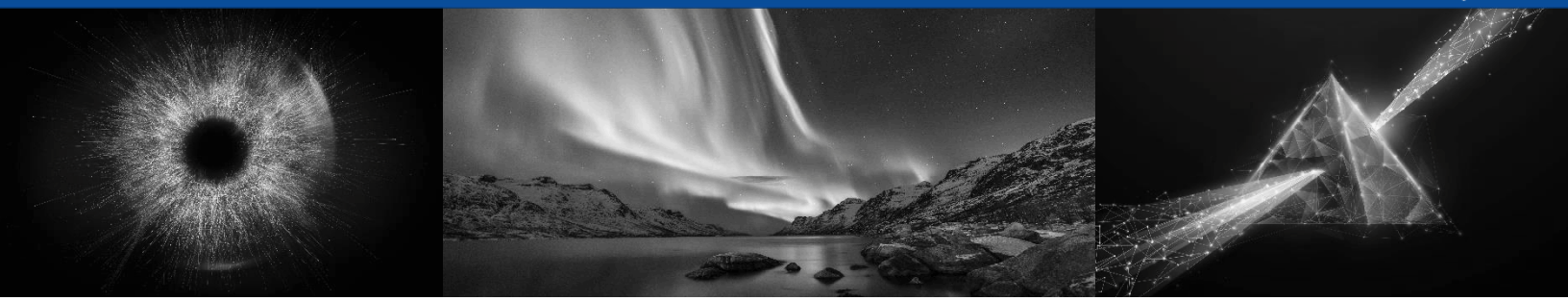


LIGHT

Concepts Covered

- Light and its properties
- Reflection and its laws
- Mirrors and their types
- Kaleidoscope
- Dispersion of White Light
- Uses of Concave and Convex Mirrors

Introduction

The eyes are the most valuable sense organ. We enjoy the beauty of nature and marvel at the wonders created by nature and man by viewing them through our eyes. It is impossible to see our surroundings in the absence of light. We are able to see an object when light that is coming from the object enters our eye. Light can be understood as a form of energy that produces the sensation of vision. In the daytime, light given out by the sun falls on different objects and the reflected light from the object enters our eyes which enables us to view different objects.

Light

Light is a form of energy (optical energy) which enables us to see.

- Light travels in a straight line.
- The speed of light changes when it travels from one medium to another medium.
- Light gets reflected back from any opaque surface.
- Light undergoes refraction (bending) when it travels from one medium to another.

Properties of Light

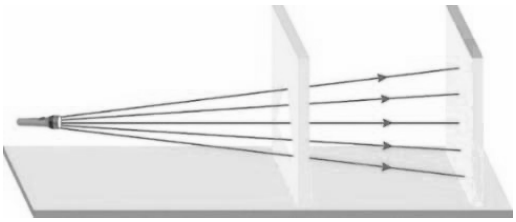
- Light is an electromagnetic wave and does not require any medium to travel.
- Light casts a shadow when any obstacle comes in its path.
- Speed of light is maximum in a vacuum which is equal to $3 \times 10^8\ \mathrm{ms}^{-1}$.
- When light falls on a surface, the following phenomena may happen:
  (1) Reflection
  (2) Refraction
  (3) Absorption

DID you KNOW

Blue light calms you down.

Ray of Light

A straight line along the direction of the motion of light is called a ray of light.



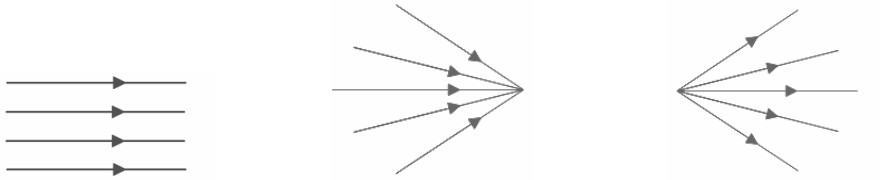
Ray of Light

DID you KNOW

The speed of light is incredible. For light to get from the earth to the moon, it takes only 1.255 seconds.

Beam of Light

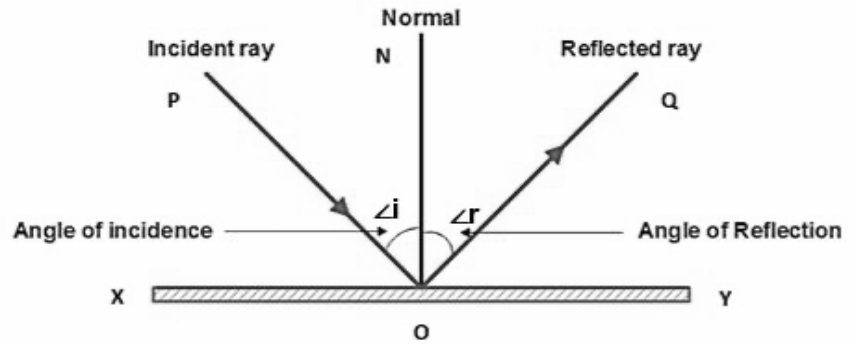
A bunch of light rays or a bundle of light rays is called a beam of light.



Parallel beam of light **Convergent beam of light** **Divergent beam of light**

Reflection of Light

When light rays are incident on any surface, they bounce back in the same medium.
This phenomenon of bouncing back of light rays in the same medium is called reflection of light.



Reflection of light

Laser light is a single color or 'monochromatic'.

Some associated terms

- **Reflecting Surface:** The surface from which the light is reflected is called the reflecting surface. In the above diagram, XY is the reflecting surface.
- **Point of Incidence:** The point on the reflecting surface at which a ray of light strikes, is called the point of incidence. In the above diagram, O is the point of incidence.
- **Normal:** A perpendicular drawn on the reflecting surface at the point of incidence, is called the normal. In the above diagram, NO is the normal.
- **Incident Ray:** The ray of light which strikes the reflecting surface at the point of incidence is called the incident ray. In the above diagram, PO is the incident ray.
- **Reflected Ray:** The ray of light which gets reflected from the reflecting surface from the point of incidence, is called the reflected ray. In the above diagram, OQ is the reflected ray.
- **Angle of Incidence:** The angle that the incident ray makes with the normal, is called the angle of incidence. It is represented by the symbol i. In the given diagram, ∠PON is the angle of incidence.
- **Angle of Reflection:** The angle that the reflected ray makes with the normal, is called the angle of reflection. It is represented by the symbol r. In the given diagram, ∠QON is the angle of reflection.

Laws of Reflection

There are two laws of reflection:
(1) The angle of incidence is equal to the angle of reflection, **∠i = ∠r**.
(2) The incident ray, the normal, and the reflected ray at the point of incidence, all lie in the same plane.

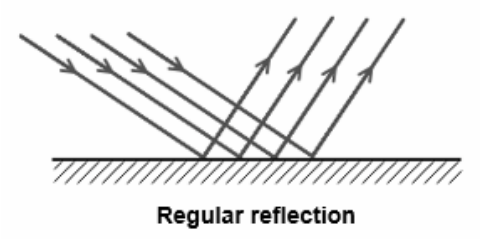
Regular and Diffused Reflection

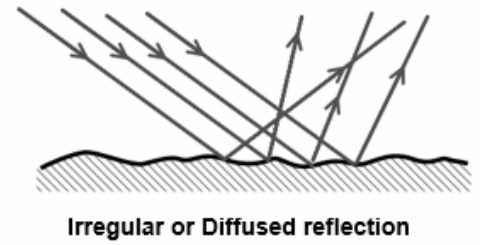
Regular Reflection

In this reflection, a parallel beam of light remains parallel even after reflecting from the plane surface. This type of reflection follows the laws of reflection.

Irregular Reflection or Diffused Reflection

In this type of reflection, a parallel beam of light goes random directions after reflection from a rough surface. This reflection also follows the laws of reflection.

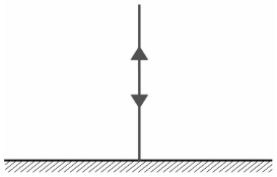




Examples:

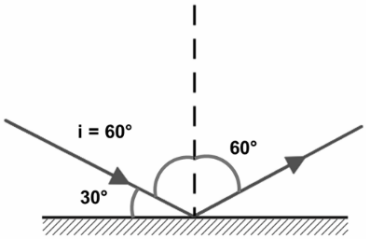
(1) What happens to a light ray that is incident on a plane mirror normally?

Solution: When a light ray is incident on a plane mirror normally,
The angle of incidence, ∠i = 0
According to the laws of reflection, ∠i = ∠r
So, the angle of reflection also must be zero.
The reflected ray must travel along the same path in the opposite direction as shown in the adjacent figure.



(2) If a light ray incident on a plane mirror makes an angle of 30° with it, find the angle of incidence and angle of reflection.

Solution: It is given that the incident ray makes an angle of 30° with the mirror.
But the angle of incidence is the angle between the incident ray and the normal.
So, ∠i = 90° – 30° = 60°
On applying laws of reflection, ∠i = ∠r = 60°.



Check Your Concept - 1

(i) If a light ray incident on a plane mirror makes an angle of 60º with it, find the angle of incidence and the angle of reflection.

(ii) The angle between the incident ray and the reflected ray from the plane mirror is **80**°. What will be the angle of incidence?

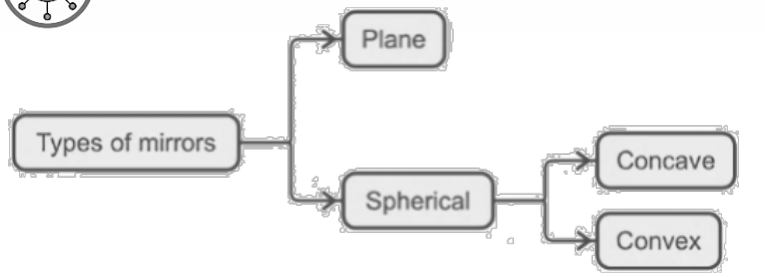
Mirror

A smooth, highly silvered reflecting surface is called a mirror.
When a glass plate is silvered on one side with reflecting material such as silver or nickel, it becomes a mirror.

Types of Mirrors

According to the shape of the reflecting surface of a mirror, there are two types of mirrors:
(1) Plane mirror (2) Spherical or curved mirror

Mind Map

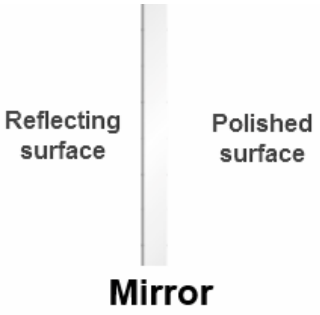


DID you KNOW

Light is used by plants to convert the light energy into chemical energy for their food.

Plane Mirror

It is a flat (totally plane) glass plate that is silvered on one side by the reflecting material.

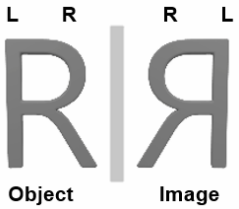


Characteristics of Image formed by a Plane Mirror

- Size of the image is the same as the size of the object.
- The distance of the object in front of the mirror is equal to the distance of the image behind the mirror.
- A virtual and an erect image is formed.
- The image formed by a mirror is laterally inverted.

Lateral Inversion

The right-hand side of an object placed in front of a plane mirror appears as the left-hand side in the image formed by the plane mirror and vice-versa.
This phenomenon is called lateral inversion.



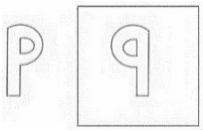
Lateral Inversion

DID you KNOW

Some mirrors can reflect matter just as they do light. These mirrors are known as atomic mirrors. They use an electromagnetic field to reflect neutral atoms and are used to trap slow atoms or to focus an atomic beam.

Activity:

Take a piece of thermocol and cut it in the form of the letter P as shown in the figure. Place this in front of a plane mirror and view it by the image formed in the mirror. The image appears to be laterally inverted as shown in the figure.



Uses of Plane Mirrors in our Daily Life

- Plane mirrors are used for dressing ourselves.
- Plane mirrors are used by opticians to maintain the standard distance of the chart required for testing eyesight.
- Plane mirrors are used for providing false dimensions in some shops.
- Plane mirrors are used in solar cookers as reflectors of sunlight.
- Plane mirrors are used in making kaleidoscopes and reflecting periscopes.

Examples:

(1) A boy standing in front of a plane mirror finds his image to be at a distance of 10 m from himself. The distance of his image from the mirror is_____m.

Solution: Distance between the boy and his image = 10 m
Distance between boy and mirror + distance between mirror and image = 10 m
But distance between boy and mirror (object distance) = distance between mirror and image
Therefore, the distance of his image from the mirror = 10/2 = 5 m.

(2) Which of the statements given below is correct?
(A) The laws of reflection of light hold true only for plane surfaces.
(B) The size of a virtual image can be measured by receiving it on screen.
(C) Plane mirrors always form an erect image.
(D) Plane mirrors always form an inverted image.

Answer: (C)

Explanation: Law of reflection of light holds true for all the mirrors irrespective of their shape and size, hence option A is false. A virtual image cannot be caught on the screen so, it is also a false statement. Plane mirror always forms an erect image, hence it is the correct statement.

(3) 8OYATU in a plane mirror appears as:
(A) 8OYATU (B) 8OYatu
(C) UTAYO8 (D) 8oYATU

Answer: (C)

Explanation: All letters given are symmetric laterally. When it undergoes reflection, letters reverse order but each looks individually the same.

DID you KNOW

If a light ray has more wavelength, it has less energy, and likewise, a shorter wavelength can produce more energy.

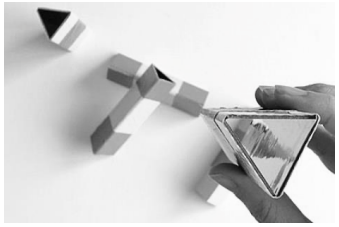
Check Your Concept - 2

(i) A boy blinks his right eye. Mirror image of the boy blinks its _____ eye.

(ii) A boy standing in front of a plane mirror finds his image to be at a distance of 20 m from himself. The distance of boy from the mirror is_____ m.

Kaleidoscope

A kaleidoscope is an optical instrument with two or more reflecting surfaces (or mirrors) tilted towards each other at an angle, so that one or more (parts of) objects on one end of these mirrors are shown as a regular symmetrical pattern when viewed from the other end, due to repeated reflections. These reflectors are usually enclosed in a tube, often containing on one end, a cell with loose, coloured pieces of glass or other transparent (and/or opaque) materials to be reflected into the viewed pattern. Rotation of the cell causes motion of the materials, resulting in an ever-changing view being presented.

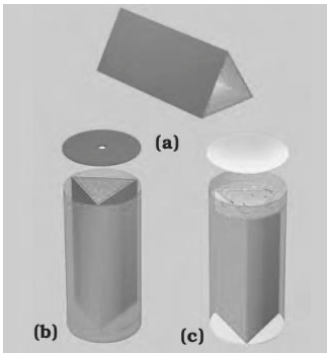


Kaleidoscope

Activity

How to make a kaleidoscope?

- Get three rectangular mirror strips each about 15 cm long and 4 cm wide.
- Join them together to form a prism as shown in the figure.
- Fix this arrangement of mirrors in a circular cardboard tube or tube of a thick chart paper. Make sure that the tube is slightly longer than the mirror strips.
- Close one end of the tube with a cardboard disc having a hole at the centre, through which you can see.
- To make the disc durable, paste a piece of transparent plastic sheet under the cardboard disc. At the other end, touching the mirrors, fix a circular plane glass plate. Place several small pieces of coloured glass (broken pieces of coloured bangles) on this glass plate.
- Close this end of the tube with a ground glass plate. Allow enough space for the colour pieces to move around.



Now kaleidoscope is ready. When we peep through the hole, we will be able to see a variety of patterns in the tube. An interesting feature of a kaleidoscope is that we will never see the same pattern again. Designers of wallpapers and fabrics and artists often use kaleidoscopes to get ideas for new patterns.

Dispersion of White Light

The process of splitting white light into its seven constituent colours is called dispersion of white light. The band of seven colours formed on a screen due to the dispersion of white light is called the spectrum of visible light or the spectrum of white light.

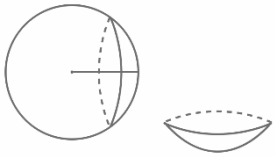
Spectrum: The band of seven colours formed due to the dispersion of white light is called a spectrum.
Acronym: It is a group of alphabets that represent sequential colours in a spectrum.

V I B G Y O R

- Red is the least deviated colour as it has the longest wavelength in the visible spectrum.
- Violet is the most deviated colour as it has the shortest wavelength in the visible spectrum.

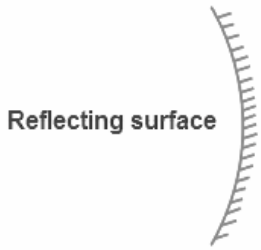
Spherical Mirrors

Spherical mirrors can be considered as a part of a glass sphere. It is like a piece cut from a hollow glass sphere.

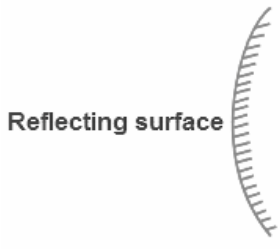


Spherical Mirror

- If the convex surface (build out surface) is silvered and the inner surface is smooth, the mirror obtained is concave mirror.
- If the concave surface (bend surface) is silvered and the convex surface is smooth, the mirror obtained is convex mirror.



Concave mirror

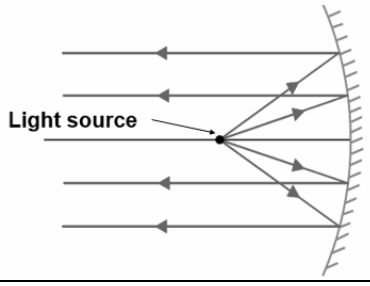


Convex mirror

DID you KNOW

The rod cells in retina detects the light intensity (brightness) while cone cells detect colours.

Uses of Concave Mirror

▪ Concave mirrors are used in torches, searchlights, and vehicle headlights to get the powerful parallel beam of light.	
▪ Concave mirrors are used by dentists to see large images of the teeth of patients. (Teeth have to be placed between pole and focus).	
▪ A concave mirror is used as a shaving mirror to see a larger image of the face.	
▪ Large concave mirrors are used to concentrate sunlight to produce heat in a solar furnace.	

Uses of Convex Mirror

▪ Convex mirrors are used as rear-view mirrors in vehicles because: (a) They always give an erect and diminished image. (b) They have a wider field of view as they are curved outwards.	 

▪ Convex mirrors are used at blind turns and on points of merging traffic to facilitate the vision of both sides' traffic.	
▪ Convex mirrors are used in shops as security mirrors.	

Solved Examples

Level – 1

(1) What are the characteristics of the image formed by a plane mirror?

Answer: The image formed by a plane mirror is always virtual (meaning that the light rays do not actually come from the image), upright, and of the same shape and size as the object, it is reflecting. A virtual image is a copy of an object formed at the location from which the light rays appear to come.

(2) The image formed by a lens is always virtual, erect and smaller in size for an object kept at different positions in front of it. Identify the nature of the lens.

Answer: Such types of lenses that always form virtual, erect and smaller images in spite of the different positions of an object are called concave lenses.

(3) The angle of incidence on a plane mirror is 60°. Calculate the angle of reflection.

Solution: We know that angle of incidence = angle of reflection

So, angle of incidence=angle of reflection = 60°

(4) A man standing in front of a plane mirror finds his image to be at a distance of 10 meters from the mirror. Calculate the distance between the man and his image.

Solution: Distance of image of a man from the plane mirror = 10m

Since, distance of object from the mirror = Distance of image from the mirror

Hence, the distance of the man from the mirror is = 10m

So, the distance between the man and his image is = distance of object from the mirror + Distance of image from the mirror

= 10 + 10 = 20m

(5) A light ray is incident normally on a plane mirror.

(i) What is the angle of incidence?

(ii) What is the path of reflected ray?

(A) (a) 180°, (b) same as incident ray **(B) (a) 180°, (b) opposite to incident ray**

(C) (a) 0°, (b) opposite to incident ray **(D) (a) 0°, (b) same as incident ray**

Answer: (C)

Explanation:

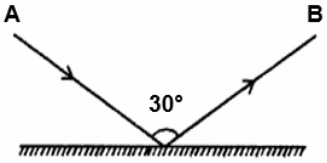
Case (a): If a ray of light is incident normal to the surface of the plane mirror, then the angle of incidence is 0°, as the normal passes perpendicularly to the mirror.

Case (b): The second law of reflection states that the angle of incidence is always equal to the angle of reflection. Therefore, the angle of reflection is the same as the angle of incidence, that is, 0°. So, the reflected ray will retrace the path of the incident ray.

(6) The diagram in the adjacent figure shows an incident ray AO and the reflected ray OB from a plane mirror. The angle AOB is 30°. Draw normal on the plane mirror at the point O and find:

(i) the angle of incidence

(ii) the angle of reflection



Solution: ON is normal on the plane mirror at point O

ON is perpendicular on a plane mirror

Angle of incidence $\angle i = \angle AON$ and angle of reflection $\angle r = \angle BON$

Since, $\angle i - \angle r$

$\angle AOB = 30^\circ$

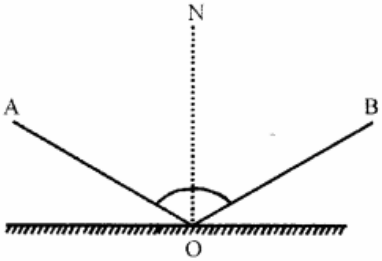
$\Rightarrow \angle AON + \angle BON = 30^\circ$

$\Rightarrow \angle i + \angle i - 30^\circ \;\; \Rightarrow 2\angle i = 30^\circ$

$\Rightarrow \angle i = \frac{30}{2} = 15^\circ$

$\therefore$ Angle of incidence $= \angle i = 15^\circ$

and Angle of reflection $\angle r = 15^\circ$



(7) Ram is observing his image in a plane mirror. The distance between the mirror and his image is $6\ m$. If he moves $2\ m$ towards the mirror, then the distance between Ram and his image will be

(A) $7\ m$ **(B) $3\ m$**

(C) $6\ m$ **(D) $8\ m$**

Answer: (D)

Explanation: We know, distance of object from the plane mirror = Distance of image from the plane mirror

So, initial distance between Ram and the mirror $= 6\ m$

Distance between Ram and the mirror after he moves $2\ m$ towards the mirror $= 6 - 2 = 4\ m$

In a plane mirror, the image is situated at the same distance from the mirror as the object.

Therefore, distance between Ram and his image $= 4 + 4 = 8\ m$.

Exercise

FILL IN THE BLANKS

(1) The image formed by a plane mirror is _____ in nature.
(2) A convex mirror is one in which the reflecting surface bulges_____.
(3) If you touch your _____ ear with right hand in front of a plane mirror it will be seen in the mirror that your right ear is touched with _____.
(4) _____ mirror is used as a shaving mirror.

TRUE OR FALSE

(1) The path of light is a straight line.
(2) The rear-view mirror used in vehicles is a convex mirror.
(3) A mirror whose surface is rough produces a clear image.
(4) Speed of light in air is 3×10^8 m s^{-1}.

OBJECTIVE TYPE QUESTIONS

(1) The number of images of an object placed between two plane parallel mirrors is ____.
(A) two (B) one
(C) infinite (D) cannot be determined

(2) When white light passes through a prism, it splits into its seven component colours. This phenomenon is called
(A) Spectrum (B) Reflection
(C) Refraction (D) Dispersion

(3) Read the following statements and choose the correct option.
(A) The angle made by the incident light ray with the plane of the mirror is equal to the angle made by the reflected light ray with the plane of the mirror.
(B) The angle between an incident light ray and a reflected light ray is twice that of the angle between the incident light ray and normal.
(A) Only A is true (B) Only B is true
(C) Both A and B are true (D) Both A and B are false

VERY SHORT ANSWER TYPE QUESTIONS

(1) What makes things visible?
(2) Do we see all objects due to reflected light?
(3) What happens when light falls on a mirror?
(4) What is reflected ray?
(5) What are the angles of incidence and reflection?
(6) Define Lateral Inversion.
(7) How many mirrors are used in Kaleidoscope?
(8) What do you mean by multiple images?
(9) Define dispersion of light.

SHORT ANSWER TYPE QUESTIONS

(1) How do we see colours?
(2) What are the characteristics of an image formed by a convex mirror?
(3) What is regular and diffused reflection?

Answer Key

CHECK YOUR CONCEPTS

(1) **(i)** $\angle i = \angle r = 30°$ **(ii)** 40°

(2) **(i)** LEFT **(ii)** 10

FILL IN THE BLANKS

(1) virtual

(2) out

(3) Left, Right hand

(4) Concave

TRUE OR FALSE

(1) True

(2) True

(3) False

(4) True

OBJECTIVE TYPE QUESTIONS

(1)	**(2)**	**(3)**
(C)	(D)	(C)