relax and therefore can change the thickness of the lens.

NOW DO PRACTICE EXERCISE 9 ON THE NEXT PAGE.

Practice Exercise 9

Answer the following questions in the spaces provided.

1. a) Where exactly are the rods and cones in the human eye?

   ____

   b) Which of these, rods or cones:

   i) detect colour? ___________

   ii) work in dim light? ___________

   ____

2. Which three features near your eye protect it from dust and other small particles?

   i) ___________ ii) ___________ iii) ___________

3. a) Does the size of the pupil of an eye look the same all the time?

   ____

   b) Explain your answer to a).

   ____

4. Describe in your own words what each of the following are:

   a) Pupil

   ____

   b) Retina

   ____

   c) Ciliary muscles

   ____

   d) Optic nerve

   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Activity

1. The eyebrows, eyelids and eyelashes protect the eye from dust and other small particles
2. The answer depends. It can be black, brown, blue or green.
3. The pupil looks smaller in bright light and smaller in dim light

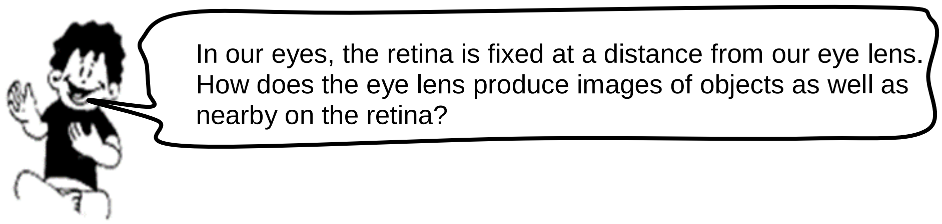
Lesson 10: Power of Accommodation and Persistence of Vision

Welcome to Lesson 10. You now know that the eyes detect light. The eyes are positioned so that each one gives you a slightly different view of the surroundings. This means you have a binocular vision. Each eye makes an image or picture of what you are looking at. Information about the image in each eye is sent along a nerve to the brain. The brain compares the image from each eye. This makes anything that you look at in depth or in three dimensions. Your brain also works out the size of an object and its distance from you.

Your Aims:

- define the power of accommodation, persistence of vision and near point
- describe normal vision
- describe the function of the ciliary muscles
- explain near point of the eye
- describe persistence of vision
- observe the given activities (near point of the eye and persistence of vision).

You know that our eye lens is a convex lens and the distance of an image from a convex lens changes as the distance of object changes.



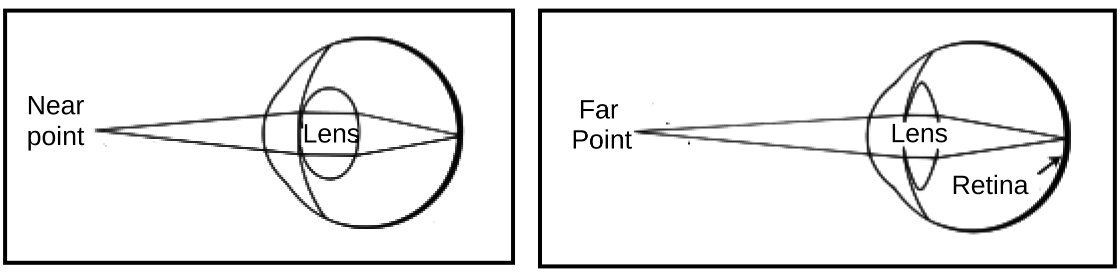
To answer this question, you must learn about the **power of accommodation** of the eye.

Normal Vision

We say that people with normal eye sight have normal vision. People with normal vision see objects nearby as well as objects far away clearly.

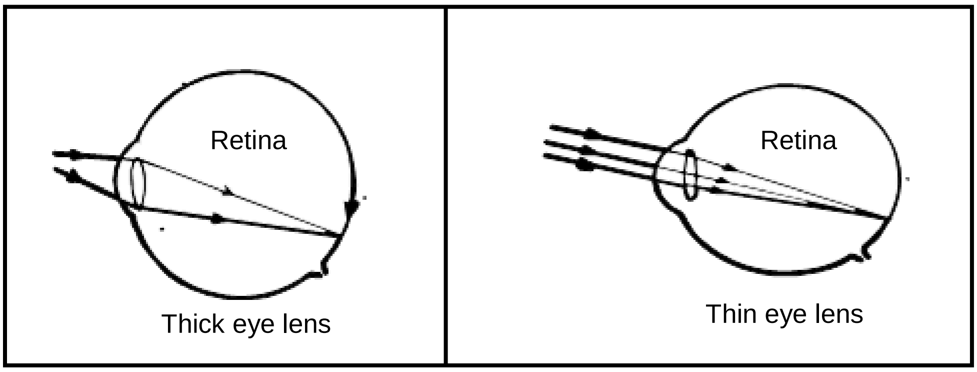
To see an image clearly, the images of objects must be focused on the retina.

Study the diagrams below to see the changes of the eye lenses as light from images of nearby and far objects enter the eye.



Light from a nearby object entering the eye and light from a far object entering the eye.

To focus the image of objects that are far away, the eye lens becomes thin, and to focus nearby image the lens become thick.



The eye lens of people with normal vision has the ability to change its thickness and hence the focal length, and to focus light rays from different distances on to the retina.

Changing the thickness of the lens means changing the focal length of the lens. Our eye lens is made of an elastic lens capsule and filled with compressible lens substance. It is suspended by ligaments to the ciliary muscles.

This ability of the eye lens to change its thickness is called the **power of accommodation.**

Power of accommodation is the ability of the eye lens to change its focal length by becoming thick and thin to focus a clear image at the retina.

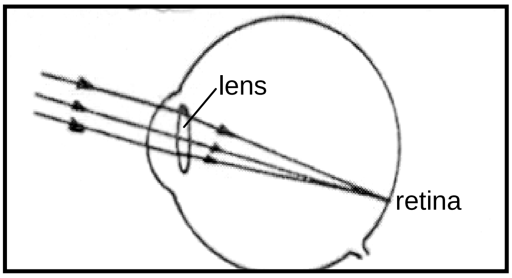
The eye lens brings the rays that diverge from the object to a focus on the retina. In order to do this, the thickness of the eye lens must change to suit the situation.

Changing the focal length

We shall now see how the lens changes its thickness and hence the focal length to suit the situation.

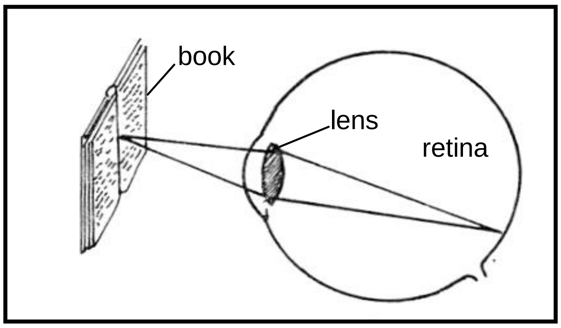
When we look at distant objects, the rays coming to the eye are parallel. The eye lens brings these parallel rays to a focus on the retina.

Look at this diagram.



It shows an eye lens that brings the parallel rays to a focus on the retina.
Note the thickness of the lens. It is fairly thin.

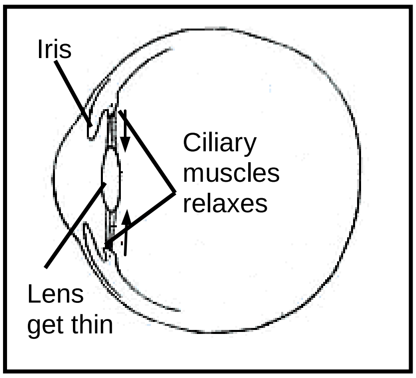
Now, look at this diagram.



The eye lens brings the rays that diverge from the object to a focus on the retina. Note the thickness of the eye lens. It is thicker than the eye lens in the former diagram.

This means that the thickness of the eye lens changes to suit the situation.

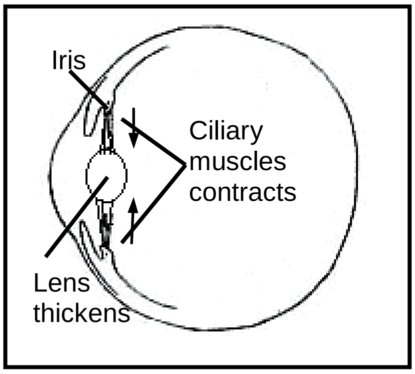
How the thickness of an eye lens changes
When we are looking at distant objects, the ciliary muscles are relaxed and the eye lens is thin*.*



Ciliary muscles relaxes to make the eye lens thin.

When we are looking at close objects

When we look at nearby objects, the muscles are tensed and the eye lens becomes thicker.



Ciliary muscle contracts to increase the thickness of the eye lens.

The eye lens is soft. The change in the thickness of the soft eye lens is made possible by the action of the **ciliary** muscles attached to the eye lens.

The thickness of the eye lens changes to suit the situation and this change is made possible by the action of the ciliary muscles.

When we grow old, our lens will turn hard. Our accommodation ability will decrease and it will get more and more difficult to focus. This defect is called **presbyopia.**

Near point

You now know that the ciliary muscles help us to see objects at different distances from the eye. They relax or tense up and change the thickness of the lens. This changes the focal length of the lens to change the situation.

There is a limit to the amount that the ciliary muscles can relax or tense up to change the lens and cause accommodation.

Activity 1: Now test yourself by doing this activity.

Select a book with normal size print. Try reading the book while holding it at close distance and at far distance from your eyes and answer the questions below.

Are you able to read comfortably when the book is about

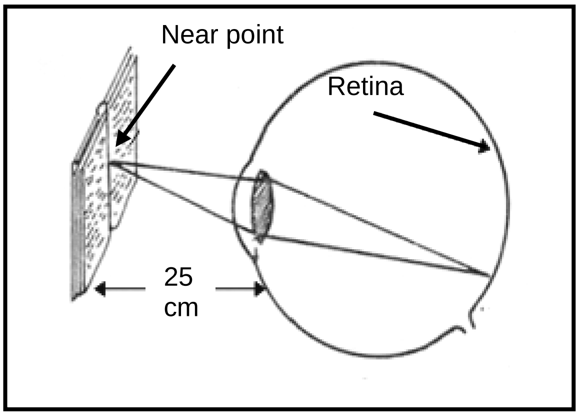
1. a metre away from the eyes?.. Yes/No

2. 10cm away from the eyes? .... Yes/No

3. 25cm away from the eyes? …………………………………………… Yes/No

In your activity, you have found that you cannot read comfortably when the book is too far from, or too close to your eyes.

The closest point at which an eye can clearly see an object is called the **near point** of the eye.



People with normal vision can read a book comfortably when the book is about 25 cm from the eyes.

People with normal vision can read a book holding it about 25cm from the eyes. If you find that you have to hold your book or a newspaper too close or too far away from your eyes to read with comfort your vision is poor or not normal.

Persistence of vision

Now, you will learn about aspect of vision - **persistence** of vision.

Activity 2: Now try doing this activity on testing persistence.

Do this: Stand in open bright sunlight for some time. Then enter a dark room.

1. Do you continue to have sensation of light for a short time afterwards? .... YES/NO

   Look at a fan that rotates slowly.

2. Do you see each of the blades separately? .... YES/NO

   Look at a fan that rotates fast.

3. Do you see each of the blades separately? .... YES/NO

   Your answers should have been YES, YES and NO.

The meaning of persistence of vision

When we stand in bright light for some time and then suddenly enter a room, the sensation of light lasts in our eyes for some more time. The sense of light continues in our eyes for a short time even after we go into a dark room. We say that the sensation of vision persists or continues for some more time.

If we look at a fan that rotates fast, we do not see the individual blades. If the fan rotates slowly, we see the individual blades.

In TV and cinema films, we see the action continuously. Bright images of films are projected fast, one after the other, and the films look continuous.

If a light flickers for more than ten times in a second, we do not see it flickering. We see it continuous.

In all these cases it is persistence of vision that gives the continuous effect.

Persistence of vision is the sense of light continuing in our eyes for some time.

The eye as a camera

The eye is easy to understand if you think of it as a camera. When you take a picture the lens in the front of the camera allows light through and focuses that light on the film. When the light hits the film, a picture is taken. The eye works in much the same way.

In a healthy eye, the lens is clear and allows light to pass through. Light is focused by the cornea and lens onto a thin layer of tissue called the retina. The retina works like the film in a camera. When light hits the retina, tiny cells collect the light signals, and convert them into electrical signals, which are then sent through the optic nerve and to the brain, where they are processed into the images we see.

Summary

You have come to the end of Lesson 10. In this lesson you have learnt that:

- the ability of the lens to focus rays from different distances on to the retina is called the power of accommodation.
- objects that are close and can be focused by the retina are said to be at near point.
- objects which are far and cannot be focused at the retina are said to be at far point .
- the thickness of the eye lens changes to suit the situation and this change is made possible by the action of the ciliary muscles.
- people with normal vision can read a book comfortably when the book is 25cm from the eye.
- persistence of vision is the sense of light continuing in our eyes for a short time when we go from a well-lit place into a dark room..
- the brain and the eye must work together to interpret the image.

NOW DO PRACTICE EXERCISE 10 ON THE NEXT PAGE.

Practice Exercise 10

Answer the following questions on the spaces provided.

1. Define the following.

   a) Power of accommodation

   b) Persistence of vision

   c) Near point

2. When are the ciliary muscles relaxed and when are they contracted?

3. Explain what happens to the lens of the eye and the focal length when an object is

   a) near the eye.

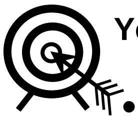
   b) far from the eye.

4. Explain how accommodation is made possible in the eye by the ciliary muscles.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Lesson 11: Common Eye Defects

Welcome to Lesson 11. You have learnt about the eye and how the parts of the eye function to give us the sense of sight. Our sense of sight is normal only when we see all things clearly.



Your Aims:

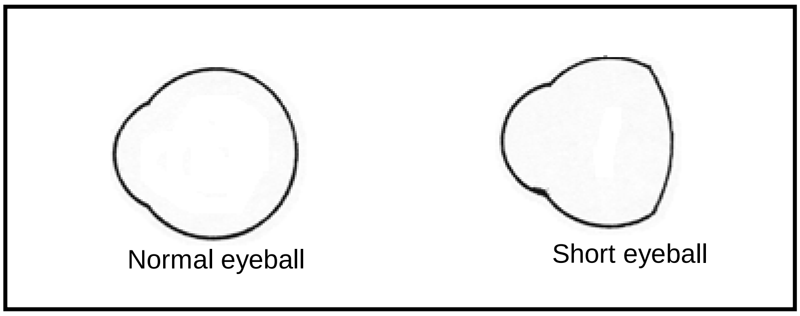
- identify the common defects of vision
- describe the cause, effect and correction of each defects
- describe the ray diagram for the causes and correction of the long and short sights
- discuss colour blindness and blind spot
- observe and draw conclusions from a given activity

Long- sightedness

As people get older, their eyesight generally becomes poorer. The eye lens becomes hard and loses the power of accommodation. This means that images of nearby objects are focused behind the retina. They find it difficult to focus on close objects, for example, when reading. But they can see distant objects clearly.

This eye defect is called **long sight** (hypermetropia). Some young people also suffer from the long sightedness (hypermetropic).

In young people, it can be caused by an eyeball that is out of shape and therefore too short. In both cases, the image focuses behind the retina of the eye and the object appears fuzzy and out of focus.



If the eyeball is shorter than the normal, the distance between the eye lens and the retina of the eye is also shorter than the normal. Hence, light rays from nearby objects, come to a focus behind the retina after refraction by the eye lens.

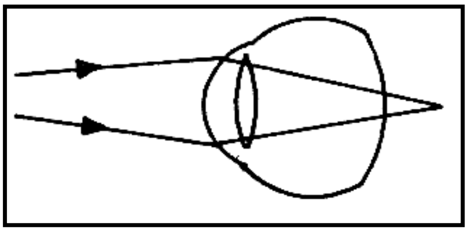


Image of nearby objects focused behind the retina of the short eyeball.

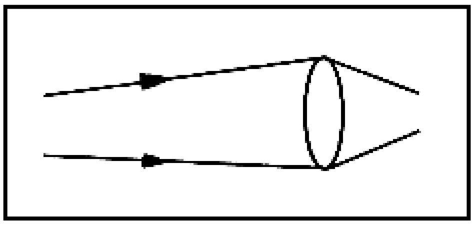
The eye lens is a convex lens; it bends rays of light inwards. Often, when we look at objects nearby, the eye lens becomes thick enough to bend the rays inwards and focus the images on the retina.But there is a limit to ciliary muscles that can act to thicken the eye lens and make the rays bend inwards.

When the distance between the retina is shorter than normal, the inward bending of the rays must be more than normal.

When the thickness of the eye lens reaches a limit, it does not thicken any more. Thus the image is focused behind the retina of the short eyeball.

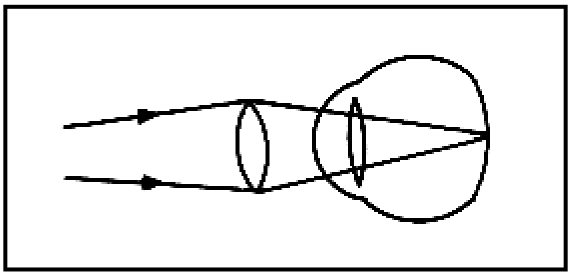
Young people are long sighted if they have short eye balls.

Correction of long sight
You have learnt that the eye lens bends light rays entering the eye inward. You also know that when the eyeball is shorter than normal, the inward bending of the ray has to be more, than is normally required. How can this be?



A convex lens bends the light rays inwards

You know that convex lenses bend light rays inwards. A convex lens when placed in front of the eye lens, bends the light rays inwards before the rays reach the eye lens.

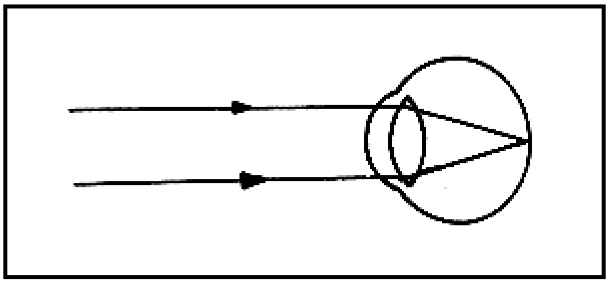


The eye lens bends the rays inwards further

When the refracted rays reach the eye lens, the rays are refracted again and focused on to the retina. Thus, long sightedness can be corrected by wearing a convex lens of suitable focal length.

The suitable lens has to be prescribed by an eye doctor, after carrying out an eye test.

Light rays from distant objects
Long sighted people have no problem seeing distant objects clearly.



The eye lens becomes thick enough to focus light rays on the retina

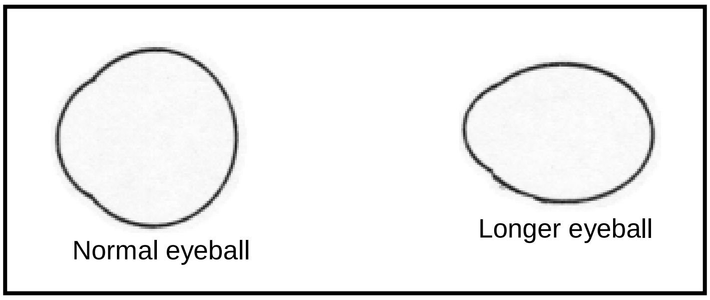
Their eye lens can become thick enough to focus light rays from distant objects on to the retina of the short eyeball.

Long sightedness can be corrected using a suitable convex lens.

Short Sightedness (Myopia)

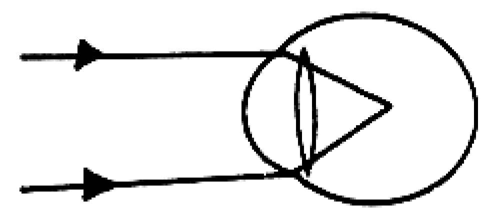
There are some people who can see nearby objects but not those at a distance. They are said to be **short sighted** (myopic).

Long eyeballs
Some people have eyeballs that are longer than normal.



Since the eyeballs are longer than normal, the distance between the lens and retina is also longer than normal. This creates a problem when they look at distant objects.

The normal eye lens focuses the image of distant objects not on to the retina but to some point in front of the retina.



Long eyeball
Light from a distant object
Image not in focus on the retina

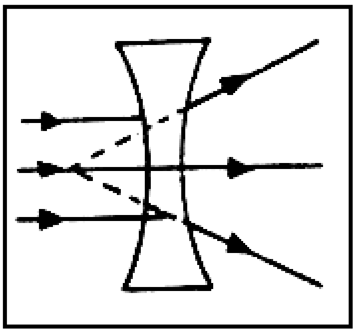
The eyes of the short sighted people need help when looking at distant objects.

The light rays from distant objects have to be bent outwards before the rays enter the eye. How is this possible?

Short sighted people can clearly see objects nearby.

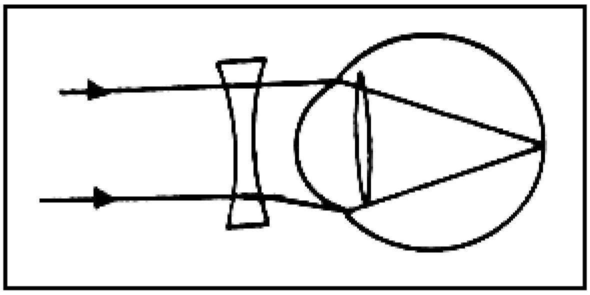
Correction of short sight

You have learnt that light rays from distant objects are bent outwards by a concave lens.



So, concave lenses can be used to correct short sightedness due to long eyeballs. We can see images of distant objects clearly by looking through concave lenses.

Look at the diagram below:



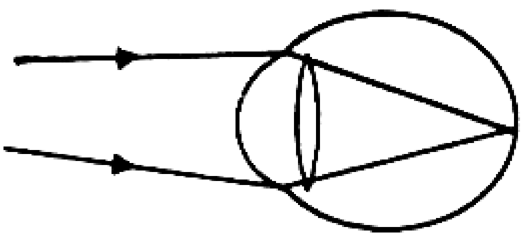
Concave lens in front of the eye

- Light rays bend out wards, before entering the eye.
- Image in focus on the retina.
- The concave lens bends light rays outwards.

By using a concave lens, the rays of light from distant objects can be focused on to the retina of long eye balls.

Light rays from nearby objects

People with long eyeballs have no problem seeing nearby objects.



Long eyeball
Light from the nearby object
Image in focus on the retina

Their eye lens can get thin enough to focus light from nearby objects on the retina.

Short sightedness can be corrected by using a concave lens

You have learnt about long sightedness and short sightedness and how these defects can be corrected. There are two other eye defects, astigmatism and colour blindness.

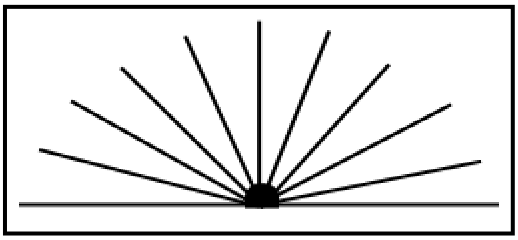
Astigmatism

Astigmatism is a very common eye problem. It is caused by either small parts of the cornea or the eye lens being out of normal shape.

You can test your eye for astigmatism by doing the activity below.

Activity: Testing for astigmatism

Do this: Look at the diagram below.



Close one eye and look at the diagram for some time then answer the following questions by putting a circle around one.

1. Do all the lines look equally dark? …………………………………… Yes/No

2. Do some of the lines look darker than the others? .... Yes/No

Repeat the activity with a friend and write the result.

The lines are all equally dark. If any of the lines appear less dark than the others, then you probably have **astigmatism**. Because of this, people who have astigmatism have difficulty in reading too.

Astigmatism can be corrected by wearing special lenses. An eye doctor must test and prescribe suitable lenses.

Astigmatism is caused by either small parts of the cornea or the eye lens being out of normal shape.

Colour Blindness

Some people find it difficult to see the difference between different colours.

For example, a red rose may appear green to them. Such people are said to be **colour blind.**

Colour blind drivers can have difficulty in differentiating between colour signals at traffic lights and so cause accidents.

Eye doctors use special cards to test for colour blindness.

Colour blindness is found mostly in males. Women are very rarely colour blind. But some though not colour blind, can pass on the defect to their sons. Generally, they are not colour blind themselves.

Eye defects and blindness in PNG
Studies have shown that only about 2% of Papua New Guinea males are colour blind. This is not bad compared to other countries.

For example, it is said that about 5.5% of male Australian Aborigines are colour blind. About 8% of white Australian males are colour blind. In some European countries up to about 22% of males are said to be colour blind.

About 0.8% of people in Papua New Guinea are totally blind. This means 8 people in every thousand are blind.

Care of the eyes.
Our eyes function better than those of other animals. If they are not looked after carefully, eye sight can be affected. Some people lost their eye sights completely by drinking spirits.

There are several causes for blindness. We cannot do anything if the blindness is natural but it can be avoided if mothers are careful and keep the eyes of their babies free from infection.

Reading in dim light can strain your eyes which can produce headaches. If you have problems with your eyes like difficulty in reading, continuous headaches or tears in your eyes, you should consult an eye doctor.

People who cannot see any difference between colours are said to be colour blind.

Blind Spot

The ‘blind spot’ in the eye is the area where the optic nerve leaves the eye. There are no nerve endings in this area and light falling in this area is not seen.

The blind spot in the eye can be located using the diagram below.

- To find your blind spot, cover your left eye, pick up this book in your other hand and look at the ● above with your right eye.
- Move the book slowly towards you while all the time looking at the ●.
- At some distance you will not be able to see the +. At this spot the light rays from the + are falling on the blind spot.

Summary

You have come to the end of Lesson 11. In this lesson you have learnt that:

- people who can clearly see distant objects but cannot clearly see objects nearby are said to be long sighted.
- if the eye lens and ciliary muscles function properly, long sightedness amongst young people is due to short eyeballs.
- when the eyeball is short, the image of the nearby object is focused behind the retina.
- convex lens glasses are used to help long sighted people read or see nearby objects clearly .
- people who can clearly see nearby objects but cannot clearly see distant objects are said to be short sighted.
- short sightedness can be corrected by using a concave lens.
- when someone is looking at equally dark lines and some lines appear less darker than the others, then that person probably has astigmatism.
- people who have astigmatism have difficulty in reading.
- astigmatism is caused by either small parts of the cornea or the eye lens being out of normal shape.
- some people find it difficult and some people do not see any difference between the different colours. Such people are said to be colour blind.
- colour blindness is found mostly in males.
- the ‘blind spot’ in each eye is the area where the optic nerve leaves the eye.

NOW DO PRACTICE EXERCISE 11 ON THE NEXT PAGE.

Practice Exercise 11

Answer the following questions in the spaces provided.

1. a) What does long sightedness mean?

   ____

   ____

   b) What causes long sightedness amongst young people?

   ____

   ____

   c) What type of lens is used to correct long sightedness?

   ____

---

2. a) What does short sightedness mean?

   ____

   b) What causes short sightedness amongst young people?

   ____

   c) What type of lens is used to correct short sightedness?

   ____

---

3. a) What is the cause of astigmatism?

   ____

   ____

   b) What kind of difficulty can you experience if you suffer from astigmatism?

   ____

   ____

   c) How can you correct astigmatism?

   ____

---

4. What do we mean by colour blindness?

   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 4.

Answers to Practice Exercises 9 - 11

Practice Exercise 9

1. a) The rods and cones are in the retina

   b) i) Cones detect colour

      ii) Rods work in dim light

2. The eyelids, eye lashes and the eyebrows prevent dirt or dust entering our eyes

3. (a) No

   (b) In dim light, the pupil looks bigger and in the bright light it looks smaller.

4. a) The pupil is an aperture through which light enters the eye.

   b) The retina is a layer of nerve cells which are sensitive to light and on which the image forms.

   c) The ciliary muscles control the thickness of the eye lens.

   d) The optic nerve carries the message about the image to the brain.

Practice Exercise 10

1. a) The power of accommodation is the ability of the eye lens to change its focal length by becoming thick and thin to focus a clear image at the retina.

   b) The sense of light continuing in our eyes for a short time when we go from a well-lit place into a dark room.

   c) The closest point at which an eye can clearly see an object.

2. The ciliary muscles are relaxed when an object is held far away from the eye and are contracted when an object is held closer to the eye.

3. a) When an object is near to the eye, the lens of the eye bulges out (thickens) which in turn shortens the focal length.

   b) When an object is far from the eye, the lens of the eye gets thinner which increases the focal length.

4. The thickness of the eye lens changes to suit the situation. This is made possible by the contraction and relaxation of the ciliary muscles.

Practice Exercise 11

1. a) Ability to see distant objects clearly but not nearby objects.

   b) Short eye balls

   c) Convex lens

2. a) Ability to see nearby objects clearly but not distant objects.

   b) Long eye balls

   c) Concave lens

3. (a) The eye lens or small parts of the cornea being out of normal shape.

   b) When looking at equally dark lines, some appear less dark than others.

   c) Using suitable lenses as prescribed by an eye doctor.

4. Inability to differentiate between different colours.

REVISE TOPIC 4 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 4: The Eye

Now, revise all lessons in this Topic and then do **ASSIGNMENT 4**.
Here are the main points to help you revise.

Lesson 9: Structure and Parts of the Eye

- The eye is an organ in our body that can detect light. It is about the size of a betel nut.
- An eye is spherical in shape and is referred to as the eyeball.
- The eyeball is set into deep depressions in the skull and is attached to the skull by muscles. These muscles keep it in position and also help to move the eyeball.
- Externally, we see the iris and the pupil. In dim light, the pupil looks bigger in size and in bright light the same pupil will look smaller.
- Our eyebrows, eyelids and eyelashes prevent dirt or dust entering our eyes.
- Tears from the eyes wash the dust out.
- The cornea is the curved outer part of the eye. It is a transparent covering.
- Light enters the eye through a small area called the pupil.
- The iris controls the amount of light entering the eye.
- The lens performs the function of image focusing.
- The image produced by the lens falls on the retina.
- The retina is a layer of two types of nerve cells which are called rods and cones.
- The space between the pupil and the lens is filled with a liquid called aqueous humour.
- The space behind the lens is filled by the fluid called vitreous humour.
- The ciliary muscles contract and relax and therefore can change the thickness of the lens.

Lesson 10: Power of Accommodation and Persistence of Vision

- The ability of the lens to focus rays from different distances on to the retina is called the power of accommodation.
- Objects that are close and can be focused by the retina are said to be at near point.
- Objects which are far and cannot be focused at the retina are said to be at far point.
- The thickness of the eye lens changes to suit the situation and this change is made possible by the action of the ciliary muscles.
- People with normal vision can read a book comfortably when the book is 25 cm from the eye.
- Persistence of vision is the sense of light continuing in our eyes for a short time when we go from a well-lit place into a dark room.
- The brain and the eye must work together to interpret the image.

Lesson 11: Common Eye Defects

- People who can clearly see distant objects but cannot clearly see objects nearby are said to be long sighted.
- If the eye lens and ciliary muscles function properly, long sightedness amongst young people is due to short eyeballs.
- When the eyeball is short, the image of the nearby object is focused behind the retina.

- Convex lens glasses are used to help long sighted people read or see nearby objects clearly.
- People who can clearly see nearby objects but cannot clearly see distant objects are said to be short sighted.
- Short sightedness can be corrected by using a concave lens.
- When someone is looking at equally dark lines and some lines appear less darker than the others, then that person probably has astigmatism.
- People who have astigmatism have difficulty in reading.
- Astigmatism is caused by either small parts of the cornea or the eye lens being out of normal shape.
- Some people find it difficult and some people do not see any difference between the different colours. Such people are said to be colour blind.
- Colour blindness is found mostly in males.
- The ‘blind spot’ in each eye is the area where the optic nerve leaves the eye.

REVISE WELL AND THEN DO TOPIC TEST 3 IN YOUR ASSIGNMENT 4.

TOPIC 5

DISPERSION OF LIGHT AND COLOURS

In this topic you will learn about:

- **colours in white light**
- **colours of objects**

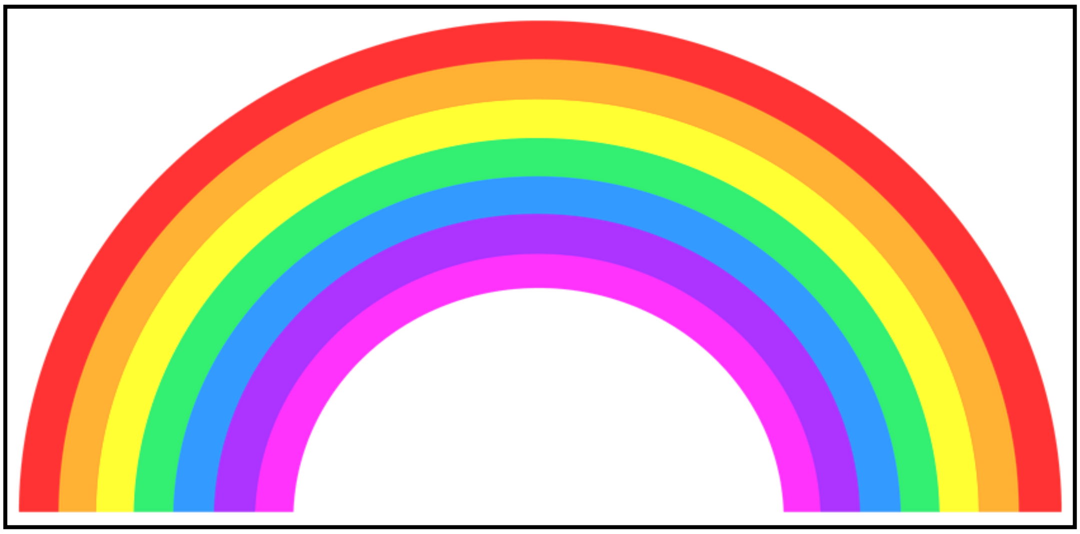
INTRODUCTION TO TOPIC 5: DISPERSION OF LIGHT AND COLOURS

The world is full of beautiful colours. You see a violet dress, a blue car, a yellow flower, and a green tree. The coloured lights on christmas trees in December mean that Christmas festive season is coming. All kinds of colours are everywhere.

White light, such as sunlight or light from a light bulb lets you see things. Dresses, cars, and all other things we see absorb (soak up) some of the colours of white light. The colours that do not get absorbed bounce off things. Red light bounces off a red dress. The dress soaks up other colours. Your eyes see the red light but not the other colours. Your eyes send this message to your brain. Your brain tells you that you are seeing a dress that looks red.

A rainbow is made by light bouncing back to you from the inside of raindrops. Ordinary light, like that from a light bulb or from the Sun, is called white light. White light is actually a mixture of seven colours. Light bends when it passes through water. Each colour bends a different amount. When white light enters a raindrop, the colours get separated. The white light splits into seven colours that you can see.

These seven colours always appear in the same order: red, orange, yellow, green, blue, indigo (bluish-purple), and violet (purple).



You should know about the dispersion of light and colours. Some of the questions you may be asking yourself now are:

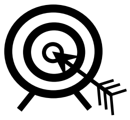
- What are the colours in white light?
- How can we separate the colours of light?
- How does a rainbow form?
- How can we describe the shades in black and white pictures?

In this topic, you will find the answers to these questions and all other questions relating to dispersion of light and colours.

Lesson 12: Colours in White Light

Welcome to Lesson 12. In the previous lessons, we have studied mostly the eyes. We learnt that the eye does a vital job of detecting light. You have also learnt that light is a form of energy and that light rays travel in straight lines. We usually refer to Sunlight and other sources of light as white light.

In some situations, white light separates into different colours. We sometimes see the different colours that make up white light. One such situation is the rainbow in the sky. In this lesson, you will learn about the rainbow and the colours in the white light.



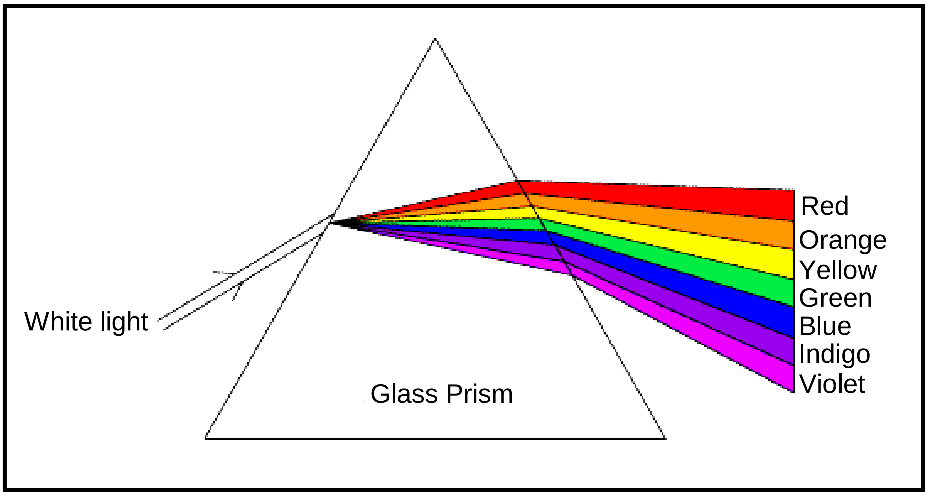
Your Aims:

- define spectrum
- describe electromagnetic spectrum
- describe rainbow formation and separation of white light
- observe and make conclusions about given activities

Spectrum

White light can be split up into different colours using a prism. When white light passes through a triangular glass prism, it refracts and separates into seven different colours. White light separating into different colours is called **dispersion**.

This occurs because each colour is refracted slightly differently when it passes through a glass prism as shown in the diagram below.

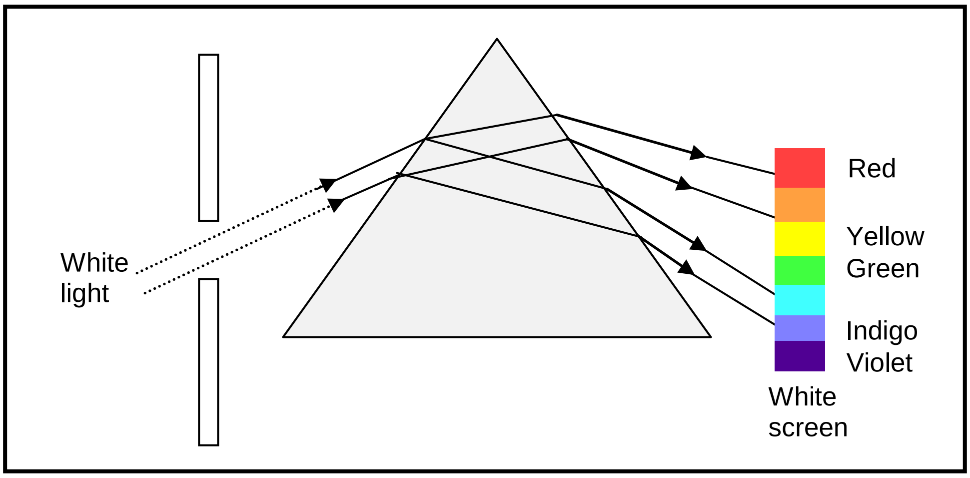


A glass prism disperses white light into seven different colours

You know that white light is made up of different colours. When it refracts, some colours bend more than others. Different colour rays bend at different speeds by different amounts and so they separate into different colours.

Separating white light

White light refracts when it passes through a triangular glass prism. White light also separates into seven different colours when it refracts under certain conditions. White light separating into different colours as you now know is called **dispersion**. The rays of different colours that emerge after dispersion can be projected on to a screen. The seven colours on a screen make a coloured band. This coloured band is called **spectrum.**



The seven colours on a screen make a coloured band called spectrum

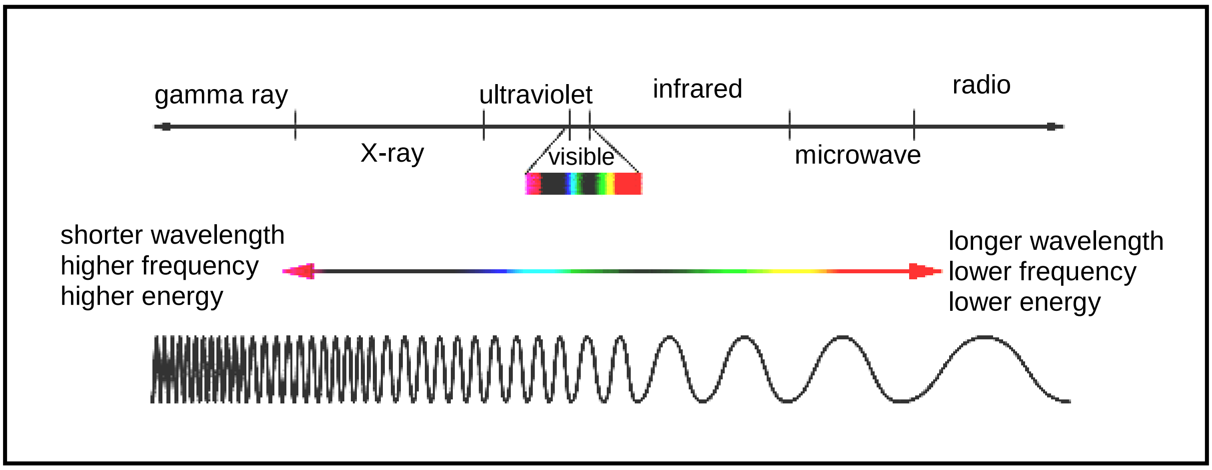
- Red rays bend the least and so red is on the top part of the spectrum.
- Violet rays bend the most and so, it is at the bottom of the spectrum.

Pure spectrum

You learnt that the seven colours on a screen make up a coloured band called a spectrum. Normally, we do not see the seven colours clearly on a spectrum. But, it is possible to obtain a clear spectrum using a narrow beam and a lens. The seven colours can be seen clearly in the spectrum on the screen. Such a spectrum is called a **pure** spectrum.

Electromagnetic Spectrum

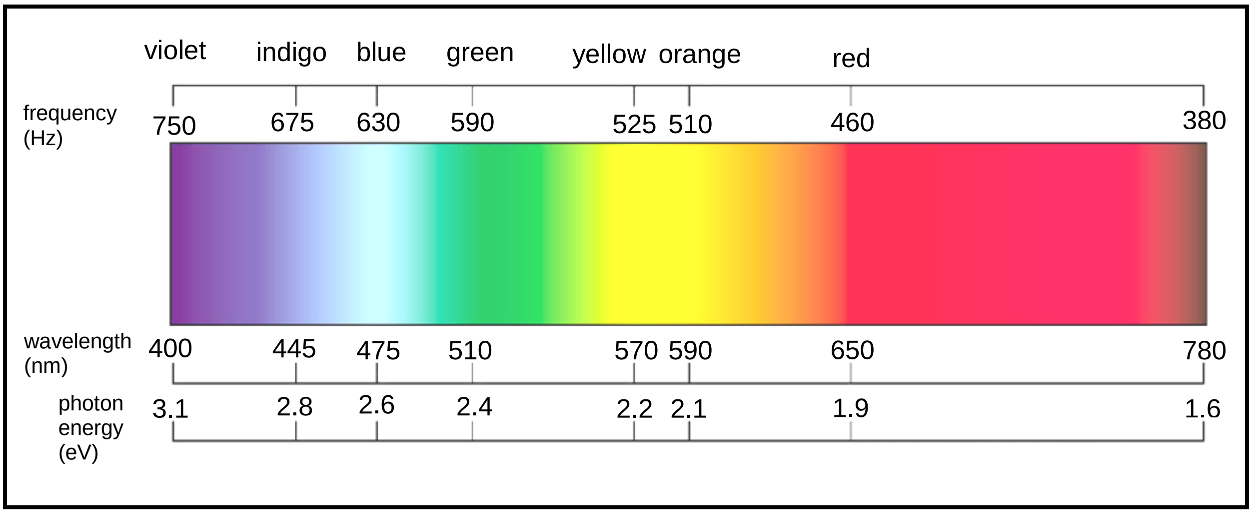
The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes. The visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of electromagnetic radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, x-rays and gamma rays.



The electromagnetic spectrum

The colours that make up the spectrum are continuous and blend into each other, but for convenience, we say there are seven colours known as **ROYGBIV** which stand for red, orange, yellow, green, blue, indigo and violet. When these colours combine they form the familiar white light we see.

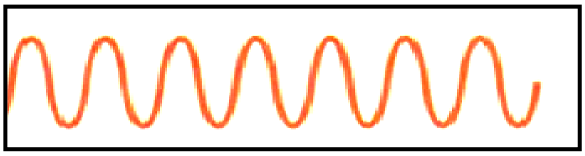
The diagram below clearly shows how the different colours are arranged and how long their wavelengths are. They range from violet, indigo, blue, green, yellow, orange and red.



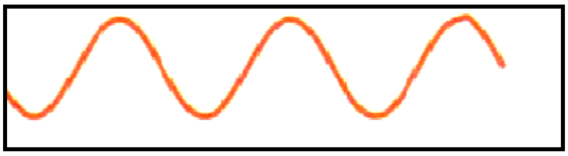
Light, the visible spectrum

The different colours we see are the different wavelengths of the visible spectrum that enter our eyes.

Each of the colours that make up white light has its own wavelength. Violet light has the shortest wave length and red has the longest.



Violet light (short wavelength)



Red light (long wavelength)

Red light is refracted the least and violet the most. Although you cannot see them, infra-red and ultra-violet rays could be present at either end of the visible spectrum.

But why is violet light refracted more than white light? It has been found that different wavelengths of light have slightly different speeds in the same substance.

For example, the speed of red light in water is about 2.280 x 10^8m/s, while that of violet light is slower at 2.255 x 10^8m/s. Even this slight difference in speed means that violet light bends more than red light when it passes through a drop of water.

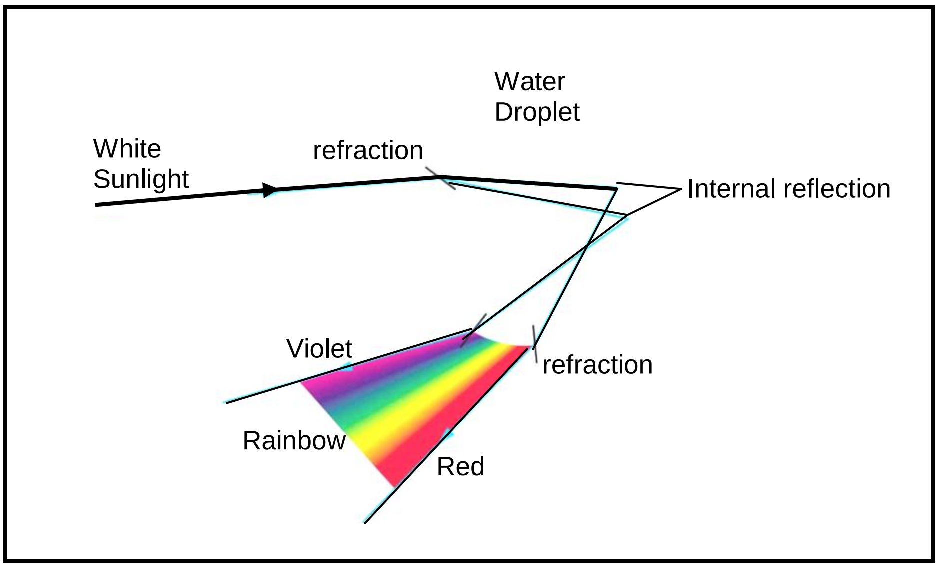
With this knowledge, you can now explain why a raindrop forms when sunlight passes through the drops of water in rain.

The Rainbow is a Spectrum

The rainbow is a spectrum formed by nature. The screen is the sky. How is the spectrum formed by nature?

This is what happens. On a cloudy or rainy day, there are tiny water droplets within the clouds. Light rays from the Sun pass through these water droplets.

In this process, white light undergoes refraction as well as dispersion and total internal reflection. This spectrum - the rainbow - is not a pure spectrum. We cannot see all the seven colours. We see only some of them.



Refraction in a raindrop

A coloured band in which the seven colours are clear to see is a pure spectrum.

Activity: Now test yourself by trying out this activity.

Circle the letter of the most correct answer from the alternatives listed

1. How many different colours make up the light that we see?

A. 5 B. 6

C. 7 D. 8

2. ROYGBIV indicates the different colours that we see. Out of these colours, which one has the longest wavelength?

A. Red B. Blue

C. Green D. Orange

3. If light is deflected and the angle of incidence is similar, then this is known as __________.

A. refraction B. deflection

C. reflection D. incidation

4. The bending of light is known as __________.

A. refraction B. reflection

C. deflection D. incidation

5. The colours that we see are the result of different __________.

A. speeds B. amplitudes

C. frequencies D. wavelengths

CHECK YOUR ANSWERS AT THE END OF THE LESSON.

Summary

You have come to the end of Lesson 12. In this lesson you have learnt that:

- the coloured band falling on a screen as a result of dispersion of white light is called a spectrum.
- the colours that make up the spectrum are continuous and blend into each other.
- white light is a mixture of seven colours - Red, Orange, Yellow, Green, Blue, Indigo and Violet (ROYGBIV).
- the splitting up of white light into the seven colours is called dispersion.
- the electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation.
- a rainbow is a spectrum formed by the refraction, total internal reflection and dispersion of Sunlight in water droplets in the sky.

NOW DO PRACTICE EXERCISE 12 ON THE NEXT PAGE.

Practice Exercise 12

Answer the following questions on the spaces provided.

1. What is the section of the electromagnetic spectrum that is visible to people called?

2. The visible spectrum contains different colours. Of these different colours,

   a) which has the longest wavelength?

   b) where along the visible spectrum is it located?

3. Write down the seven colours of the visible spectrum in order, starting with red.

4. Explain how we are able to see the different colours of objects.

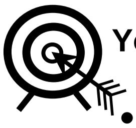
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 5.

Answers to Activity

1. C 2. A 3. C 4. A 5. D

Lesson 13: Colours of Objects

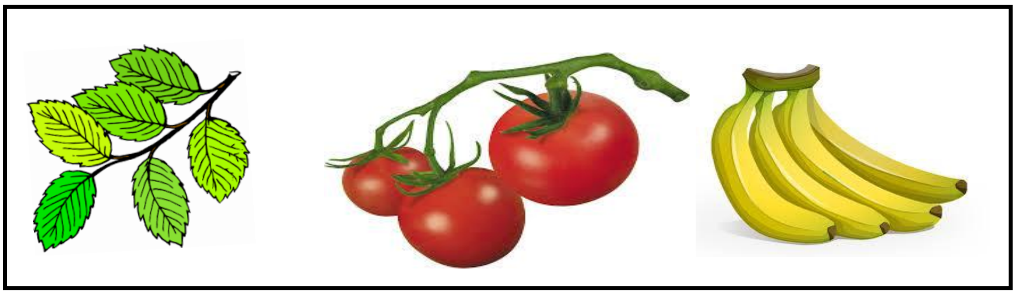
Welcome to Lesson 13. You have learnt that non-luminous objects do not produce light. We see them when white light reflected by them reaches our eyes. In this lesson, you will learn about the colour of objects and how we see different colours when objects reflect the same white light.



Your Aims:

- describe absorption, transmission and reflection of light
- describe black and white objects
- describe colour and reflections of coloured objects

Leaves, fruits and plants are all examples of non-luminous objects.

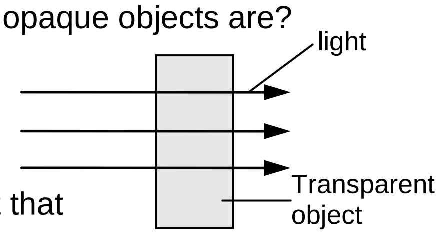


Green leaves Red tomatoes Yellow bananas

We see them when Sunlight (white light) which falls on them is reflected to our eyes. How do we see different colours if all of them reflect the same white light?

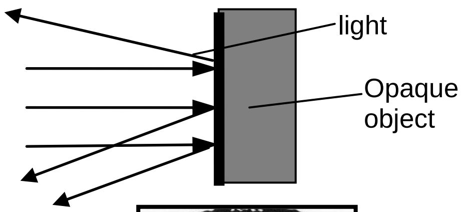
Transmission, Absorption and Reflection

Do you remember what transparent, translucent and opaque objects are?



- Transparent objects allow all the light falling on them to pass through.

We say that transparent objects **transmit** all the light that falls on them.



Opaque objects do not allow any light to pass through them. They **absorb** a part and **reflect** the rest of the light that falls on them .

If the object is shiny or bright, most of the light is **reflected**. If the object is dull or dark, most of the light is **absorbed**.

Translucent objects allow a part of the light falling on them to pass through.

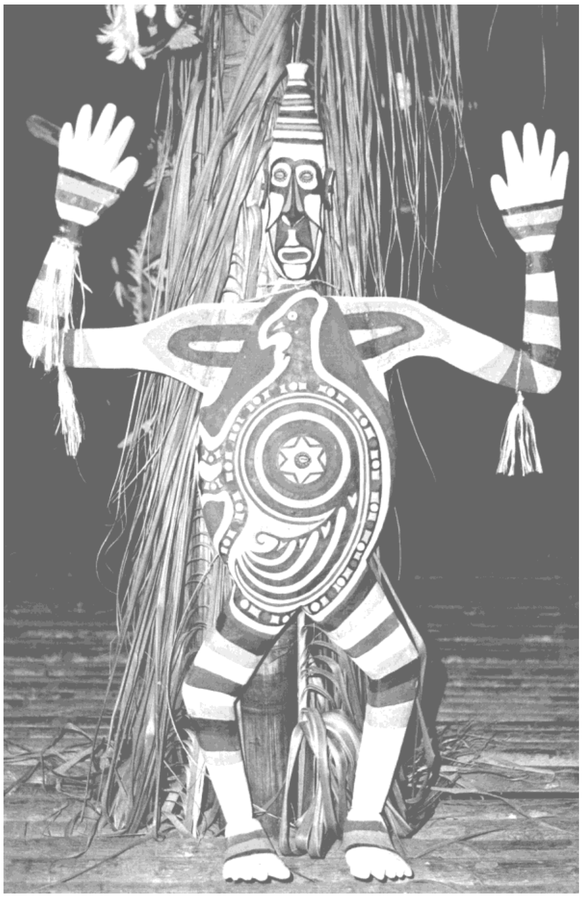
A man wearing sunglasses

We say that translucent objects transmit a part of the light that falls on them. They absorb or reflect the other part.

An object may reflect, transmit or absorb the light that falls on it.

Black and white

You learnt that opaque objects absorb part of the light that falls on them and reflect the rest. The amount of light absorbed and the amount reflected determine the appearance of the object. We shall look at an example. Opposite is a black and white photograph of an effigy of 'Malesa', an ancestral hero of people living in the Gulf province of PNG.



Effigy of Malesa

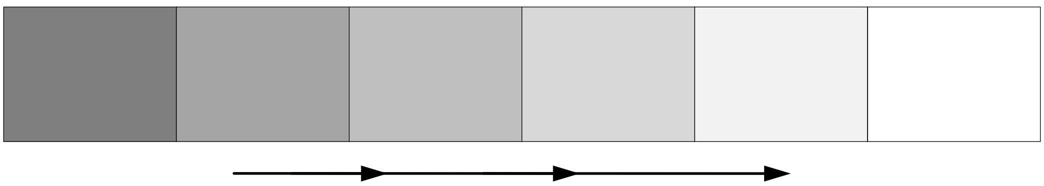
Some parts of the photograph appear dark (black). Some other parts of the same appear bright (white). There are other parts that have different shades of black and white.

If a photograph has areas that all reflect the same white light, how do we explain the difference in brightness of the different parts?

An egg shell looks white because it reflects all of the colours in white light.

The brightness of any object depends on the amount of white light it reflects. The parts that absorb more white light and reflect less appear black. The parts that reflect more white light and absorb less appear whiter.

Look at this strip which shows the different shades we see in the photograph above:



Absorbs most
Reflects least

Less and less light absorbed
More and more light reflected

Reflects most
Absorbs least

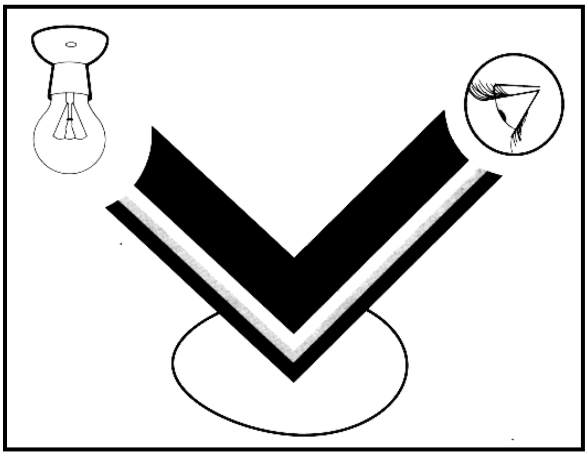
Objects we see in white light look blacker or whiter depending on the amount of white light they reflect.

Remember that black is not a colour. Objects that appear black are objects which absorb all the white light that falls on them.

Objects that reflect more white light appear whiter and brighter.

Colour and reflection

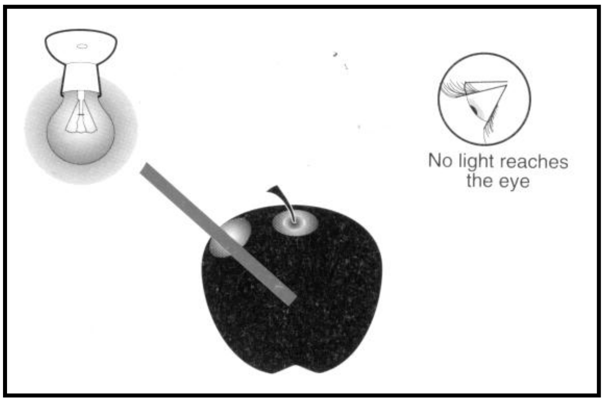
Now, when does an object appear white? You have learnt that an object looks white when it reflects all the white light that falls on it. This means that the object does not absorb any part of the white light that falls on it.



White is **not** a colour by itself. It is a mixture of the seven different colours.

An object looks white because it reflects all the white light that falls on it.

Now, when does an object appear black? You have learnt that we see objects because they reflect light rays. An object appears black when it absorbs all the white light that falls on it. It does not reflect any part of that light. That is why an object looks black. So an object, like a red apple will look black if a yellow, green, blue, indigo or violet light is shown onto it since its skin will absorb all of these colours.

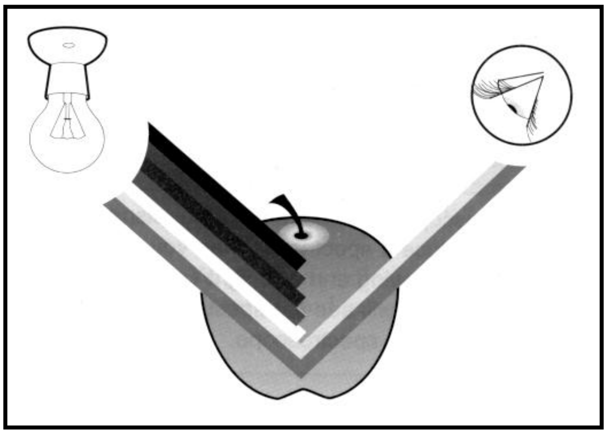


If green light is shone onto a red apple, it looks black as no colour would be reflected.

So, remember, objects we see in white light look black or white depending on the amount of white light they reflect to our eyes.

Coloured objects

Now, in white light apples appear *red* in colour. But, we see them in white light. How does this happen? Apples appear red in white light because they reflect only the red (and some orange) colour in white light. Apple skins absorb all the other colours in white light. Similarly, leaves appear green in white light because they reflect only the green colour in white light. They absorb all the other colours in white light.



An apple skin reflects red (and some orange) and absorbs the other colours in white light.

The colour of objects we see in white light depend on the amount of white light or the colour they reflect.

Summary

You have come to the end of Lesson 13. In this lesson you have learnt that:

- an object may reflect, transmit or absorb light that falls on it.
- objects that reflect more white light appear brighter and whiter.
- the colour of an object depends on the colour it reflects.
- black is not a colour. An object looks black because it absorbs all the light falling on it.
- white is not a colour. An object looks white because it reflects all the light falling on it.

NOW DO PRACTICE EXERCISE 13 ON THE NEXT PAGE.

Practice Exercise 13

Answer the following questions on the spaces provided.

1. Complete the statements.

   (a) Rays of white light falling on opaque objects may be reflected or __________ by the objects.

   (b) An object appears white in colour when it __________ all the white light rays that fall on it.

   (c) An object appears black in colour when it __________ all the white light rays that falls on it.

   (d) An object appears blue in colour because it __________ only the blue colour rays from the white light that falls on it.

2. State, with reasons, the colour of a blue sheet of paper when

   (a) white light falls on it.

   (b) blue light falls on it.

   (c) green light falls on it.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 5.

Answers to Practice Exercises 12 – 13

Practice Exercise 12

1. The section of the electromagnetic spectrum that is visible to people is called light

2. a) The colour that has the longest wavelength is red

   b) It is located at the far right end of the visible spectrum.

3. Red, Orange, Yellow, Green, Blue, Indigo, Violet

4. We are able to see the different coloured lights because each colour has its' own wavelength.

Practice Exercise 13

1. (a) absorbed

   (b) reflects

   (c) absorbs

   (d) reflects

2. (a) It will appear blue. The blue paper absorbs all colours other than blue and reflects only blue rays.

   (b) It will appear blue. Only blue light falls on it and so the blue paper reflects the blue rays.

   (c) It will appear black. Only green light falls on the blue paper and so the blue paper absorbs the green rays. The paper will look black as it reflects no rays of light.

REVISE TOPIC 5 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 5: Dispersion of Light and Colours

Now, revise all lessons in this Topic and then do **ASSIGNMENT 4**.
Here are the main points to help you revise.

Lesson 12: Colours in White Light

- The coloured band falling on a screen as a result of dispersion of white light is called a spectrum.
- The colours that make up the spectrum are continuous and blend into each other.
- White light is a mixture of seven colours - Red, Orange, Yellow, Green, Blue, Indigo and Violet (ROYGBIV).
- The splitting up of white light into the seven colours is called dispersion.
- The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation.
- A rainbow is a spectrum formed by the refraction, total internal reflection and dispersion of Sunlight in water droplets in the sky.

Lesson 13: Colours of Objects

- An object may reflect, transmit or absorb light that falls on it.
- Objects that reflect more white light appear brighter and whiter.
- The colour of an object depends on the colour it reflects.
- Black is not a colour. An object looks black because it absorbs all the light falling on it.
- White is not a colour. An object looks white because it reflects all the light falling on it.

NOW DO TOPIC TEST 3 IN YOUR ASSIGNMENT 4.

TOPIC 6

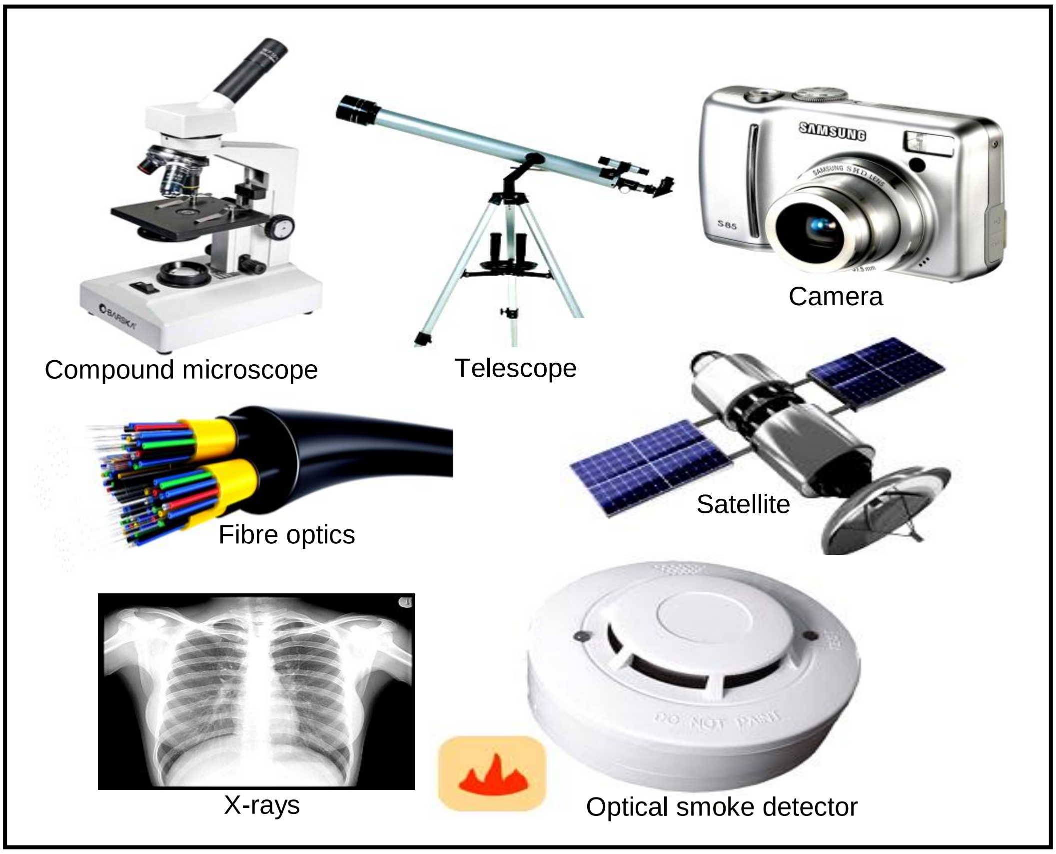
USEFUL INVENTIONS AND APPLICATIONS OF LIGHT

In this topic you will learn about:

- **compound microscope**
- **telescope**
- **camera**
- **fibre optics**
- **satellites**
- **x-rays**
- **optical smoke detector**

INTRODUCTION TO TOPIC 6: USEFUL INVENTIONS AND APPLICATIONS OF LIGHT

When you use an optical instrument, whether it be something very simple like a magnifying glass, or more complicated like a telescope or microscope, you are usually trying to make things look bigger so you can more easily see fine details. One thing to remember about this is that if you want to make things look bigger, you are always going to use converging mirrors or lenses. Diverging mirrors or lenses always give smaller images.



You should know about useful inventions and applications of light. Some of the questions you may be asking yourself now are:

- What is
  - a microscope?
  - a telescope?
  - a camera?
  - fibre optics?
  - a satellite?
  - an X-ray?
  - an optical smoke detector

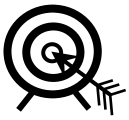
- How does each instrument work?

- What are the uses of these instruments?

In this topic, you will find the answers to these questions and all other questions relating to useful inventions and applications of light.

Lesson 14: Compound Microscope

Welcome to Lesson 14. By now, you should know that there is a smaller minute world that we could not see. This world is made up of very small objects which can only be seen through a lens. In this lesson, you will learn about an instrument that is used to study these very small objects.



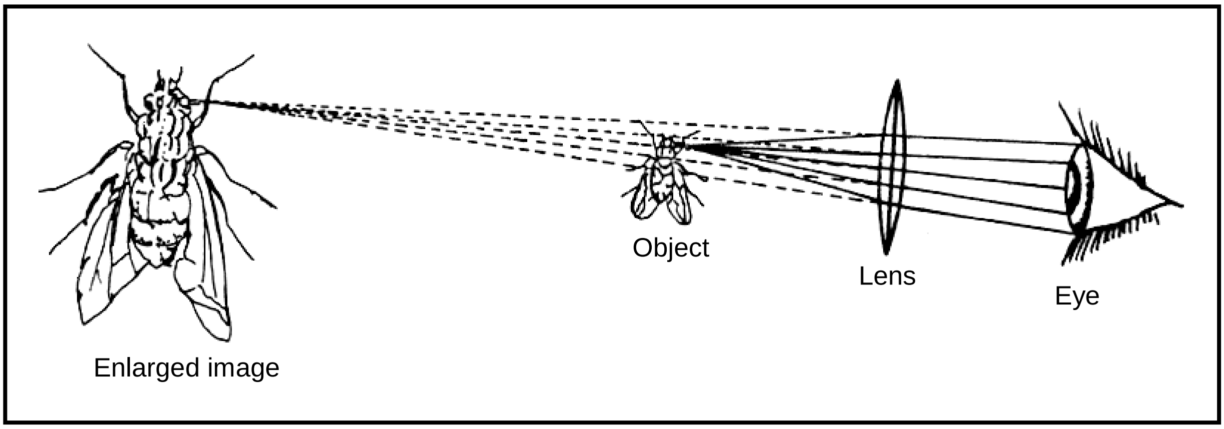
Your Aims:

- define microscope
- identify the parts of a compound microscope
- state the uses of compound microscopes

A Simple Microscope

A magnifying glass is used for looking at and studying very small objects. It is just a convex lens which gives an upright, magnified, virtual image.

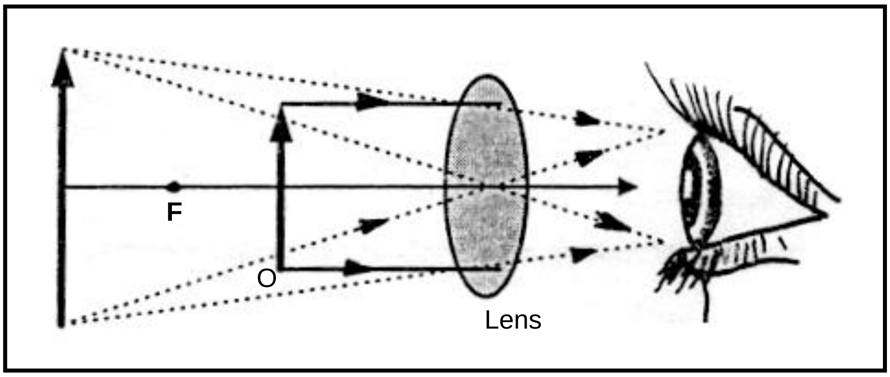
For example, look at this diagram. It shows the enlarged image of a fly.



A convex lens produces an upright and enlarged (magnified) image when the object is between the lens and its principal focus. If we look through the lens, we see the magnified image of the object.

The diagram below shows the path of the rays which produce the image.

You see that the object (a vertical arrow) is between the lens and its focus **F**.



The diagram also shows the path of the light rays from the object, through the lens to the eye. The broken lines indicate the paths along which the rays appear to travel but do not actually travel.

Since a magnifying glass helps us to see a magnified image of a small object, we call it a **simple microscope.**

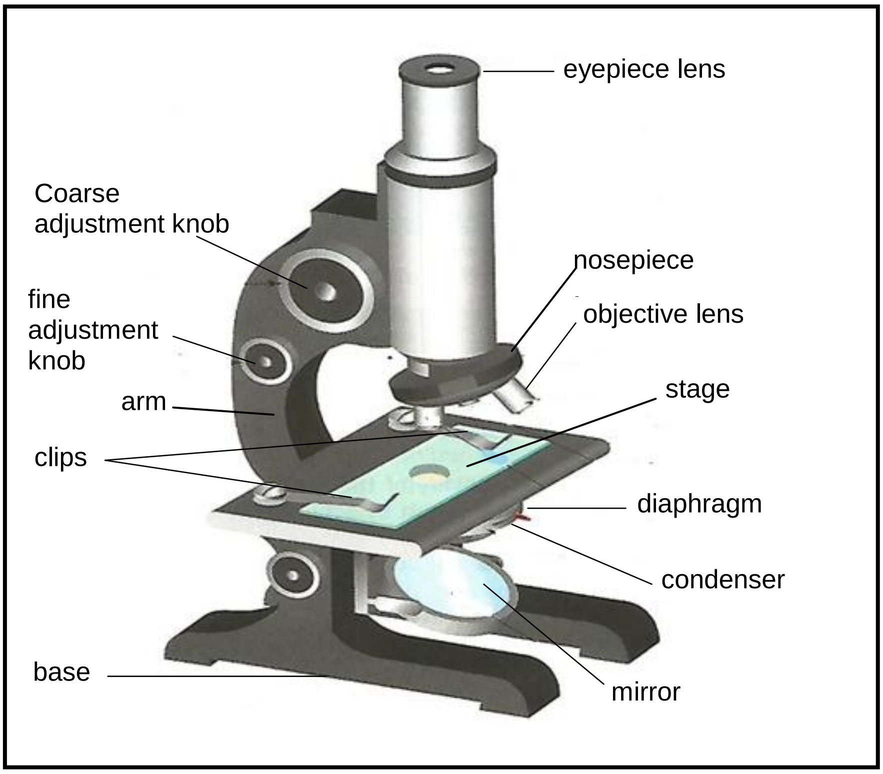
A simple microscope is another name for a magnifying glass.

Background information on compound microscope
One of the first people to ever view microscopic (very small objects through a lens) was someone named **Antonie Philips van Leeuwenhoek**. He not only invented one but many microscopes that could enable him to see microscopic organisms that were invisible and alien to humans before the invention. The word micro means “small” and scopic means “tube”. So when put together tells you something small is being viewed under the tube.

Biologists use microscopes to study things that are too small to be seen with the naked eye. One microscope that is common and used in most schools today is the compound microscope.

Parts of a compound Microscope

The parts of a compound microscope are shown in the illustration below.



Parts of a microscope

Lenses used in a Microscope
The microscope uses two or more convex lenses in a tube to produce enlarged images of very small objects. Look at the positions of the two lenses in the picture given above. One lens is very close to the object. It is called the **objective** lens. It has a short focal length. The other lens is at the top, close to the eye. It is called the **eyepiece**.

Microscopes are focused by moving the tube which contains the lenses closer to or further away from the object being viewed. The magnifying power of the microscope depends on the power of each of the lenses. For example, a microscope of power 200X will produce an image 200 times the size of the object.

Function of the different parts of a compound microscope
Most microscopes are called **light microscopes** because they accomplish their task by using lenses to bend light. The functions of the different parts of a compound microscope are listed in the table below.

Parts	**Function**
Eyepiece (Ocular)	The eyepiece is the lens you look through to observe specimens. It magnifies the image of the specimen. Usually contains a 10X lens.
Arm	Contains the housing for the fine and coarse adjustments and connects the base of the microscope to the nosepiece and ocular
Nosepiece	A rotating head that has the objective lenses attached to it. The lens to be used should "click" into position when the wheel is gently turned so that it is directly over the specimen slide.
Objective	Basically, housing for a lens. The objective lens magnifies the specimen. Rotating an objective lens can change the magnification. Most high school microscopes have three objective lenses - 4X, 10X, and 40X.
Stage	The specimen slides rests on this part of the microscope.
Clip	Holds prepared slide in place.
Coarse adjustment knobs	The larger of two sets of knobs located on either side of the arm, just above the base. This adjustment is used to make large adjustments in focusing by moving the lenses up and down. *Never use this adjustment when using the 40X objective.*
Fine adjustment knobs	The smaller of two sets of knobs located on either side of the arm. This adjustment is used to make small adjustments in focusing. It has a limited amount of movement and is most efficiently used after focusing with the 4X objective and coarse focus, then increasing magnification and making final adjustments with the fine focus knob.
Mirror	The mirror reflects light from a light source up through the diaphragm.
Adjustable diaphragm	This rotating wheel on the underside of the stage allows the user to adjust the amount of light that passes through the specimen. As a general rule, the lowest intensity of light that allows you to resolve the structure of the object you are viewing should be used.
Condenser	The condenser concentrates light from the mirror onto the specimen.
Base	The base stabilises the microscope so that it will not fall over.

Uses of (Compound) Microscope

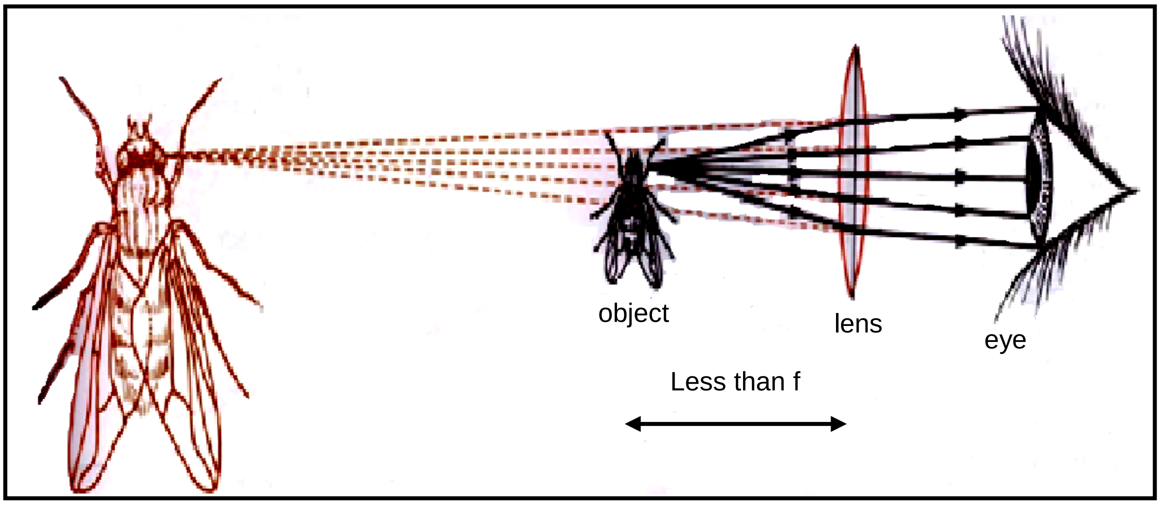
Ever since they were invented compound microscopes were used to enable us to view very small objects, in which, our own eyes were not capable of viewing.

How a microscope works

Convex lenses can be used as a magnifying glass. The virtual image (which is not real) is magnified and appears closer to our eyes. This only occurs if the virtual image is shorter than the focal length.

The **focal length** is where all the light rays from the image combine. However, if you were to try and look behind a magnifying (convex) glass you would not see the image. The image only exists if you look through the magnifying glass.

However, if an image is longer than the focal length than the image will be up-side down (inverted) and a second convex lens would be needed to enable the image to be right-side up. This is essentially how a microscope operates, because it has two convex lenses.



Microscopes are instruments that produce a larger image of an object.

A compound microscope is made using two convex lenses.

Activity: Now test yourself by doing this activity.

Circle the letter of the correct answer from the alternatives listed.

1. A compound microscope is used to see __________ objects,

    A. smaller B. larger

    C. very tiny (microscopic) D. macroscopic

2. Most microscopes are __________ microscopes.

    A. light B. electron

    C. objective D. compound

3. What part of the microscope allows you to see specimens in detail?

    A. Body tube B. Eyepiece Lens

    C. Fine Adjustment knob D. Coarse Adjustment Knob

4. What type of lens is used as an objective lens in a microscope?

    A. Convex lens
    B. Concave lens
    C. Double convex lens
    D. Double concave lens

5. How many convex lenses are used in a microscope?

    A. One B. Two

    C. Three D. Four

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 14.

Summary

You have come to the end of Lesson 14. In this lesson you have learnt that:

- a simple microscope is another name for a magnifying glass.
- a microscope is an instrument which is used to study very small objects.
- a microscope gives an enlarged image of an object.
- the focal length of a convex lens is where the rays of light converge. Any image within this length or smaller will be magnified. Any image longer than the focal length will be up-side down.
- most microscopes are light microscopes because they use light to see images.
- a compound microscope has two lenses; an objective and an eyepiece.

NOW DO PRACTICE EXERCISE 14 ON THE NEXT PAGE.

Practice Exercise 14

Answer the following questions on the spaces provided.

1. Who invented the microscope?

2. What is the function of the

   a) stage clip?

   b) coarse adjusting knob?

   c) fine tuning knob?

3. Explain how a convex lens enables you to magnify an object.

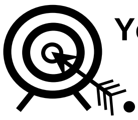
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Answers to Activity

1. C
2. A
3. C
4. A
5. B

Lesson 15: Telescope

Welcome to Lesson 15. In your previous lesson, you learnt about a compound microscope. In this lesson, you will learn about another important instrument called a **telescope**. It is used to see clearly and study objects that are a long way off - both on earth and in space.



Your Aims:

- define telescope
- identify the types of telescopes
- state the uses of telescopes

What is a Telescope?

A telescope is an optical instrument that enables us to see far away objects look nearer. It magnifies an image of a distant object. Most telescopes consist of two or more convex lenses placed in a long tube of metal or plastic.

Galileo's telescope

The first telescope was invented by a scientist called Galileo about 400 year ago for studying the planets. He used a **convex** lens as the **objective** and a **concave** lens as the **eyepiece**. The lenses were enclosed in a cylindrical tube.

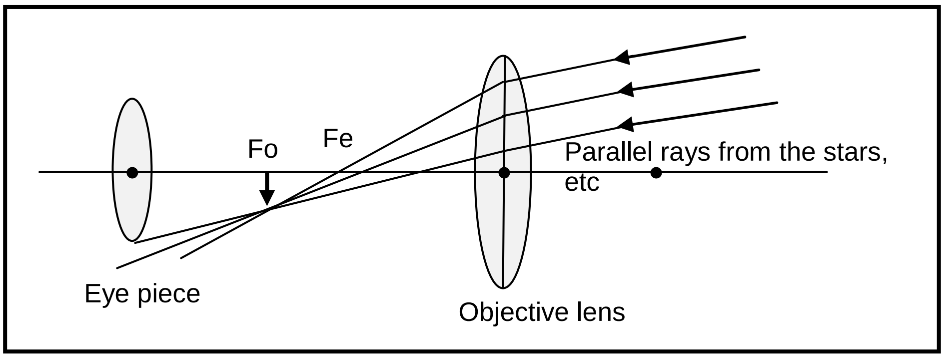
Types of Telescope

The astronomical telescope

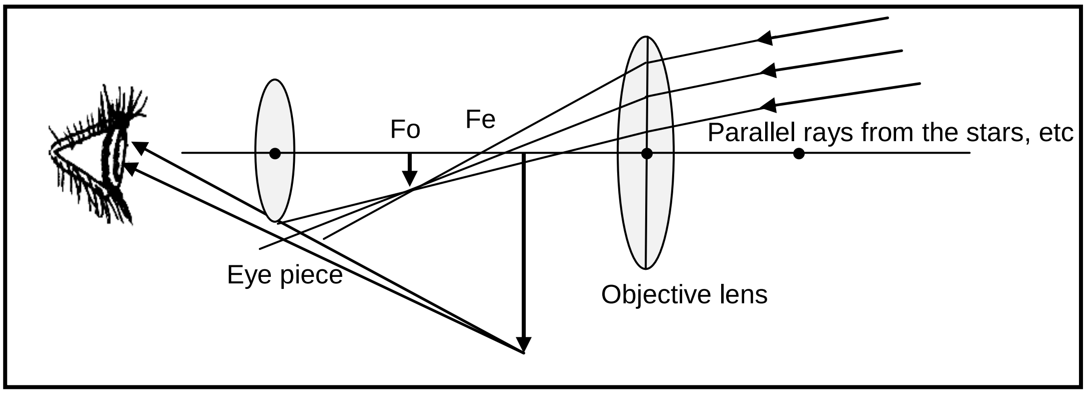
A few years later, Kepler improved on Galileo's telescope. He used **convex** lenses for both the objective and the eyepiece. It is called the **astronomical** (or **refracting**) telescope. In this telescope,

- the objective has a long focal length (for example, 50cm).
- the eyepiece has a short focal length (for example 5cm).

This combination causes maximum magnification. This happens in two stages. Look at the diagram below. It shows parallel rays from stars falling on the objective and forming an image.



- The objective produces an **image** of the distant object at its focus **Fo**. It is just inside the focus **Fe** of the eyepiece. This image is **real, inverted** and **diminished.**



- This image is the *object* for the eyepiece. The eyepiece acts like a magnifying glass and produces a **magnified, inverted, virtual image** of the object.

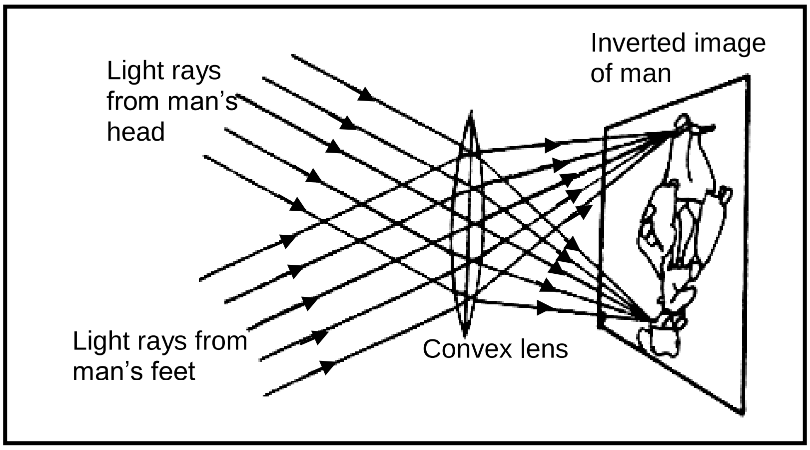
  An inverted image is good enough since it is used to look at planets and stars.

An astronomical (refracting) telescope has two convex lenses as well as two prisms.

The terrestrial telescope

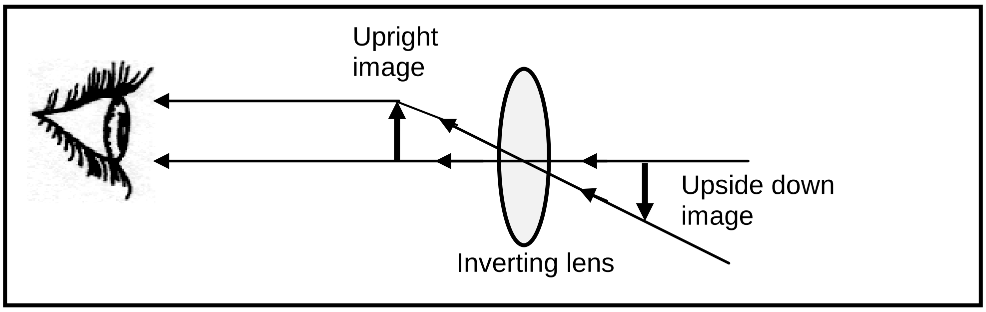
You learnt that astronomical telescopes have two convex lenses and produce inverted images. If we use it to see things on earth which are a few kilometres away, we will see inverted images.

For example, if we look at a man, we will see an inverted image of the man.



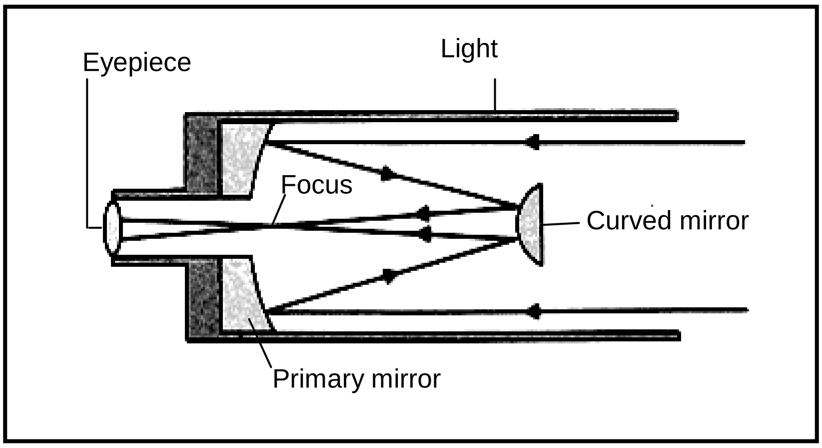
To get over this problem in the **terrestrial** (earth) telescope, a third convex lens is introduced between the objective lens and the eyepiece.

This diagram shows how the third lens gives a final upright image of the inverted image. This convex lens is called the **inverter** or inverting lens.



Newton's telescope
To improve on the refracting telescope, Newton replaced its objective lens with a **concave** mirror. Hence, it is called a **reflecting** astronomical telescope. Thus, in Newton's telescope, the objective is a concave mirror.

The eyepiece is at right angles to the length of the telescope and so the reflected rays must be turned through a right angle. Hence, a **plane** mirror is fixed to turn the reflected rays through a right angle. The diagram shows rays from distant objects reflected by the concave mirror turned through a right angle by the plane mirror and then the image enlarged by the eyepiece (lens).

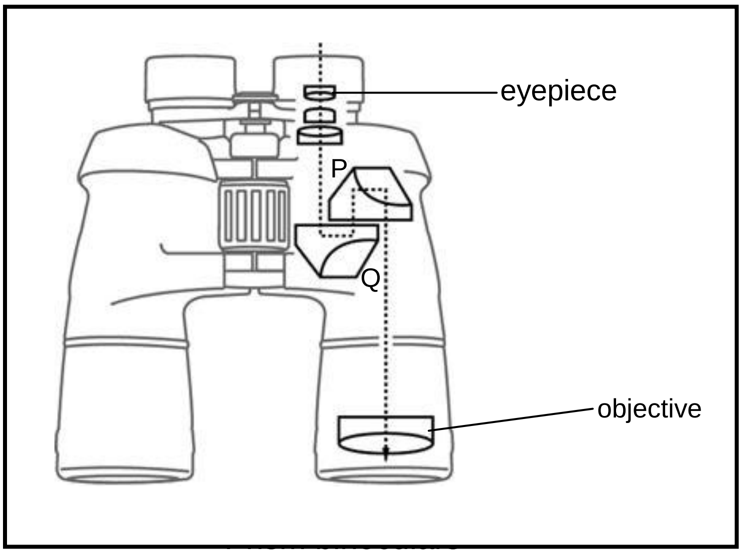


Newton's telescope

A concave mirror, a plane mirror and a convex lens are used in Newton's telescope.

Binoculars
Have you ever used a pair of binoculars to look at distant objects? Binoculars are a pair of short astronomical telescopes. Since prisms are also used to construct them, they are called **Prism binoculars**.

Look at this diagram: It shows the main parts of a pair of prism binoculars.



Prism binoculars

Each binocular has a convex lens as the objective and a convex lens as the eyepiece.

In addition to the two lenses, there are two prisms (**P** and **Q** of the diagram) - each with angles 90º, 45º and 45º to make the image upright and to correct lateral inversion.

- Light rays from the object we look at, pass through the objective and are first reflected by the first prism than on the other prism.

- The second prism reflects the rays to the eyepiece.

Without the prisms, the image obtained will be inverted and laterally inverted.

One prism corrects inversion and the other corrects lateral inversion.

Binoculars are short telescopes with two convex lenses and two prisms.

Summary

You have come to the end of Lesson 15. In this lesson you have learnt that:

- telescopes are used to see clearly and study objects that are very far away on earth or in space.
- the first telescope was invented by Galileo for studying the planets. He used a convex lens as the objective and a concave lens as the eyepiece.
- in an astronomical telescope, a convex lens is used as the objective and another convex lens as the eyepiece. The objective has long focal length and the eyepiece has short focal length.
- a terrestrial telescope is used to see things on earth which are a few kilometres away.
- an astronomical telescope gives inverted images. In a terrestrial telescope a third convex lens is introduced between the objective and the eyepiece to give a final upright image.
- in Newton's telescope, a concave mirror, a plane mirror and a convex lens are used and so it is called a reflecting astronomical telescope.
- binoculars are short telescope with two convex lenses and two prisms.

NOW DO PRACTICE EXERCISE 15 ON THE NEXT PAGE.

Practice Exercise 15

Answer the following questions on the spaces provided.

1. (a) What is a telescope?

   (b) Who invented the first telescope?

   (c) What type of lenses were used in the first telescope?

2. Name the optical instrument made using:

   (a) two prisms and two convex lenses.

   (b) a concave mirror, a plane mirror and a convex lens.

3. (a) What is an astronomical telescope?

   (b) What does the objective of an astronomical telescope do?

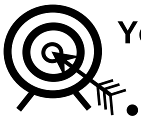
   (c) What does an eyepiece of an astronomical telescope do?

   (d) What type of a lens is used as the eye lens in an astronomical telescope?

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Lesson 16: The Camera

Welcome to Lesson 16. In this lesson, you will learn about another popular optical instrument called a camera.



Your Aims:

- define what a camera is
- identify the parts of a camera
- state the uses of a camera
- explain the difference between an analogue camera and a digital camera

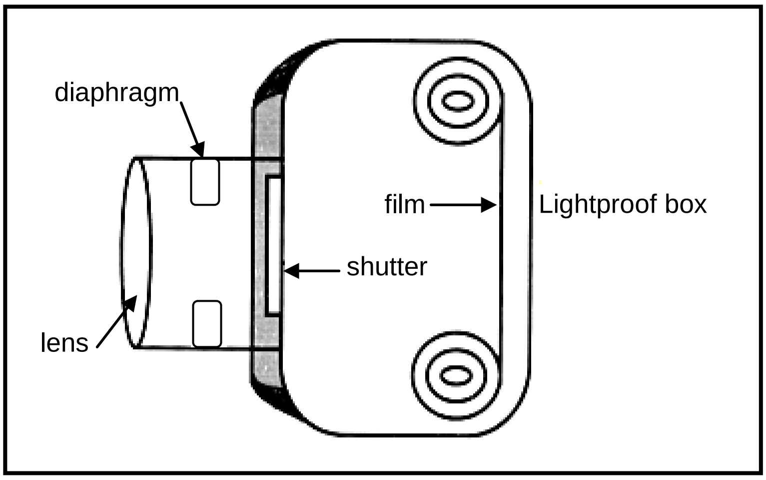
What is a Camera?

In Lesson 10, we learnt how our eyes translate the light that enters our eyes into vision. However, nowadays we have technology that enables us to do the same job and even more. The camera is a marvellous instrument that was created to capture moments in our lives. It is a device that records images that can be stored directly, transmitted to another location, or both. These images may be still photographs or moving images such as videos or movies. The camera functions much the same way as our eyes. Our eyes are our natural cameras that enable us to see or have that vision.

Main parts

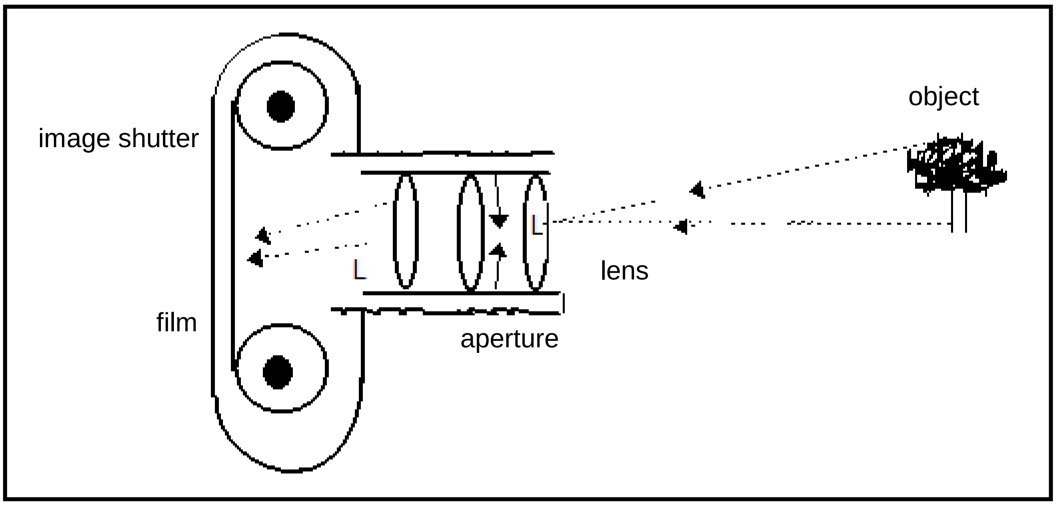
Look at the diagram below:

It shows the main parts of a camera. They are the **light proof box**, the **convex lens**, the **film**, the **shutter** and the **diaphragm.**



Main parts of a camera

A camera (analogue) contains a light-proof box with one or more convex lenses at the front end and some photographic film at the back. Light from an object passes into the light proof box through the convex lens. The lens focuses an image of the object onto the surface of a film. The rays of light from the image are refracted in the lens so the rays converge at a certain point to form an image of the object on the film.



The lens in a camera has a fixed focal length. The film too is in a fixed position. To obtain a good photograph, the image has to be focused clearly on the film. This is done by moving the lens closer and away from its original position.

When we move the lens closer and away from its original position, the distance of the object from the lens changes and hence we adjust until the image is clearly focused on to the film.

The main parts of a camera are the light proof box, the lens, the film, the shutter and the diaphragm.

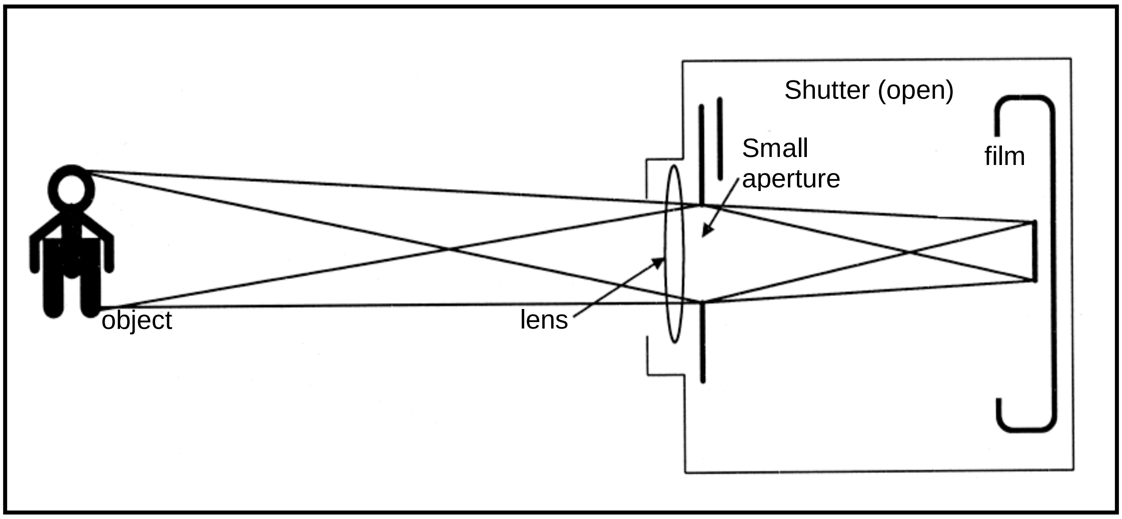
The amount of light that enters is also important. If there is too much light, then the film will be **over exposed**. If too little light enters then the film is **under exposed**.

In a camera the **aperture** and the **shutter** control the amount of light. The size of the aperture can be controlled by the **diaphragm**. The shutter is like a door, if it is open, then light enters, if it is closed, then no light will enter.

To take pictures of fast moving objects, a short time, exposure to light is needed. Taking pictures of low light objects, a longer time exposure to light is needed. A flash of light can fix that problem if there is low light.

Controls in a camera

The image produced by the lens must be clear. Too much or too little light will not give a clear photograph. So the amount of light entering the camera has to be bright enough to give a clear picture.



Light tight box

A camera has devices to control the amount of light that enters it. One such control is provided by the **diaphragm.**

Adjusting the diaphragm changes the aperture (size of the circular opening) through which light enters the camera. The exposure time too can be controlled.

The light entering the camera can be completely cut off by closing the shutter.

Taking a photograph

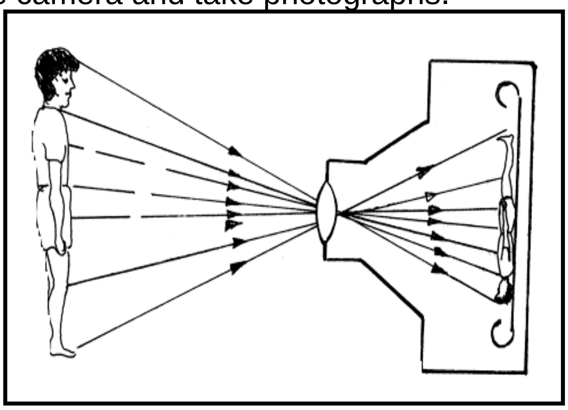
We shall now see how it is possible to use the camera and take photographs.

What happens when we take a photograph?

Light reflected by the object falls on the camera lens.

(At daytime, it is sunlight. At night, it is light from the flash in the camera.)

An image of the object is formed on the film. It is inverted and diminished.



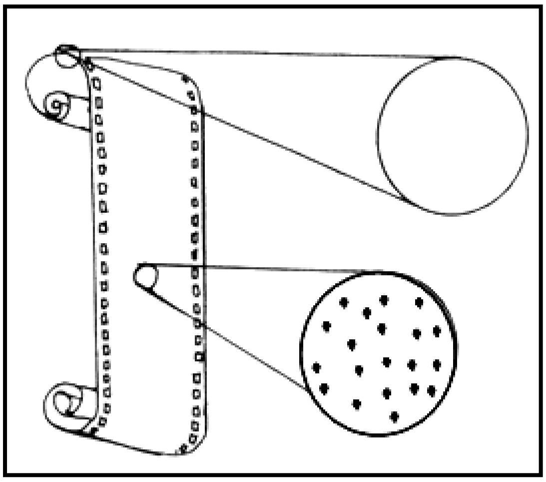
An image of an object formed on a film is inverted and diminished.

The film on which the image forms is a strip of celluloid with a thin coating of a chemical compound. It is usually a compound of silver iodide.

The image formed on the film is inverted and diminished.

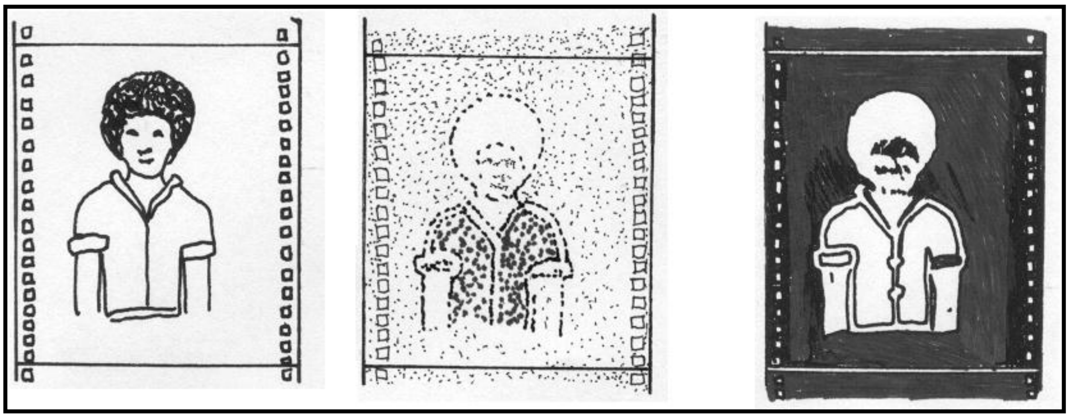
The chemical is in the form of tiny grains which are sensitive to light.

When exposed to light, this compound undergoes a chemical change.



The film is made of silver iodide

Brighter light causes more change and dimmer light causes less change. The chemical change in the film captures the image on the film.



The process of developing gives the negative

The image has to be fixed before the film is exposed to any more light. This is called developing and involves the use of more chemicals.

The process of developing gives us the negative of the photograph.

The image is fixed on the film by the process called developing.

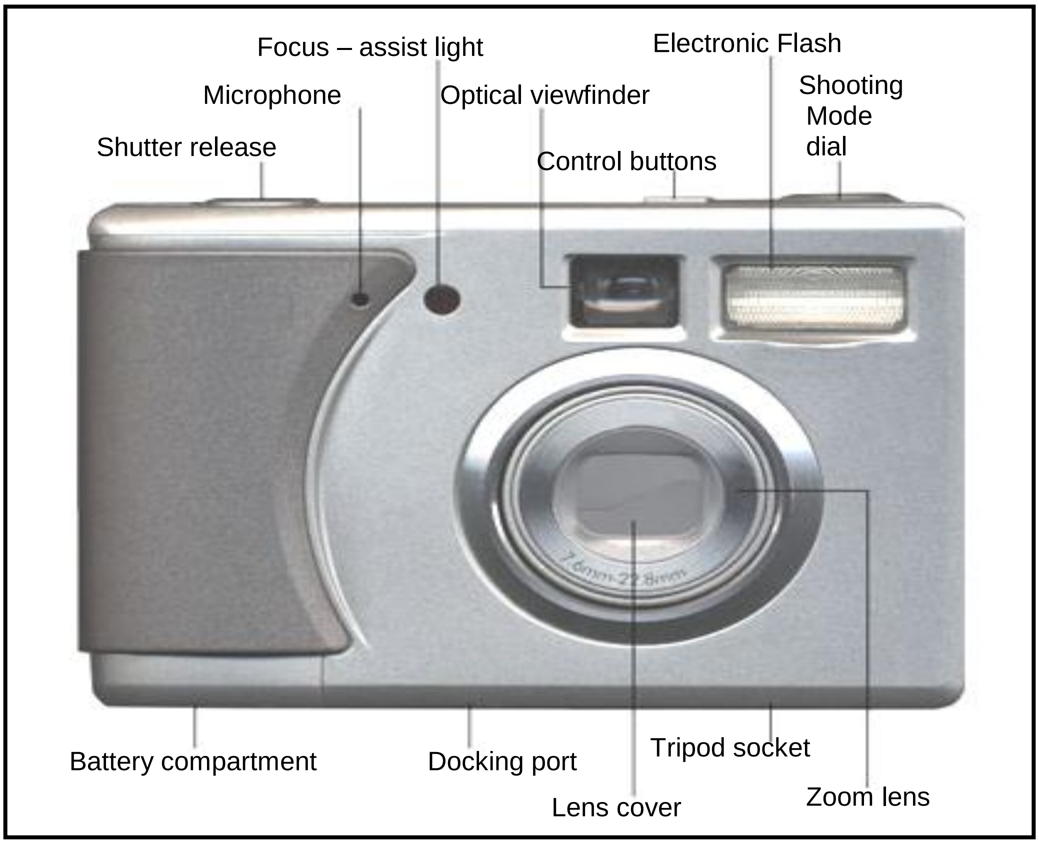
Types and functions of a camera

There are two types of cameras which are the **analogue** camera and the **digital** camera. The analogue camera captures pictures and stores them in a roll of film for later processing. It comes out as a photo after processing.

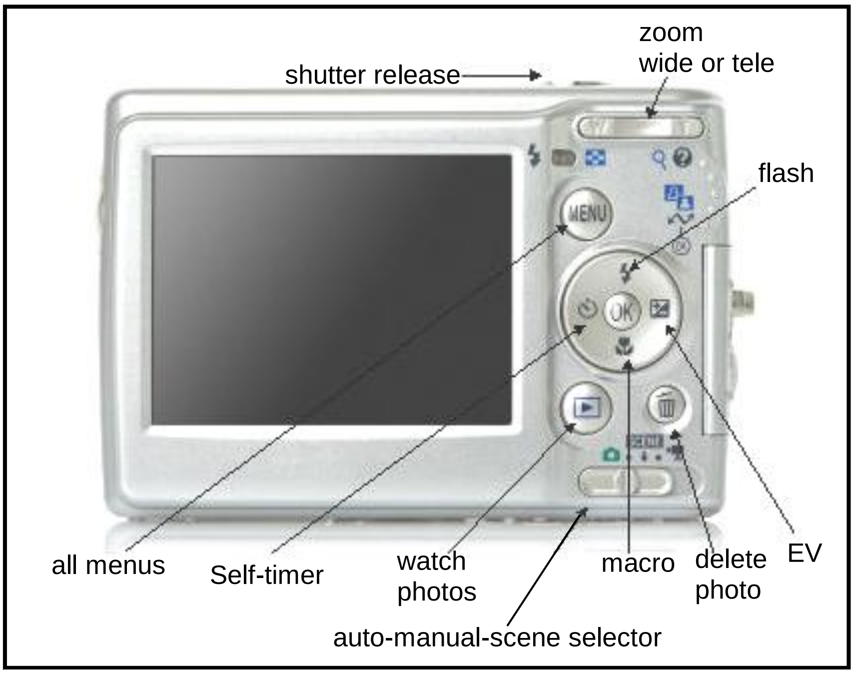
There are also varieties of analogue cameras. Some analogue cameras can process photos immediately and some can only take photos. The digital camera takes both photos and videos and stores them digitally. It is instantaneous and both pictures taken and videos captured can be viewed immediately.

Parts of a Camera

The parts of a camera may differ from analogue and digital but both do the same function. The diagram below shows the parts of a digital camera. Most digital cameras will have the same parts and a few functions may differ depending on how new the camera may be. The second diagram below shows the parts of an analogue camera.



Analogue camera is less complex and requires less buttons



Digital Camera requires more button and is more complex

Activity: Now test yourself by doing this activity.

Circle the letter of the most correct answer from the alternatives listed.

!. How many types of cameras are there?

A. 2 B. 3

C. 4 D. 5

2. Which part of a camera controls the exit and entry of light?

A. shutter B. aperture

C. diaphragm D. exposure counter

3. Which part of the camera controls the amount of light?

A. shutter B. aperture

C. diaphragm D. exposure counter

4. Which part of the camera controls the size of the aperture?

A. Lens B. film

C. shutter D. diaphragm

5. When we take photographs, the image formed on the film is

A. upright and magnified.
B. inverted and magnified.
C. upright and diminished.
D. inverted and diminished.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 16.

Summary

You have come to the end of Lesson 16. In this lesson you have learnt that:

- a camera is a device that records images that can be stored directly, transmitted to another location, or both. These images may be still photographs or moving images such as videos or movies.
- there are two (2) types of cameras. The analogue camera and the digital camera.
- the main parts of an analogue camera are the light proof box, lens, film, shutter and the diaphragm.
- over exposure occurs when too much light enters the camera and subsequently the film.
- under exposure occurs when too little light enters the camera.
- the shutter controls the entry and exit of light.
- the diaphragm controls the amount (intensity) of light through the aperture.

NOW DO PRACTICE EXERCISE 16 ON THE NEXT PAGE.

Practice Exercise 16

Answer the following questions on the spaces provided.

1. What is a camera?

2. How many types of cameras are there and name them?

3. What are the main differences between the types of cameras you named in Question 2?

4. Describe what we mean by *developing* a film.

5. Explain the function of the aperture and diaphragm.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

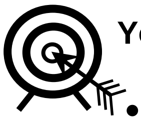
Answers to Activity

1.	A	2.	A	3.	C
4.	D	5.	C		

Lesson 17: Fibre Optics

Welcome to Lesson 17. In Lesson 2, you learnt about the transmission of light. In this lesson you will learn about the transmission of light through fibre optics.

We are used to the idea of information travelling in different ways. When we speak into a landline telephone, a wire cable carries the sounds from our voice into a socket in the wall, where another cable takes it to the local telephone exchange. Mobile phones work in a different way. They send and receive information using radio waves. This technology is called wireless because it uses no cables. Fibre optics works in a third way. It sends information coded in a beam of light down a glass or plastic pipe.



Your Aims:

- define fibre optics
- explain how fibre optics transmit light
- identify and explain the uses of fibre optic

What is Fibre Optics?

Fibre optics was developed in the 1950s to help doctors see inside the human body without having to cut it open. In the 1960s, engineers found a way of using the same technology to transmit telephone calls at the speed of light.

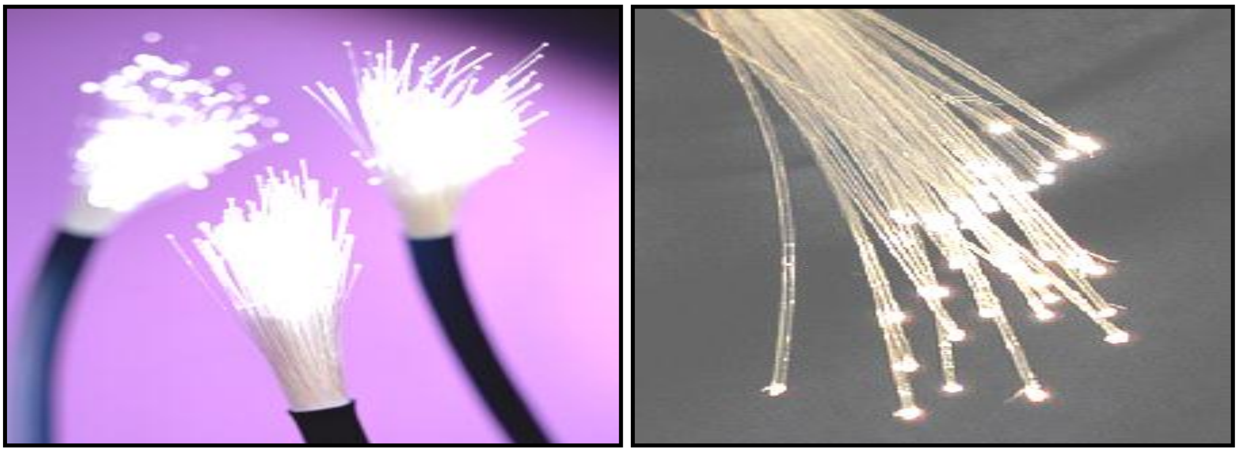
Fibre optics is a technology that uses glass (or plastic) threads (fibres) to carry information coded in light. The information is sent as light beams down thin strands of plastic or glass by making them bounce repeatedly off the walls. The fibres that carry the light are as thin as hair and are transparent.

Optical fibres

A fibre optic cable is made up of very thin strands of high quality glass or plastic known as optical fibres. One cable can have as few as two strands or as many as several hundred. Each strand is as thin as a human hair and can carry something like 25, 000 telephone calls, so a whole fibre-optic cable can easily carry several million calls.

Information such as computer data and telephone calls can be converted into electrical signals. These can then be converted into either visible light signals or infrared signals and transmitted by optical fibres.

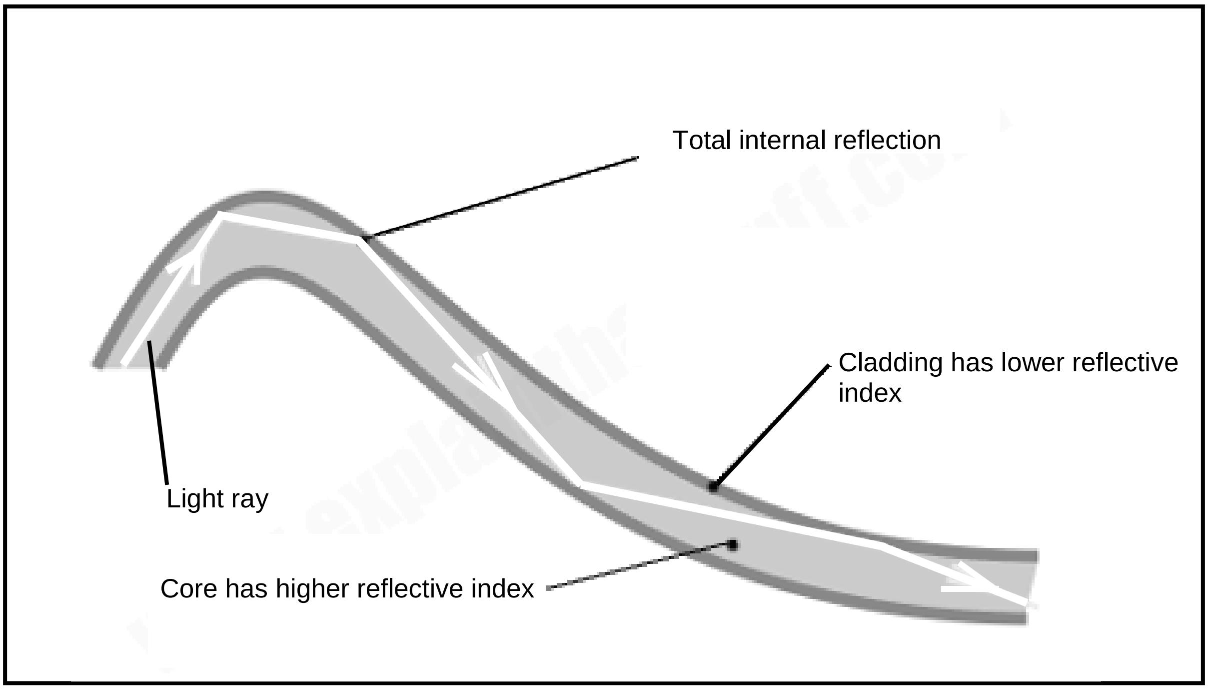
Optical fibres can carry more information than an ordinary cable of the same thickness. The signals in optical fibres do not weaken as much over long distances as the signals in ordinary cables.



Bundles of optical fibres

How Fibre Optics Works

Light travels down a fibre-optic cable by bouncing repeatedly off the walls. Each tiny **photon** or particle of light, travels through the cable bouncing back and forth off the boundary between the core and cladding. Now you might expect a beam of light, travelling in a clear glass pipe, simply to leak out of the edges. But if light hits glass at a really shallow angle like less than 42 degrees, it reflects back in again as though the glass were really a mirror. This phenomenon is called total internal reflection. It is one of the things that keep light inside the pipe.



Total internal reflection keeps light rays bouncing down the inside of a fibre-optic cable.

The other thing that keeps light in the pipe is the structure of the cable, which is made up of two separate parts. The main part of the cable which is in the middle is called the core and that is the part that light travels through. Wrapped around the outside of the core is another layer of glass called the cladding. The cladding's job is to keep the light signals inside the core. It can do this because it is made of a different type of glass to that of the core.

The Uses of Fibre Optics

Fibre optic technology has grown tremendously over the years and it can be found today in many surprising places. In fact, fibre optics are an essential part of our everyday lives.

The most widespread use of fibre optics is in **communications**. Fibre-optic communications systems have key advantages over older types of communication. This is because they offer vastly increased **data rate**, allowing very good amounts of information to be carried quickly from one place to another.

The optical fibre is used in modern communications systems to transmit information in the beam of light. Fiber-optic lines carry digital information over long distances.

Most of us today are using the internet which is information sent digitally through fibre optics across the entire world.

Massive undersea fibre optic cables, wrapped in layer upon layer of insulation and protection extend across the Earth's oceans to allow people all over the planet to be connected through Facebook and take photos of your favourite food and post on Instagram.

The photograph on the right shows, a child communicating using a cell phone.

Cell phone communication

Data rate is how quickly information is exchanged between electronic devices.

Long distance communication

Many long-distance fibre-optic communications networks for both transcontinental connections and undersea fibre cables for international connections are in operation. Communication companies such as AT&T and WorldCom have nearly replaced their long-distance copper lines with optical-fibre cables. Local telephone service providers use fibre-optic cables between central office switches and sometimes extend it into neighbourhoods and even individual homes. Cable TV companies transmit high data rate signals to users through fibre-optic cable. Telephone networks often use optical fibres for long-distance transmission.

Local Area Networks (LANs)

Another growing application of fibre optic is LANs. Unlike long-distance communications, LANs connect many local computers to shared equipment such as printers and servers. Private companies also use fibre optics and its basic security to send and receive data. Firms and institutions such as IBM, Wall Street brokerages, banks, and universities transfer computer and monetary information between buildings and around the world via optical fibres.

Both local and long-distance communication, copper telephone cables carrying electric currents are being replaced very rapidly by optical fibres.

Other applications or uses of optical fibres include:

- transmitting images of human internal body parts using some medical instruments. Example, dentists' drills often incorporate a fibre-optic cable that light up the inside of patients' mouths.
- image transmission in photocopiers, in phototypesetting, in computer graphics, and in other imaging applications.
- used in a wide variety of sensing devices such as thermometers and gyroscopes. The fibres are especially useful where electrical effects make ordinary sensors or wiring useless, less accurate or even hazardous.
- carrying high-power laser beams for cutting and drilling. Fibres-optic lasers are sometimes used in surgery.
- used as light guide in medical and other applications where bright light needs to be shone on a target without a clear line-of-sight path.
- in some buildings, optical fibers route sunlight from the roof to other parts of the building.
- optical fiber is also used for decorative applications, including signs, arts, toys and artificial Christmas trees.
- optical fiber is also used in imaging optics.
- medical endoscopes are used for minimally invasive exploratory or surgical procedures.
- industrial endoscopes are used for inspecting anything hard to reach, such as jet engine interiors. Many microscopes use fiber-optic light sources to provide intense illumination of samples being studied.

Activity: Now test yourself by doing this activity.

Circle the letter of the correct answer.

1. Optical fibres are basically manufactured from which of the following material?

   A. Plastic and silica

   B. Copper and Glass

   C. Aluminium and plastic

   D. Copper and aluminium

2. Which of the following is an advantage of using an optical fibre?

   A. Transmit few lights.

   B Save a lot of energy.

   C. Transmit few information.

   D. Save a lot of reflected light.

3. The optical fibres are used in modern communication to transmit

   A. sound.
   B. information.
   C. light signals.
   D. electrical impulses.

4. Optical fibres are also used in transmitting internal images of human body parts using

   A. microscope.
   B. medical knowledge.
   C. medical instruments.
   D. total internal reflection.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 17.

Summary

You have come to the end of Lesson 17. In this lesson you have learnt that:

- fibre optics is a technology that uses glass (or plastic) threads (fibres) to carry information coded in light.
- a fibre optic cable is made up of very thin strands of high quality glass or plastic known as optical fibres.
- optical fibres can carry more information than an ordinary cable of the same thickness.
- optical fibres make use of the total internal reflection. Total internal reflection occurs when light strikes the boundary between substances at an angle greater than the critical angle.
- the cable is made up of two separate parts. The main part of the cable which is in the middle is called the core and wrapped around the outside of the core is the cladding.
- the most widespread use of fibre optics is in communications.

NOW DO PRACTICE EXERCISE 17 ON THE NEXT PAGE.

Practice Exercise 17

Answer the following questions on the spaces provided.

1. What are fibre optics?

____
____
____
____
____

2. What is an optical fibre?

____
____
____
____

3. Briefly explain how optic fibres transmit light?

____
____
____
____
____

4. State two uses of optical fibres.

a. ____
____
____
____

b. ____
____
____
____

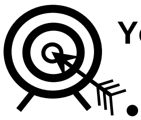
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Answers to Activity

1.	A	2.	B
3.	B	4.	C

Lesson 18: Satellites

Welcome to Lesson 18. In the last lesson, you learnt about fibre optics. In this lesson, you will learn about satellites. Satellites do things like getting a television signal to the other side of the world in seconds, telling ships exactly where they are in the middle of the ocean, warning us that storms are coming and they can do many more.

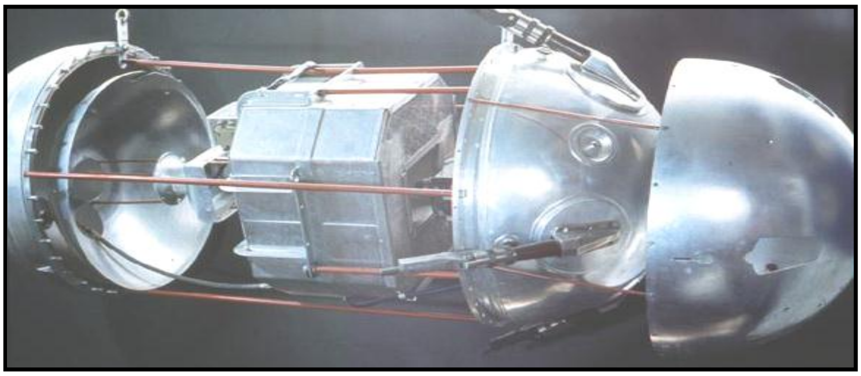


Your Aims:

- define satellite
- state the uses of satellite
- identify the types of satellite

What are Satellites?

Satellites are objects in outer space that fly around planets in circular paths called **orbits**. Artificial satellites are made by people. Thousands of satellites are roaming around our planet right now. The first artificial satellite was Sputnik 1 which was launched by the Soviet Union in 1957. It orbited Earth about once every 90 minutes for two months before it burned up in the atmosphere. The satellite is shown in the diagram below.



Sputnik 1

How do satellites get into space?

Satellites need to reach a height of at least 200 kilometres to orbit. They also need to travel faster than 18,000 miles per hour or 29,000 kilometres per hour. A satellite any lower or slower would soon fall back down to Earth. It takes a rocket to bring satellites up to the required height and speed.

Most satellites are launched into space by rockets. Others are launched using space shuttles. Small satellites can be launched from high-flying planes.

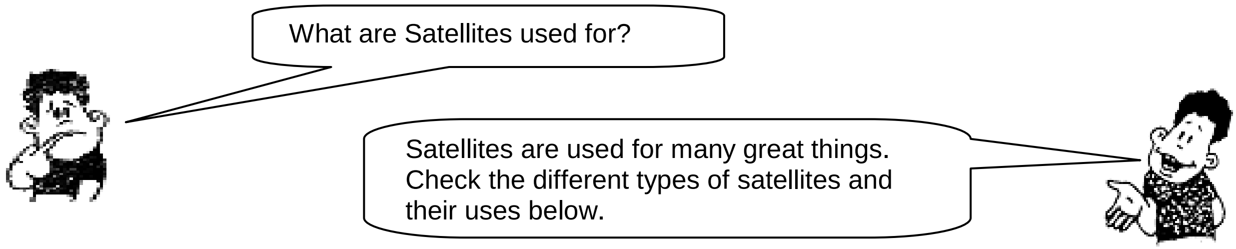
The astronauts on the space shuttle always make sure the satellite is functioning well to get into the right orbit. The diagram on the opposite side shows a rocket launching a satellite.

Launching a Satellite

How many satellites are there in space?

Since Sputnik 1, more than 5,000 satellites from many countries have been launched. Artificial satellites are now orbiting the Sun, Mars, Venus, and other planets and their moons. Most satellites orbit Earth. Thousands of satellites circle the planet every day.

Satellite Uses or Applications



The satellites serve many different purposes. They are useful for:

- Communication
  - relay (pass on) TV, radio, and telephone signals all around the world.
- for navigation
  - direction to help people know where they are and where they are going.
- spy satellites
  - look down and snoop on other countries.
- space study
  - help scientists to study earth and outer space, other planets and solar radiation.

Some satellites are used to gather information about the weather. The satellite photo below shows the swirling clouds of Hurricane Mitch, which hit Central America in 1998 and killed more than 11,000 people.

NASA's satellite image of Tropical Cyclone Ita just southwest of Sudest Island in the Milne Bay Province, Papua New Guinea

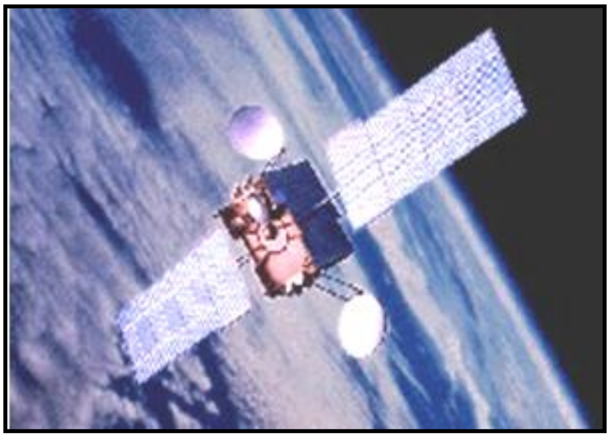
Where do satellites get their energy (power)?
Most satellites use both power from the Sun and batteries to work. They catch the Sun’s energy using large flat solar panels. Satellites keep these panels pointed at the Sun. They also use batteries when the Sun does not shine.

Types of Satellites

There are many different types of satellites used for many different purposes. Listed below are some satellites and their uses.

1. **Communications satellites**
   Communication satellites allow radio, television, and telephone transmissions to be sent live anywhere in the world. Before satellites, transmissions were difficult or impossible for long distances. Today, because satellites are in orbit, the signals can be sent into space and then redirected to another satellite or directly to their destination.

   Communication satellite, Anik E was created by a company called Telesat to provide communications for Canadians. It was the most powerful domestic communications satellite in orbit. It was launched in 1991.


Communication satellite, Anik E


A Communication Satellite in orbit

2. **Weather satellites**
   Because of weather and communications satellite technology, you can find out the weather anywhere in the world at any time of the day. There are television stations that carry weather information all day long. **Meteosat** is a weather satellite launched by the European Space Agency. It provides weather photographs of the Earth

People who study weather are called Meteorologists.


GOES Weather Satellite

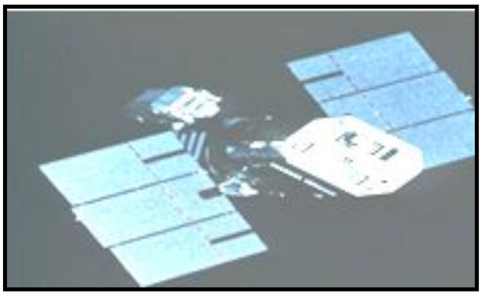
Weather satellites are used for many reasons, and they rely on images from other satellites.

Here are some examples of the uses:

- measure earth and atmospheric radiation.
- monitor the amount of snow in winter, the movement of ice fields in the Arctic and Antarctic, and the depth of the ocean.
- measure and describe how much water vapour is in different parts of the atmosphere.
- detect volcanic eruptions and the motion of ash clouds.
- receive environmental information.

3. Solar Maximum Mission Satellite

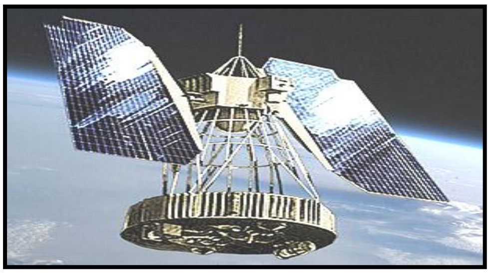
The Solar Maximum Mission Satellite was designed to study solar radiation. It was launched in early 1980. A picture of a solar satellite is shown below.



Solar Satellite

4. Environmental Satellite

An environmental satellite is used to take photographs of the earth's atmosphere and oceans every day. The pictorial information is sent back to the earth's surface and is used to monitor changes in the environment. Satellite ***Nimbus*** is an example of an environmental satellite.



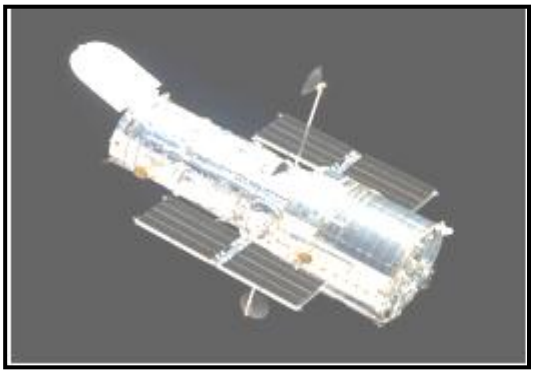
Satellite Nimbus

5. Astronomy satellite

An **astronomy satellite** is basically a big telescope floating in space. Astronomy satellites can be used to look into space and can provide up to ten times better view than a telescope.

The **Hubble Space Telescope** is a space telescope that was carried into orbit by a Space Shuttle in April of 1990. The telescope is named after the astronomer Edwin Hubble.

Hubble Telescope about to be released into space.

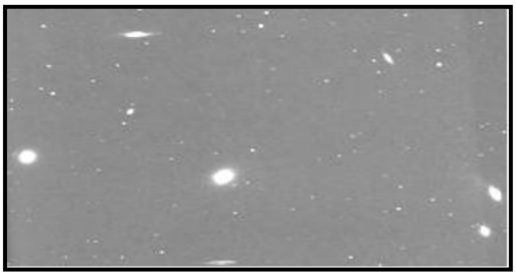


A departing Hubble Telescope

Can you guess what kinds of things an astronomy satellite would be looking at? Do you know what an astronomy satellite does?

Here are some galaxy pictures which have been taken by an astronomy satellite Hubble.

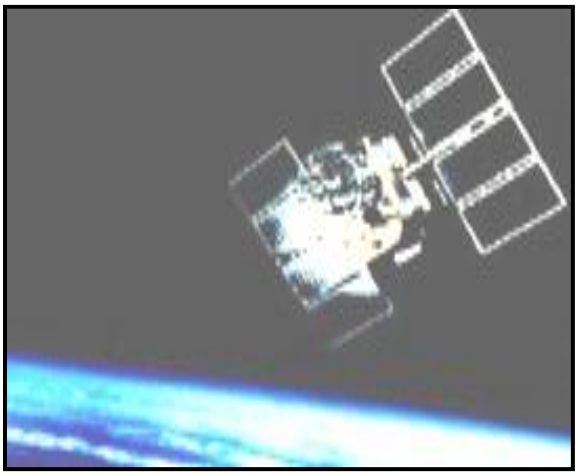
Spiral galaxies



Lenticular galaxies

6. Navigation satellites

Satellites for navigation were developed in late 1950's because ships needed to know exactly where they were at a particular time. They are used to find out positions accurately. Planes and ships usually make use of these satellites. Today, most navigation systems use time and distance to determine location. An example of a navigational satellite is called **Navstar.** In 1985, there were 10 Navstar satellites in space orbit. At this moment, there are 24 orbiting. A picture diagram of a navigational satellite is shown on the right.



Navigational satellite

7. Atmospheric Satellites

Atmospheric studies satellites were some of the very first satellites launched into space. The first atmospheric satellite was called **Alouette**. It was the world's first atmospheric studies satellite launched by Canada. The Alouette was used to study the Earth's ionosphere.

8. Space exploration satellites

Space exploration satellites are not really satellites. They are similar to orbiting satellites in design and function. They are responsible for many of astronomy's most important achievements. Jupiter's rings, for example, were discovered by a space exploration satellite. An example of a space exploration satellite is called NASA's Galileo. It was sent into space on October 18, 1989. Galileo was sent to Jupiter to study the planet's atmosphere, moons, and other surroundings.

Space exploration satellites

Most of these satellites are **geostationary,** that is, they are programmed to orbit at the speed similar to earth to provide uninterrupted information for that particular location.

Activity: Now test yourself by doing this activity.

Circle the letter of the correct answer.

1. What is a satellite?

   A. A rocket that orbits the earth.
   C. An object that lives in the outer space.
   B. An object in outer space that flies around the planets.
   D. The natural objects in the outer space that fly around in the night.

2. An artificial satellite is a __________ satellite.

   A. solar B. military
   C. man-made D. natural

3. Which of the following statements correctly explains the function of a satellite?

   A. Geologists normally use satellites to study rocks.
   B. Communication systems used satellites to monitor call rates.
   C. Scientists use to study earth and other space planets and solar radiation.
   D. Ship captains and pilots use satellites to take photographs of their destination.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 18.

Summary

You have come to the end of Lesson 18. In this lesson you have learnt that:

- satellites are objects in the outer space that orbit the planets.
- artificial satellites are made by people.
- Sputnik 1 is the first artificial satellite launched by the Soviet Union in 1957.
- satellites are used for communication, navigational purposes, weather forecast, military and spy work and to study the Earth and other planets.
- most satellites are launched into the space by rockets or space shuttles.

NOW DO PRACTICE EXERCISE 18 ON THE NEXT PAGE.

Practice Exercise 18

Read the questions carefully and answer them correctly on the spaces provided.

1. Explain the work of space astronauts in your own words.

____
____
____
____
____

2. State the number of Navstar satellites orbiting in our outer space currently.

____

3. Name the first artificial satellite**.**

____

4. In your own words, briefly explain how satellites are sent into space.

____
____
____
____
____
____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Answers to activity

1. C
2. C
3. D

Lesson 19: X – Rays

Welcome to Lesson 19. Imagine that you can see right through your own skin and see the bones inside your body. You can also watch food go down your throat when you swallow it. Imagine looking inside someone else's suitcase to see what is inside. Does that sound impossible? Not when you know about X- rays.

Your Aims:

- define X-rays
- explain how an X-ray machine works
- state the uses of X-ray

What are X-rays?

X- rays are very powerful light rays that eyes cannot detect. These light rays can slip through objects from which visible light bounces off. The X-rays are used as a powerful tool to detect and discover things that our eyes cannot see.

How were X-rays discovered?

X-rays were first discovered by German Physicist, Wilhelm Roentgen in 1895, while he was experimenting electricity in vacuum tubes in a black cardboard box in his laboratory. During the experiment, he noticed that a special screen he had nearby, glowed when electricity went through the tubes. He then did further experiments and found out that the invisible light rays from the tubes caused the screen to glow. The rays went right through the cardboard box. He called the invisible light rays he had found **X-rays**.

Wilhelm Roentgen

How X-rays are produced

X-rays are produced when high-speed electrons are stopped by a metal target in the X-ray tube. X-rays have smaller wavelengths than ultra violet (UV) rays.

How X-rays Work

When a doctor takes an X-ray of you:

- the X-ray machine shoots X-rays at you.
- most of the rays go through you and into a special film, which catches them.
- some of the X-rays that hit your bones, however, do not pass through you.
- the bones absorb more X-rays than other parts of your body.
- because the X-rays absorbed by your bones never make it to the film, lighter areas appear on the film where your bones are and provide a picture of the bones.

X-rays can be harmful. Doctors use X-rays to kill cells that are harmful to people such as cancer tumours. Because too many X-rays can be harmful, doctors warn that X-rays should be used only when necessary.

Types of Medical X-rays

Radiography
A radiograph is an X-ray image or photograph obtained by placing a body part of a patient in front of an X-ray detector. This is used extensively in medicine as a diagnostic or treatment tool. Radiographs are useful in the detection of diseases of the skeletal system as well as some disease processed in the body's soft tissues. Some common examples are chest X-ray, which is used to identify lung diseases like pneumonia, lung cancer and the abdominal X-ray which can detect intestinal obstruction.

Computer tomography
Computer tomography is sometimes called **CT scanning**. It is a medical imaging process by which tomographic images or slides of specific areas of a human internal body parts are obtained. This is used to identify and treat diseases.

Fluoroscopy
This is an imaging technique commonly used by physicians to obtain real-time moving images of the internal structures of a patient through the use of a fluoroscope. The fluoroscope consists of an X-ray source and a fluorescent screen. The patient is placed between the two.

Radiotherapy
In radiotherapy, X-rays are used to treat certain diseases, especially cancer by exposing tumours to the X- radiation.

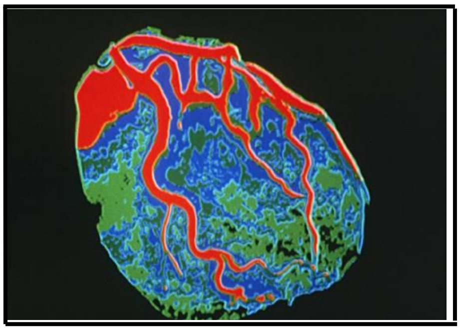
The Application of X-rays

X-Rays have many important applications or uses. One of the vital areas where X-ray is used is with medical imaging of patients' internal body tissues and bones. X-rays provide the most important method of diagnosing to treat various diseases.

A. Medicine

X-rays are used for medical imaging or photograph of patients' internal body parts such as tissues and bones. Often, this is done to identify diseases and get treatment. There are several different medical X-rays. An X–ray allows doctors to see inside the human body without surgery. The diagrams below show X-ray photographs of a human skull and heart.

An X–ray of human skull

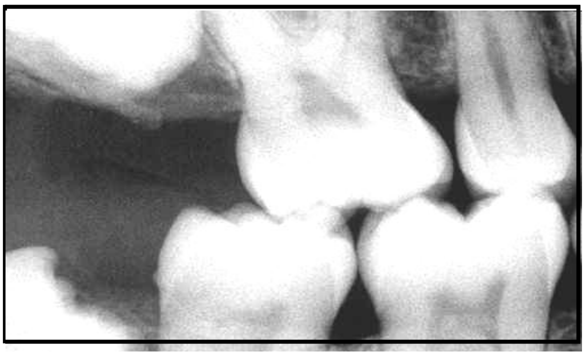


X-ray of a human heart

An X-ray of the human heart is called an angiogram.

Dental X-rays

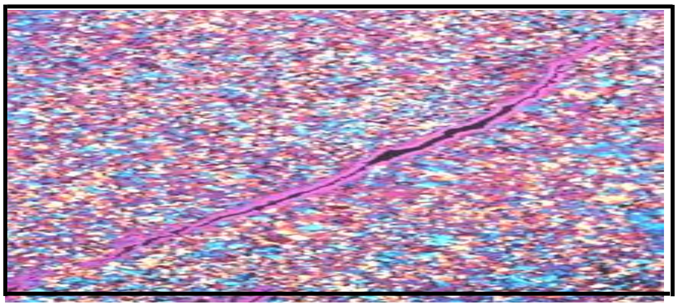
Dentists often use X-rays to look for hidden problems with your teeth. The X-ray diagram below shows a tooth on the upper left that stuck in the tissue of the jaw.



A dental tooth x-ray

B. Research

The study of X-rays plays an important role in Physics as well as other major science fields. It is one of the research tools. For instance, many chemical elements were discovered using X-rays. Scientists who study matter and energy often use X-rays in their research to help them identify what they are made of. They can also use X-rays to find very small cracks in materials. This X-ray photograph shows a crack in a metal tube.



Detecting a crack

C. Industry

X-rays are also used in industries as a research tool and for many testing processes. They are useful in industry to test objects without destroying them. For instance, X-rays are used to test products and materials for destructive features such as cracks in an airplane wing. Border guards use X-rays to look inside cars and containers. Many industrial products are inspected by means of X-rays to remove spoiled products at the point of production. X-rays can identify goods being smuggled from one country to another

D. X-rays in airport security

Security machines use low energy X-rays to check luggage for dangerous items. Bags are passed through a conveyor belt which has a detector beneath. When a metal object is detected, its image is formed when the X-ray passes through it hitting the detector. The image is transmitted to a viewing screen where it is examined by security personnel for potential risk.

Activity: Now test yourself by doing this activity.

Circle the letter of the correct answer.

1. What is an X-ray?

   A. A Medical photograph.
   B. The light rays that penetrate bones.
   C. Light rays that your eyes cannot detect.
   D. Strong light rays that your eyes can see.

2. In what year did German Physicist, Wilhelm Roentgen first discover X-ray?

   A. 1859 B. 1895

   C. 1959 D. 1995

3. What human body structure can an X-ray hit but cannot pass through?

   A. Bone B. Blood vessels

   C. Brain cells D. Muscle tissues

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 19.

Summary

You have come to the end of Lesson 19. In this lesson you have learnt that:

- X-rays are very powerful light rays that eyes cannot detect.
- X-rays were first discovered by German Physicist, Wilhelm Roentgen in 1895.
- X-rays are used as a powerful tool to detect and discover things.
- some of the X-rays that hit our bones, however, do not pass through us.
- X-rays should be used only when necessary as too many X-rays can be harmful.
- radiography, computed tomography, fluoroscopy and radiotherapy all use x-rays.
- in medicine, X-rays are used for medical photographs of internal body parts.
- X-rays are used in research, industry and for security checks at the airports and the wharves too.

NOW DO PRACTICE EXERCISE 19 ON THE NEXT PAGE.

Practice Exercise 19

Write your answers on the spaces provided.

1. In your own words, briefly explain how an X-ray works.

2. List down four medical processes that use X-ray to treat diseases.

   a.
   b.
   c.
   d.

3. State four general uses of the X-ray.

   a.
   b.
   c.
   d.

4. What is Radiotherapy? Explain in your own words.

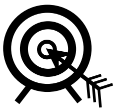
CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Answers to activity

1. D   2. B   3. A

Lesson 20: Optical Smoke Detector

Welcome to Lesson 20. In this lesson, you will learn about two common optical smoke detectors and their functions and uses.



Your Aims:

- define optical smoke detector
- explain how optical detector works
- state the uses of optical smoke detector

What is a Smoke Detector?

A smoke detector is an electronic device that was originally invented in 1890. The device was designed to detect the presence of smoke and alert people in the area of the potential danger of fire.

A smoke detector should not be mistaken for a fire detector. A smoke detector is much more effective. It sends out loud siren-like noise which can alert people of the danger in time to evacuate the building or stop the fire before it has the chance to spread. It is a device designed to prevent serious harm to people and their properties.

At present there are two types of smoke detectors. They are the photoelectric smoke detector and the ionization smoke detector.

Examples of optical smoke detectors

An electric smoke detector

Smoke detectors alert people of the presence of fire.

Parts of smoke detectors

A smoke detector has these two very important parts; sensor to sense the smoke and a very loud electronic horn or alarm to wake people up.

What does a smoke detector do?

They usually sense the presence of smoke during the early stages of fires. Due to their sensitivity, smoke alarms can alert you of the presence of a fire before it gets out of control, giving you and your family a chance of getting out unhurt. Smoke detectors are also known as smoke alarms or fire detectors.

How an Optical Smoke Detector works
When smoke gets into the sensor of the detector, it triggers the loud alarm. The alarm is purposely designed to alert people in an area and also wake them up if a fire occurs at night. For instance, when you cross a beam of light and block it, the photo or light detector will sense the lack of light and triggers a bell. In this way, the sensor acts as a smoke detector.

Where do smoke detectors get their energy?
Smoke detectors are powered by either a 9-volt battery or household electrical current. Some are wired into the 120-volt house current and may have a battery for backup in case the fire causes the electrical system to fail.

Types of smoke detectors

1. **Photoelectric Smoke Detector.**
   A photoelectric smoke detector comprises of a few simple parts and they are a T-shaped chamber with a small light bulb which is aimed toward the top of the T, a lens to focus the light into a concentrated beam and a photodiode which detects the presence of the beam.

   How does a photoelectric smoke detector work?
   With a photoelectric detector, a beam of light is used to detect smoke in the surrounding area. When it functions normally, the bulb sends out light in a steady beam at the photodiode which is a semiconductor used to detect light. The sides of the T-shaped chamber are vented and open. When there is smoke, it rises up to the smoke detector and seeps into the vents of the chamber. By doing so, the smoke disturbs the light, preventing it from striking the photodiode. When this happens the alarm is triggered.

Sometimes, when you walk into a store, a bell will go off as you cross the threshold. If you look, you will notice that a **photo beam detector** is used. Near the door on one side of the store is a light, (either a white light, and a lens or a low-power laser, and on the other side is a photodetector that can "see" the light.

2. **Ionization detectors**
   These are much more common because they are sensitive and are compact or tightly packed. They are the type of smoke detectors mainly used in homes. An ionization smoke detector is cheaper and more effective than a photoelectric smoke detector. The device is comprised of an air filled chamber with small openings (vents) that allows air to enter. Each vent contains a tiny amount of a radioactive chemical element called **americium**. The chamber or room of the detector contains two electrodes which are slightly separated by a small amount of current.

   How Does an Ionization Smoke Detector Work?
   When smoke enters the chamber of the detector it carries with it some of the americium. The material generates brightest particles within the detector and it causes the surrounding oxygen and nitrogen atoms to turn into ions or charged particles. Since the ions are charged particles they create a small electrical current so when the smoke gets in, the current is disturbed and the detector sets off the alarm.

Activity: Now test yourself by doing this activity.

Circle the letter of the correct answer.

1. How many main parts are there in an optical smoke detector?

   A. 2 B. 3

   C. 4 D. 5

2. Which of the following optical smoke detectors is not commonly used?

   A. Ionization smoke detector
   B. Photoelectric smoke detector
   C. Reflected optical beam detector
   D. Projected optical beam smoke detector

3. Smoke detectors are also known as fire detectors because they

   A. can start a fire.
   B. can set off a fire.
   C. are fire extinguishers.
   D. can warn of a possible fire.

4. Which of the following materials play a major role in the function of a photoelectric smoke detector?

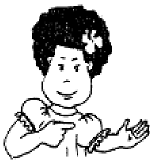
   A. Alarm B. Smoke

   C. Light D. Electric current

5. The main function of an optical smoke detector is to detect the

   A. strength of fire.
   B. smell of smoke.
   C. presence of fire.
   D. presence of smoke.

CHECK YOUR WORK. ANSWERS ARE AT THE END OF LESSON 20.



Summary

You have come to the end of Lesson 20. In this lesson you have learnt that:

- a smoke detector is an electronic device designed to detect the presence of smoke.
- smoke detectors alert people of fire.
- the two types of smoke detectors are photoelectric detectors and ionization detectors.
- an ionization smoke detector is cheaper and more effective than a photoelectric smoke detector.
- smoke detectors consist of sensors and large electric horns or alarms.
- smoke detectors use 9-volt battery or household electric current.
- smoke alarms can alert the presence of a fire before it gets out of control.
- a photodiode is a semiconductor used to detect light.

NOW DO PRACTICE EXERCISE 20 ON THE NEXT PAGE.

Practice Exercise 20

Read the questions carefully and answer the questions in the spaces provided.

1. Name the two main parts of an optical smoke detector.

   a. ______________________________

   b. ______________________________

2. Name the two main types of optical smoke detectors used in most homes.

   a. ______________________________

   b. ______________________________

3. Is it a good idea to have smoke detectors in homes and public buildings? State a reason for your answer.

   ____
   ____
   ____

4. What are optical smoke detectors?

   ____
   ____
   ____

5. What is a sensor? Explain in your own words.

   ____
   ____
   ____
   ____

CHECK YOUR WORK. ANSWERS ARE AT THE END OF TOPIC 6.

Answers to Activity

1.	C	2.	A	3.	D
4.	C	5.	B		

Answers to Practice Exercises 14 – 20

Practice Exercise 14

1. Antoni Philips Van Leeuwenhoek

2. It is used to

   a) pin down slides that contain the specimen for viewing

   b) focus the specimen so that it is easily seen.

   c) enable the viewer to see the specimen in detail.

3. It does this by keeping the object being seen between the focal length.

Practice Exercise 15

1. (a) A telescopes is an optical instrument that is used to see clearly and study objects that are very far away - on earth or in space.

   (b) The first telescope was invented by a scientist called Galileo about 400 years ago for studying the planets.

   (c) There were two types of lenses used in the first telescope. A convex lens was used as the objective and a concave lens as the eyepiece. The lenses were enclosed in a cylindrical tube.

2. (a) Binoculars

   (b) Newton’s telescope

3. (a) An astronomical telescope has two convex lenses and produces an inverted image.

   (b) The objective produces an image of the distant object at its focus, Fo

   (c) The eyepiece acts like a magnifying glass and produces a magnified, inverted, virtual image of the object.

   (d) Convex lenses

Practice Exercise 16

1. A camera is a device that records images that can be stored directly, transmitted to another location, or both. These images may be still photographs or moving images such as videos or movies.

2. There are two types of cameras and they are the analogue and digital.

3. An analogue camera is less complex and requires less buttons while the digital camera is more complex and requires more buttons.

4. An image is fixed on a photographic film by the process of developing the film. The process of developing gives us the negatives and it involves the use of chemicals.

5. The size of the aperture can be controlled by the diaphragm. Adjusting the diaphragm changes the aperture (size of the circular opening) through which light enters the camera.

Practice Exercise 17

1. Is a branch of optics that deals with the transmission of light through hair-thin, flexible transparent fibres.

2. An optical fibre is a thin, flexible transparent fibre, wire or thread, especially one of several twisted together to form a rope of cable.

3. When the light travels inside the core of the fibre, it strikes the outside surface at an angle of incidence greater than the critical angle. As a result all light is reflected toward the inside of the fibre without loss. By being reflected inward thousands of times with no loss light gain the advantage to be transmitted over long distances. The light is reflected from side to side when it enters one end of a fibre until it comes out on the other end.

4. a. Use as transmitting cables in communication systems.

   b. Used in transmitting images of human internal body parts using medical instruments.

Practice Exercise 18

1. Astronauts on the space shuttle can make sure the satellite is working and gets into the right orbit.

2. 24 Navstar satellites

3. The first artificial satellite is called Sputnik 1.

4. Most satellites are launched into space by rockets, space shuttles or high-flying planes.

Practice Exercise 19

1. When a doctor takes an x-ray of you; the x-ray machine shoots x-rays at you. Most of the rays go through you and into a special film, which catches them. Some of the x-rays that hit your bones, however, do not pass through you.
   The bones absorb more x-rays than other parts of your body. Because x-rays absorbed by your bones never make it to the film, lighter areas appear on the film where your bones are. These lighter areas provide a picture of the bones.

2. X-rays are used in radiography, computer tomography, fluoroscopy and radiotherapy all use x-rays.

3. a. medicine.
   b. scientific research.
   c. manufacturing industries.
   d. security industry.

4. Radiotherapy is a medical treatment process using x-radiation. It is mainly used in the treatment of cancer.

Practice Exercise 20

1. a) Sensor

   b) Electric horn or alarm

2. a) Photoelectric optical smoke detector.

   b) Ionization optical smoke detector.

3. Yes, because apart from detecting smoke it can also alert of a possible fire danger**.**

4. These are devices that can detect smoke across large areas.

5. a) It is a device capable of detecting and responding to a physical change such as movement, light, heat or smoke.

   b) It is a substance that gives off energy which can damage the health of people who are exposed to it.

REVISE TOPIC 6 USING THE MAIN POINTS ON THE NEXT PAGE.

REVIEW OF TOPIC 6: Useful Inventions and Applications of Light

Now, revise all lessons in this Topic and then do **ASSIGNMENT 6**.
Here are the main points to help you revise.

Lesson 14: Compound Microscope

- A simple microscope is another name for a magnifying glass.
- A microscope is an instrument which is used to study very small objects.
- A microscope gives an enlarged image of an object.
- The focal length of a convex lens is where the rays of light converge. Any image within this length or smaller will be magnified. Any image longer than the focal length will be up-side down.
- Most microscopes are light microscopes because they use light to see images.
- A compound microscope has two lenses; an objective and an eyepiece.

Lesson 15: Telescope

- Telescopes are used to see clearly and study objects that are very far away on earth or in space.
- The first telescope was invented by Galileo to study the planets. He used a convex lens as the objective and a concave lens as the eyepiece.
- In an astronomical telescope, a convex lens is used as the objective and another convex lens as the eyepiece. The objective has long focal length and the eyepiece has short focal length.
- A terrestrial telescope is used to see things on earth which are a few kilometres away.
- An astronomical telescope gives inverted images. In a terrestrial telescope a third convex lens is introduced between the objective and the eyepiece to give a final upright image.
- In Newton's telescope, a concave mirror, a plane mirror and a convex lens are used and so it is called a reflecting astronomical telescope.
- Binoculars are short telescope with two convex lenses and two prisms

Lesson 16: Camera

- A camera is a device that records images that can be stored directly, transmitted to another location, or both. These images may be still photographs or moving images such as videos or movies.
- There are two types of cameras. The analogue and the digital camera.
- The main parts of an analogue camera are the light proof box, lens, film, shutter and the diaphragm.
- Over exposure occurs when too much light enters the camera.
- Under exposure occurs when too little light enters the camera.
- Shutter controls the entry and exit of light.
- Diaphragm controls the amount (intensity) of light through the aperture

Lesson 17: Fibre Optics

- Fibre optics is a technology that uses glass (or plastic) threads (fibres) to carry information coded in light.
- A fibre optic cable is made up of very thin strands of high quality glass or plastic known as optical fibres.

- Optical fibres can carry more information than an ordinary cable of the same thickness.
- optical fibres make use of the total internal reflection. Total internal reflection occurs when light strikes the boundary between substances at an angle greater than the critical angle.
- The cable is made up of two separate parts. The main part of the cable which is in the middle is called the core and wrapped around the outside of the core is the cladding.
- The most widespread use of fibre optics is in communications.

Lesson 18: Satellites
- Satellites are objects in the outer space that orbit the planets.
- Artificial satellites are made by people.
- Sputnik 1 is the first artificial satellite launched by the Soviet Union in 1957.
- Satellites are used for communication, navigational purposes, weather forecast, military and spy work and to study the Earth and other planets.
- Most satellites are launched into the space by rockets or space shuttles.

Lesson 19: X-Rays
- X-rays are very powerful light rays that your eyes can not detect.
- X-rays were first discovered by German Physicist, Wilhelm Roentgen in 1895.
- X-rays are used as a powerful tool to detect and discover things.
- Some of the X-rays that hit your bones, however, they do not pass through you.
- Too many X-rays can be harmful. X-rays should be used only when necessary.
- Radiography, computed tomography, fluoroscopy and radiotherapy all use X-rays.
- In medicine, X-rays are used for medical photographs of internal body parts.
- X-rays are used in research, industry and security checks at airports and wharves too.

Lesson 20: Optical Smoke Detector
- An optical beam smoke detector is a device that uses a beam of light to detect smoke across large areas.
- Smoke detectors alert people to the presence of fire.
- The two types of smoke detectors are photoelectric and ionization detectors.
- An ionization smoke detector is cheaper and more effective than a photoelectric smoke detector.
- Smoke detectors consist of sensors and large electric horns or alarms.
- Smoke detectors use 9-volt battery of household electric current.
- Smoke alarms can alert the presence of a fire before it gets out of control.
- A photodiode is a semiconductor used to detect light.

NOW DO TOPIC TEST 4 IN YOUR ASSIGNMENT 4.

NOW YOU MUST COMPLETE ASSIGNMENT 4.
RETURN IT TO THE PROVINCIAL CO-ORDINATOR.

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Other References

Some notes and images on the Unit on Light were retrieved from http://www.google.pg.com/search? at different times.

FODE PROVINCIAL CENTRES CONTACTS

PC NO.	FODE PROVINCIAL CENTRE	ADDRESS	PHONE/FAX	CUG PHONES	CONTACT PERSON		CUG PHONE
1	DARU	P. O. Box 68, Daru	6459033	72228146	The Coordinator	Senior Clerk	72229047
2	KEREMA	P. O. Box 86, Kerema	6481303	72228124	The Coordinator	Senior Clerk	72229049
3	CENTRAL	C/- FODE HQ	3419228	72228110	The Coordinator	Senior Clerk	72229050
4	ALOTAU	P. O. Box 822, Alotau	6411343 / 6419195	72228130	The Coordinator	Senior Clerk	72229051
5	POPONDETTA	P. O. Box 71, Popondetta	6297160 / 6297678	72228138	The Coordinator	Senior Clerk	72229052
6	MENDI	P. O. Box 237, Mendi	5491264 / 72895095	72228142	The Coordinator	Senior Clerk	72229053
7	GOROKA	P. O. Box 990, Goroka	5322085 / 5322321	72228116	The Coordinator	Senior Clerk	72229054
8	KUNDIAWA	P. O. Box 95, Kundiawa	5351612	72228144	The Coordinator	Senior Clerk	72229056
9	MT HAGEN	P. O. Box 418, Mt. Hagen	5421194 / 5423332	72228148	The Coordinator	Senior Clerk	72229057
10	VANIMO	P. O. Box 38, Vanimo	4571175 / 4571438	72228140	The Coordinator	Senior Clerk	72229060
11	WEWAK	P. O. Box 583, Wewak	4562231/ 4561114	72228122	The Coordinator	Senior Clerk	72229062
12	MADANG	P. O. Box 2071, Madang	4222418	72228126	The Coordinator	Senior Clerk	72229063
13	LAE	P. O. Box 4969, Lae	4725508 / 4721162	72228132	The Coordinator	Senior Clerk	72229064
14	KIMBE	P. O. Box 328, Kimbe	9835110	72228150	The Coordinator	Senior Clerk	72229065
15	RABAUL	P. O. Box 83, Kokopo	9400314	72228118	The Coordinator	Senior Clerk	72229067
16	KAVIENG	P. O. Box 284, Kavieng	9842183	72228136	The Coordinator	Senior Clerk	72229069
17	BUKA	P. O. Box 154, Buka	9739838	72228108	The Coordinator	Senior Clerk	72229073
18	MANUS	P. O. Box 41, Lorengau	9709251	72228128	The Coordinator	Senior Clerk	72229080
19	NCD	C/- FODE HQ	3230299 Ext 26	72228134	The Coordinator	Senior Clerk	72229081
20	WABAG	P. O. Box 259, Wabag	5471114	72228120	The Coordinator	Senior Clerk	72229082
21	HELA	P. O. Box 63, Tari	73197115	72228141	The Coordinator	Senior Clerk	72229083
22	JIWAKA	c/- FODE Hagen		72228143	The Coordinator	Senior Clerk	72229085

FODE SUBJECTS AND COURSE PROGRAMMES

GRADE LEVELS	SUBJECTS/COURSES
Grades 7 and 8	1. English
	2. Mathematics
	3. Personal Development
	4. Social Science
	5. Science
	6. Making a Living
Grades 9 and 10	1. English
	2. Mathematics
	3. Personal Development
	4. Science
	5. Social Science
	6. Business Studies
	7. Design and Technology- Computing
Grades 11 and 12	1. English – Applied English/Language& Literature
	2. Mathematics - Mathematics A / Mathematics B
	3. Science – Biology/Chemistry/Physics
	4. Social Science – History/Geography/Economics
	5. Personal Development
	6. Business Studies
	7. Information & Communication Technology

REMEMBER:

- For Grades 7 and 8, you are required to do all six (6) subjects.
- For Grades 9 and 10, you must complete five (5) subjects and one (1) optional to be certified. Business Studies and Design & Technology – Computing are optional.
- For Grades 11 and 12, you are required to complete seven (7) out of thirteen (13) subjects to be certified.

Your Provincial Coordinator or Supervisor will give you more information regarding each subject and course.

GRADES 11 & 12 COURSE PROGRAMMES

No	Science	Humanities	Business
1	Applied English	Language & Literature	Language & Literature/Applied English
2	Mathematics A/B	Mathematics A/B	Mathematics A/B
3	Personal Development	Personal Development	Personal Development
4	Biology	Biology/Physics/Chemistry	Biology/Physics/Chemistry
5	Chemistry/ Physics	Geography	Economics/Geography/History
6	Geography/History/Economics	History / Economics	Business Studies
7	ICT	ICT	ICT

Notes: You must seek advice from your Provincial Coordinator regarding the recommended courses in each stream. Options should be discussed carefully before choosing the stream when enrolling into Grade 11. FODE will certify for the successful completion of seven subjects in Grade 12.

CERTIFICATE IN MATRICULATION STUDIES		
No	**Compulsory Courses**	**Optional Courses**
1	English 1	**Science Stream:** Biology, Chemistry, Physics
2	English 2	**Social Science Stream:** Geography, Intro to Economics and Asia and the Modern World
3	Mathematics 1	
4	Mathematics 2	
5	History of Science & Technology	

REMEMBER:
You must successfully complete 8 courses: 5 compulsory and 3 optional.