

Practical Notebook

Physics

Grade X

Web Version of PCTB Textbook

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**Punjab Curriculum and
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Learning Outcomes of Practical Work

Students are required to carry out practical work as an integral part of the course. They are advised to maintain a practical notebook in which they record all their practical work, the experimental arrangements used, the observations made and the analysis of these observations and the conclusions drawn. The students are expected to develop the following skills through experimental work:

1. Techniques

- i. Reading to the maximum accuracy of linear and angular scales; use of vernier scales, the use of stopwatch for recording different timings.
- ii. Accurate focusing and location of images.
- iii. Drawing a circuit diagram according to the circuit.
- iv. Recognizing and observing appropriate safety measures.

2. Information Handling

- i. Search, select and interpret scientific information from a variety of sources.
- ii. Display of results in tabular and graphical forms.
- iii. Translate information between graphical, numerical, algebraic and verbal forms.
- iv. Accurate plotting of graphs with suitable scales and interpreting information from them.

Note: Use of centimetre graph be made compulsory.

3. Attitudes

- i. Share the responsibility for accomplishing the group task.
- ii. Show concern for the maximum possible involvement of each group member.
- iii. Display respect for evidence, rationality and intellectual honesty during investigative tasks.
- iv. Show concern for accuracy and precisions in investigations and practical work.

General Safety Procedures

Before you begin.....

1. Keep your work table neat and clean. Make sure that it has no unnecessary things such as school bag, files, clothes and books etc.
2. Read carefully all the instructions in your practical manual / book before you start the experiment.
3. Look out for possible safety precautions.
4. Be sure that the equipment and the glassware are cleaned before use.

While you are doing the experiment....

1. Follow the directions in the practical manual / book precisely.
2. Do not wander around and do not endanger people around you.
3. Wear or use protective devices that are provided to you. These protective devices include goggles, gloves, apron and safety tongs.
4. Use wire gauze or sand bath for heating. Never leave heating apparatus unattended. Turn off Bunsen burners or the spirit lamp when you have to leave your work table for a while or when you have finished your experiment.
5. Handle the apparatus and other instruments particularly sharp objects carefully to avoid damage and injury.
6. If you have broken any glassware (beakers, test-tubes and thermometers etc.) or spilt anything, report to your teacher immediately. You may have to help in cleaning up.
7. Be aware of where fire extinguishers, fire blankets and first aid box are located in the laboratory.
8. Do not eat or drink anything in the laboratory.

After you have finished....

1. Turn off the water and the gas, disconnect electrical connections.
2. Clean your equipment, glass ware and work table and return the apparatus to the lab. staff.
3. Do not dispose of material in the sink unless you are instructed to do so.
4. Wash your hands thoroughly.

The best preventive measure is to always be careful and alert. Take care of yourself and people working around you.

CHAPTER Geometrical Optics

12

Experiment 12.1

Verify the laws of refraction of light using a glass slab.

Date _____

Background Information

It has been observed that when light travels from one medium to another, its speed changes. In a denser medium the speed of light is less than the speed in a rarer medium. When the light rays are incident obliquely to the denser medium, they bend towards the normal at the point of incidence and in case of rarer medium they bend away from the normal. This bending of light is called refraction. It is to be noted that incident light rays along normal go straight through the mediums without bending. There are two laws of refraction stated as:

1. Incident ray, refracted ray and the normal at the point of incidence, all lie in the same plane.
2. The ratio of the sine of angle of incidence and the sine of angle of refraction is constant. This is called Snell's law. This ratio is also known as refractive index n of denser medium with respect to a rarer medium.

CAUTIONS

- Pins must be fixed vertically.
- Use sharp pencil for drawing work.
- The direction of the ray should be marked with an arrow head.
- The pins should be about 5 cm apart.

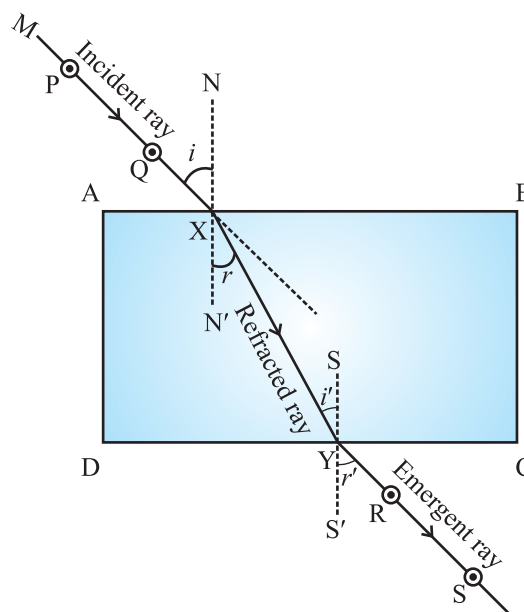


Fig. 12.1.1



Materials Required

Glass slab, drawing board, thumb pins, common pins, sheet of paper, pencil, protractor and ruler.



Procedure



DO YOU KNOW?

The rays from the Sun coming through space enter the Earth's atmosphere that is a denser medium. They bend slightly towards the normal and appear above the horizon. Thus the Sun appears to rise a few minutes earlier than the actual rise. Similar effect happens at sunset. The sun sets few minutes later. Hence, a day become about 4 minutes longer.

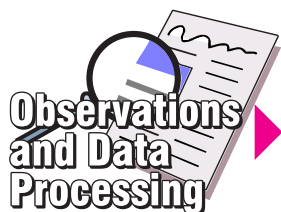
1. Fix the paper sheet on the drawing board with the help of thumb pins.
2. Place a rectangular glass slab on the sheet and mark its boundary ABCDA.
3. Remove the slab and draw an incident ray MX oblique to the interface AB.
4. Draw the normal NN' at the point of incidence X.
5. Fix two pins P & Q vertically on the incident ray MX about 5cm apart.
6. Place the slab within the boundary ABCDA.
7. Looking through the opposite side of the glass slab, fix two more pins R and S such that all the four pins appear to lie along a straight line.
8. Remove the slab and the pins. Mark and encircle the pins pricks.
9. Join R & S and extend the line upto the side CD. Let it meet CD at point Y.
10. Join X and Y. Line XY is the refracted ray.
11. Measure the angle MXN. This is the angle of incidence i .
12. Measure the angle YXN'. This is the angle of refraction r .
13. Using Snell's law, determine the refractive index as
14. Repeat the experiment two more times with different angles of incidence.

Think

Why should the pins be vertical?

Think

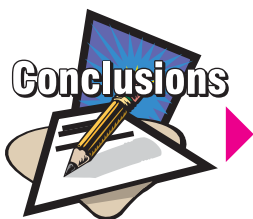
Can you predict whether a ray of light will bend towards or away from the normal?



Observations and Data Processing

No. of Obs.	Angle of incidence i	Angle of refraction r	
1			
2			
3			

Mean refractive index =



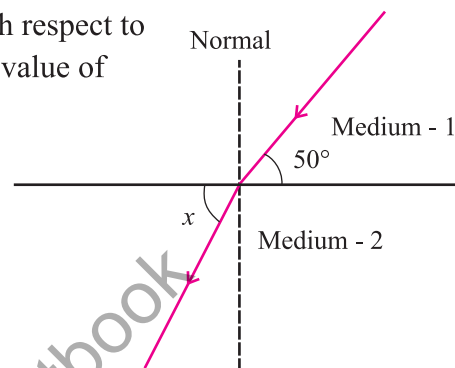
Conclusions

= cm²



Post Lab Activities

1. Refractive index of medium 2 with respect to medium 1 is 2.4. What will be the value of angle x .



2. A transparent solid with refractive index $n = 1.65$ is immersed in a liquid of exactly the same refractive index. The solid disappears. Explain this phenomenon.

3. Find the refractive index of the glass slab by applying geometrical construction on Fig. 12.1.1 without measuring the angle of incidence and angle of refraction.

4. How does this experiment prove the validity of first law of refraction?

5. A ray travels from water to air at an angle of 40° with the normal. Find the angle of refraction in the air if the refractive index of water is 1.33.

6. When you look at reflection in a sheet of glass, you often see a double image. Why?



BRAIN TEASER

1. Why does a stick immersed obliquely in water appear to be bent or short? Explain with the help of a ray diagram.
2. Why do faces of the persons sitting opposite to you around a camp fire appear to shimmer?

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Experiment 12.2

Find the refractive index of water by using a concave mirror.

Date _____

Background Information

If the object is placed at the centre of curvature of a concave mirror, the incident ray will be normal to the mirror and will be reflected back along the same path. The image will be formed at the same position as that of object. This image will be real, inverted and equal in size.

In Fig. 12.2.1, an object is placed at point A which is the centre of curvature of the concave mirror. The ray ABC strikes the surface of the mirror at C normally. This ray reflects back along the same path. The image is formed at A. There will be no parallax between the object and image at A.

On pouring some water on the surface of the mirror, the previous position of the image is changed and a parallax occurs. In order to remove this parallax the object has to be moved down to another position D.

Now the ray DB strikes the surface of water making an angle of incidence $i = \angle NBD$. It refracts into water and bends towards the normal along BC. As it strikes at C normally, so retraces its path and the image is formed at D.

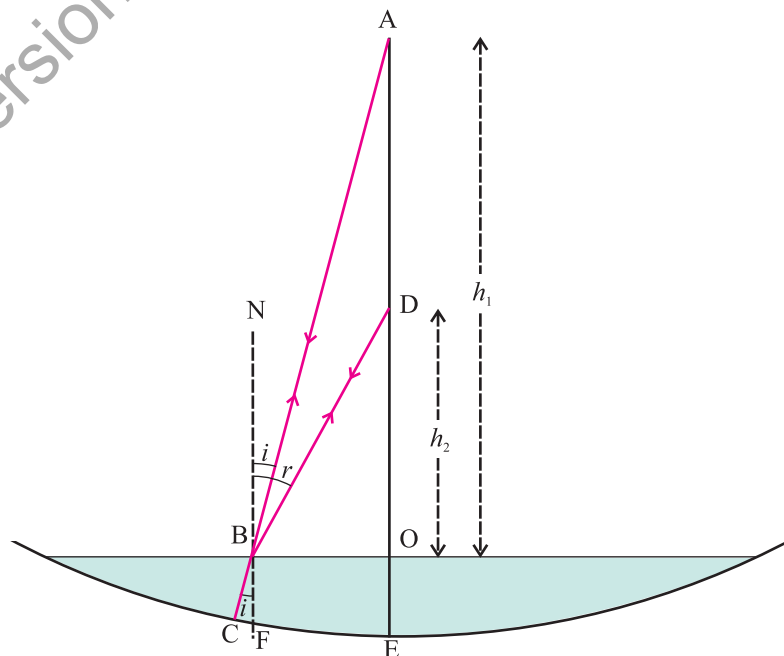


Fig. 12.2.1

Since the ray passes from denser to rarer medium, so according to Snell's Law

$$\dots\dots\dots (1)$$

In Fig. 12.2.1

$$DBN = ODB \text{ (Alternate angles)}$$

$$CBF = ABN \text{ (Vertically Opposite angles)}$$

and

$$CBF = OAB \text{ (Alternate angles)}$$

Thus relation (1) becomes

Since, angle of incidence is very small

So,

$$\dots\dots\dots (2)$$

In $\triangle ODB$

In $\triangle OAB$

Thus equation (2) becomes



DO YOU KNOW?

A car travelling on road turns around if it moves at an angle on the thick mud. The mud slows down one side of the car, and the path of the car bends.

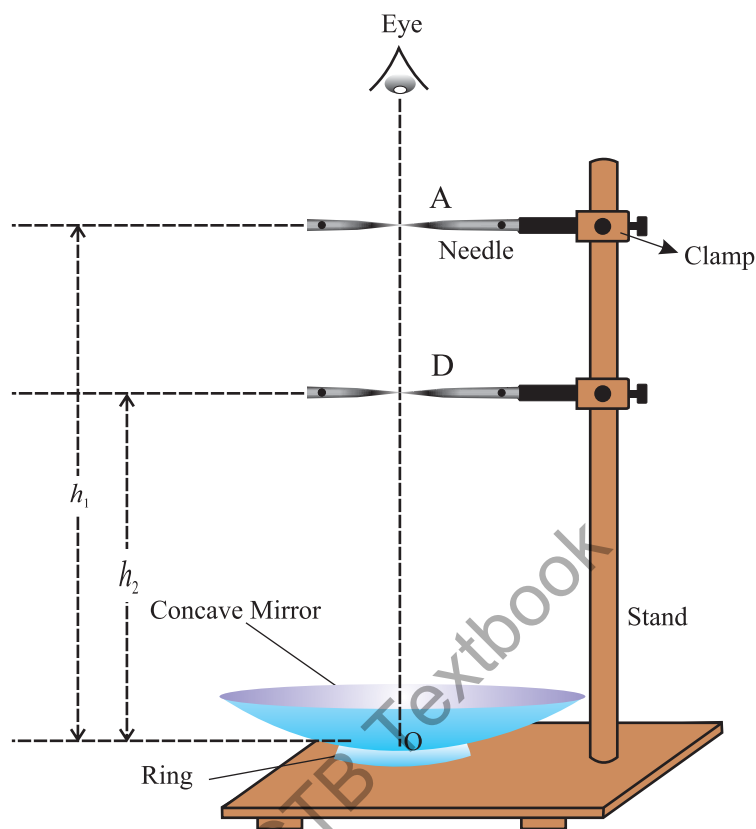
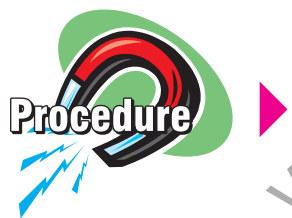


Fig. 12.2.2

Concave mirror, sharp pointed parallax needle, metre rule, iron stand with retort ring, split corks or needle holder, plumb line, water



Materials Required



Procedure

1. Clean the concave mirror with cotton cloth.
2. Obtain a clear and distinct image of a distant object on a screen/wall. Measure the distance between screen and mirror. This is approximate focal length of the concave mirror.
3. Place the concave mirror on the retort ring such that its principal axis is vertical.
4. Clamp the parallax needle horizontally above the mirror at a distance about twice the approximate focal length.
5. By viewing from the top of the needle adjust the position of needle to remove the parallax between the tip of the needle and the inverted image. (In this position, both the tips remain coincident at the center of curvature C regardless of the movement of the eye).
6. Measure the distance $OA = h_1$ between the tip of the needle 'A' to the center (pole) of the mirror 'O' using plumb line.
7. Put a few drops of water on the mirror to form a thin layer of water on the surface of mirror.....

Think

What happens to the image by pouring water on the mirror?

8. Adjust the position of the needle to remove the parallax between the tip of the needle and its image again.
9. Measure the distance h_2 between the positions of needle B to the surface of the liquid O using plumb line.
10. Measure the refractive index n using formula
11. Repeat the experiment by changing the mirror and take the mean value of n

Think

- i. How will the refractive index be affected using more amount of water?
- ii. Explain why the index of refraction of air is smaller than the index of refraction of a solid.

Observations and Data Processing

No. of Obs.	Approximate focal length f cm	Distance between needle & mirror $OA = h_1$	Distance between needle & water surface $OB = h_2$	Refractive index
1				
2				
3				

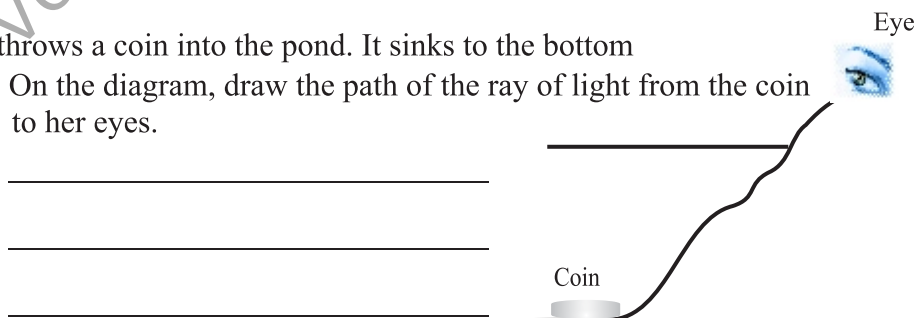
Average refractive index $n = \dots\dots\dots$ cm

Conclusions

Post Lab Activities

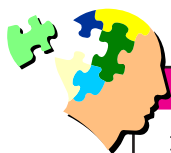
A girl throws a coin into the pond. It sinks to the bottom

- i. On the diagram, draw the path of the ray of light from the coin to her eyes.



- ii. What happens to light when it passes from water into air?.

- ii. The girl sees a virtual image of this coin. Mark 'x' on your diagram to show where this image is formed.



BRAIN TEASER

1. A hunter with his fishing spear does not aim his spear at where the fish appears to be. Explain?
2. A swimming pool appears to be shallower than its real depth is, why? Explain with the help of a ray diagram.
3. A solid and a liquid have the same refractive index. What happens on dropping the solid into the liquid?

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Experiment 12.3

Determine the critical angle of glass using a semi-circular slab and a light ray box/ or by prism.

Date _____

Background Information

When light enters from a denser medium into a rarer medium, it refracts away from the normal. With the increase of angle of incidence the value of angle of refraction also increases (Fig. 12.3.1). For a certain value of angle of incidence the angle of refraction becomes 90° (Fig. 12.3.2). This value of angle of incidence is called critical angle C . If the angle of incidence is further increased then no more refraction takes place but the light is totally reflected back in the same medium. This phenomenon is called total internal reflection. Total internal reflection can be demonstrated clearly by using a semi circular glass slab

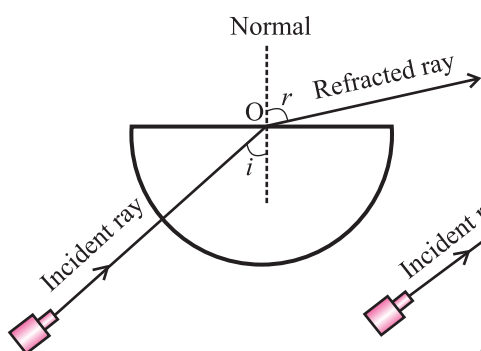


Fig. 12.3.1

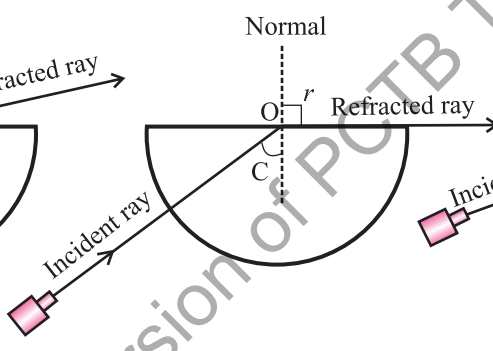


Fig. 12.3.2

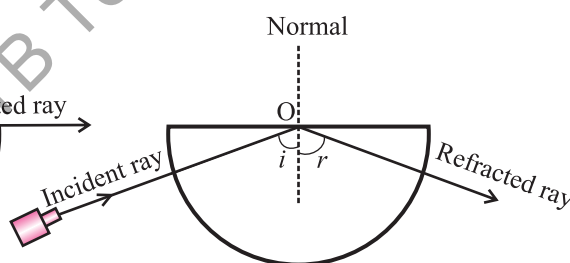


Fig. 12.3.3

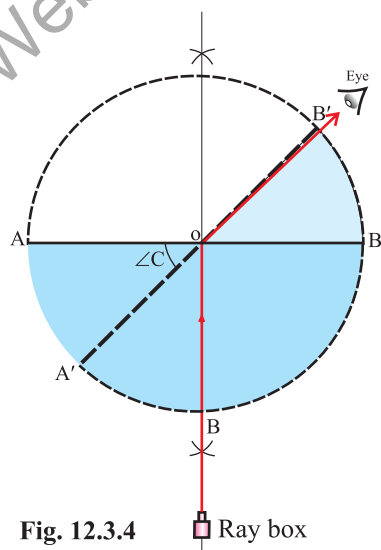


Fig. 12.3.4 Ray box

CAUTIONS

- Lasers are not toys. Do not look into the laser or point the laser towards someone's eyes. Turn off the laser when you are not using the laser light.
- The semi-circular slab should be scratchless.
- Laser / Ray box should be placed closed to the semi-circular side of the slab.



Materials Required

Semi circular glass slab, ray box / laser light, power supply (12V), single-slit slide, ruler, pencil and protractor, paper sheet, drawing board and thumb pins.



Procedure

1. Fix a paper sheet on a drawing board with the help of thumb pins.
2. Draw a straight line across the paper.
3. Place the semi-circular glass slab such that its straight edge AB coincides with this line and mark the boundary of the circular side of the slab. Rotate the slab to the other side of the straight line and mark the circular boundary to complete the circle.
4. Remove the slab and draw a right bisector PQ of the line AB to locate the centre O of the slab.
5. By using a single slit slide, adjust the ray box to get a single ray.
6. Fix the laser light ray in such a way that the ray of light exactly coincided with the line PQ.
7. Replace the slab such that its straight edge coincides with line AB and the circular edge faces towards the ray of light. In this position the ray of the light is incident normally to the edge AB at point O and it passes through the slab undeviated.
8. Now slowly rotate the slab keeping it all the time within the circle and observe the refracted ray.
9. Gradually increase the angle of incidence by rotating the semi-circular slab and continue observing the refracted ray till it just appears as reflected ray on the circular side of the slab.
10. This value of incident angle is the critical angle C.
11. Remove the glass slab and measure the angle of incidence which is the critical angle. Record this value in the table.
12. Repeat the experiment four more times and find the mean value of critical angle.

Think

Why should the ray of light be perpendicular to the semi circular edge?



DO YOU KNOW?

The reflected ray does not undergo loss in energy during total internal reflection. This fact is used in optical fibres to carry light signals over large distances in modern telecommunication system.

This experiment can also be performed by using a triangular glass prism instead of semi-circular glass slab. A circle can be drawn that passes through its vertices. Then the prism can easily be rotated with the circle with fixed centre at O (Fig. 12.3.5).

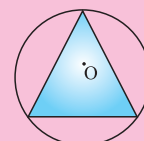
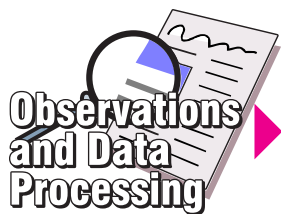
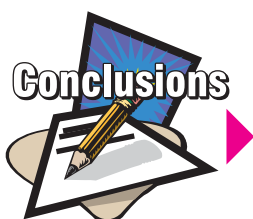


Fig. 12.3.5



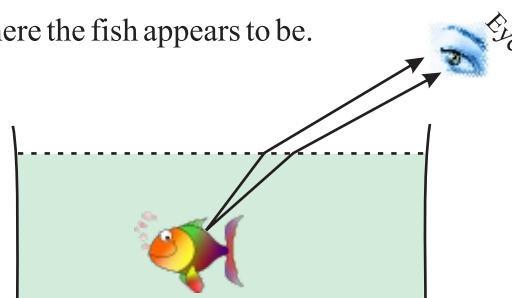
No. of Obs.	Critical angle C
1	
2	
3	
4	
5	



Mean critical angle of the glass slab, $C = \dots\dots\dots$



- Complete the diagram to show where the fish appears to be.



- Why does a road appear wet when one looks out of a car at a distant point in a summer afternoon?

- Can total internal reflection occur when light travels through water to a boundary with glass?



1. If a ray box is not available what alternative method can be used to find the critical angle?

2. Find the refractive index of glass with the help of the same apparatus by applying Snell's Law.

3. Obtain a light spectrum using a ray box and a prism.



BRAIN TEASER

Why a fish deep in water is able to see the fisherman standing at the river bank?

Experiment 12.4

Trace the path of a ray of light through glass prism and measure the angle of deviation.

Date _____

Background Information

Prism is a transparent object which has three rectangular and two triangular surfaces. The angle of the triangular surface opposite to its base is called angle of prism. It is denoted by A .

In case of refraction through a glass slab the incident ray and emergent ray are parallel to each other but in case of refraction through prism, the incident ray and emergent ray are not parallel. There is a deviation in the direction of incident ray. The angle between the incident ray and the emergent ray is called angle of deviation and is usually denoted by D .



DO YOU KNOW?

After rain, a droplet of water behaves as a prism which causes rainbow.

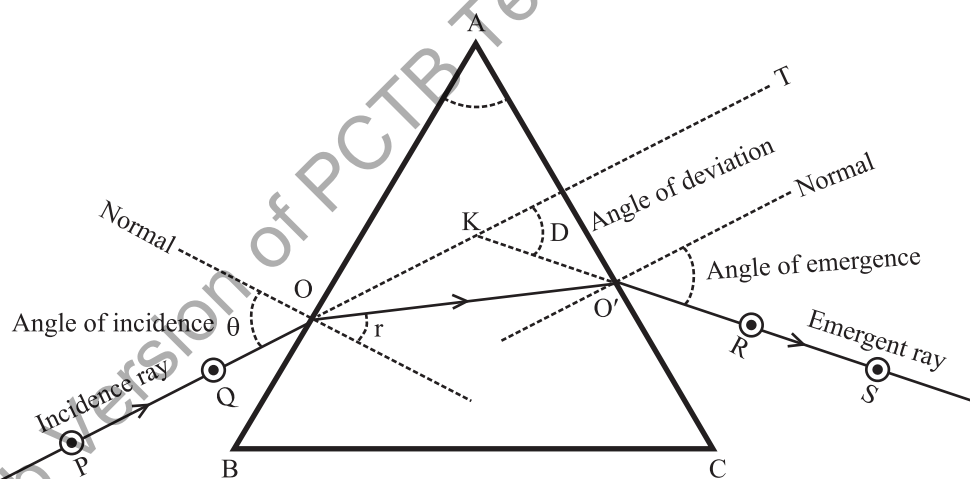


Fig. 12.5.1



Materials Required

Glass prism, common pins, sheet of paper, cello-tape, ruler, protractor



CAUTIONS

- Prism must be correctly placed within its boundary line and should not be disturbed.
- Pins must be vertical
- Do not press the pins very hard in the board otherwise you may hurt your thumb and it will become difficult to remove them.
- The angle of incidence must be 35° to 40° .



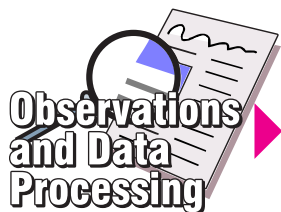
1. Fix a paper sheet on the drawing board with a cello-tape.
2. Place a glass prism in the middle of the sheet in such a way that its base is towards you.
3. Mark the boundary of the prism with a sharp pencil. Indicate the angle of prism as A and base of the prism as BC .
4. Fix a pin Q at about middle of the side AB of the prism. Fix another pin P at about 5cm away from the pin Q as shown in Fig 12.5.1.
5. Observe through the side AC and locate the position where both the pins P and Q come in a line.
6. Keeping eye in the same position fix two more pins R and S on the side AC in such a way that all the four pins appear to be in the same straight line.
7. Remove the prism and pins and encircle the pin pricks carefully.
8. Join points P and Q by a straight line and extend this line to the face AB . It meets the face AB at point O .
9. Similarly, join points R and S by a straight line and extend it to the face AC . It meets AC at point O' .
10. Join points O and O' by a straight line. $POO'S$ is the path of the light ray passing through the prism.
11. Extend the incident ray PQ forward and emergent ray RS backward. They intersect each other at a point K .
12. Measure the angle K with the help of protractor. This is the angle of deviation ' D '.
13. Repeat the experiment four times more for different values of angle of incidence and find the angle of deviation in each case.

Think

What happens if line PQ is not slanting to line AB ?

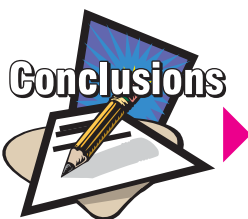
Think

Does the angle of deviation remain the same for different angles of incidence?



No. of Obs.	Angle of incidence i	Angle of deviation D
1		
2		
3		
4		
5		

Mean critical angle of the glass prism =



Conclusions

.....



Post Lab Activities

1. You are given a hollow prism. Fill it with water and find the angle of incidence and corresponding angle of refraction. Determine the refractive index of water.

2. A triangular prism is shown in the figure. The angles of prism are 90, 45 and 45. What can you say about the refractive index of the prism?



Extended Activities

1. Repeat the experiment to take at least six readings. Now plot a graph between angle of incidence and angle of deviation. Determine the value of angle of minimum deviation.

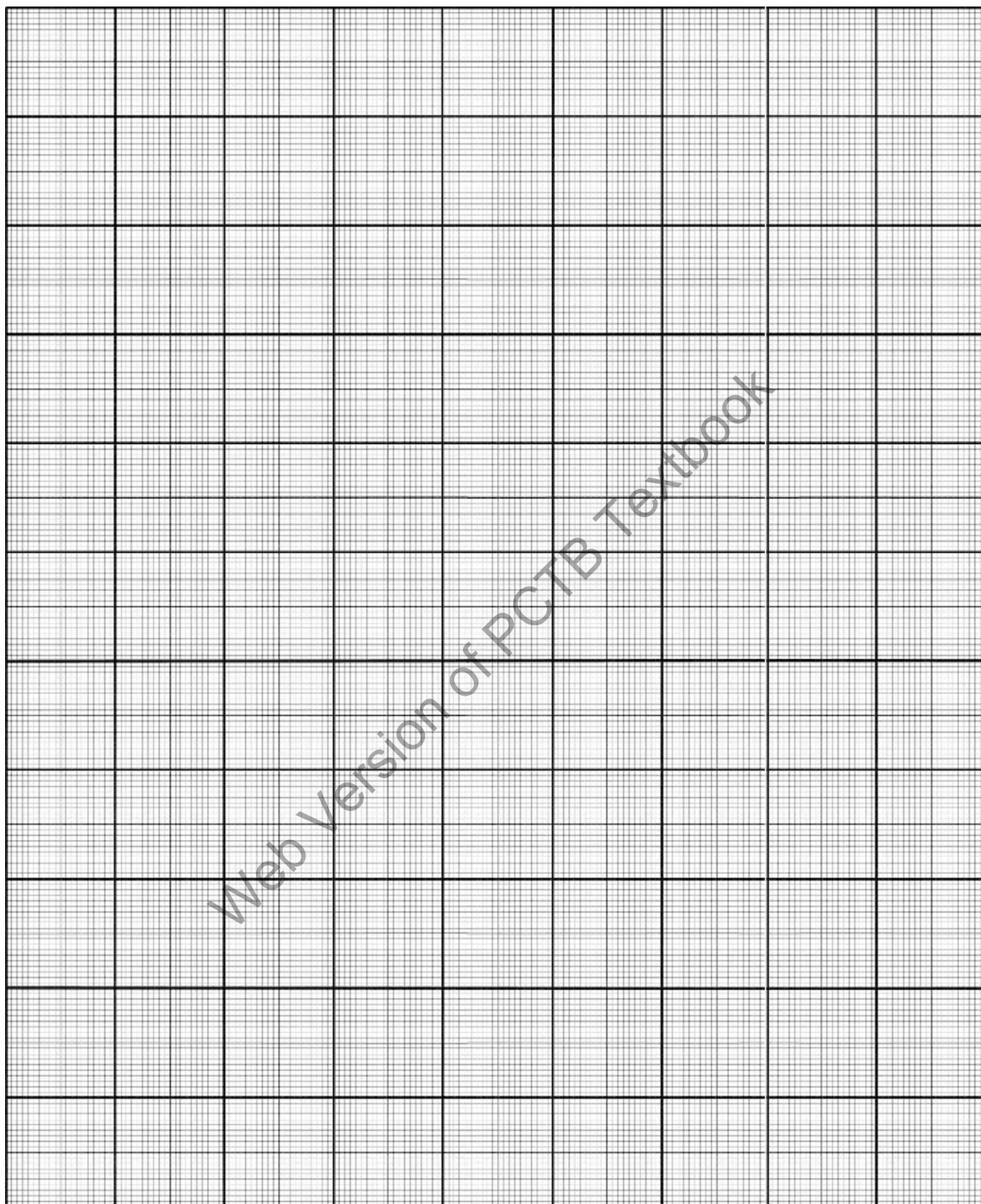
2. Determine the refractive index of the glass prism by using the formula

3. Construct a periscope by using two right angled prisms.



BRAIN TEASER

Why a fish deep in water is able to see the fisherman standing at the river bank?



Experiment 12.5

Find the focal length of a convex lens by parallax method.

Date _____

Background Information

A lens is a part of a refractive medium bounded by one or both curved surfaces.

There are two kinds of lenses

- (i) Convex lens
- (ii) Concave lens.

Parallel rays of light after passing through a convex lens, meet at a single point known as principal focus (F) as shown in Fig. 12.5.1.

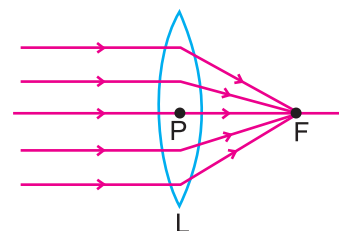


Fig. 12.5.1

The distance between optical centre O of lens and focus F is called focal length ' f '.

There are two types of images formed by lenses, (i) Real (ii) Virtual

If the rays coming from the object meet at a point on the other side of the lens after passing through it, the image is real as shown in Fig. 18.5.2. A real image can be obtained on the screen. On the other hand if the rays do not converge after passing through the lens but instead diverge, the image is not formed on the other side of the lens. It appears to be formed on the same side of the lens by backward reproducing the rays as that of the object. This is known as virtual image and cannot be obtained on the screen.

If ' p ' is the distance between the lens and the object and ' q ' is the distance between the lens and the image then the focal length ' f ' is given by



DO YOU KNOW?

1. A water drop trapped in small ring acts as a magnifying glass.
2. A thermometer stem has an oblong cross section so that due to refraction it acts as magnifying glass and the mercury thread appears magnified.

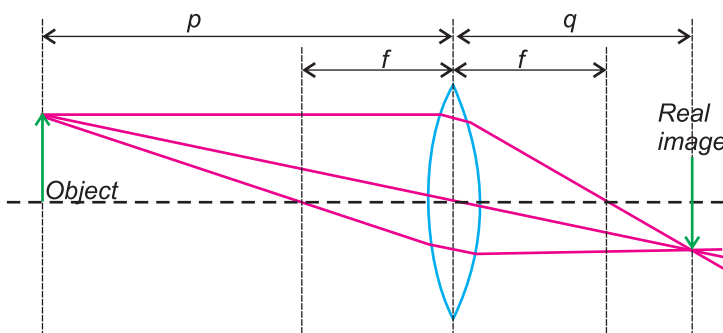


Fig. 12.5.2

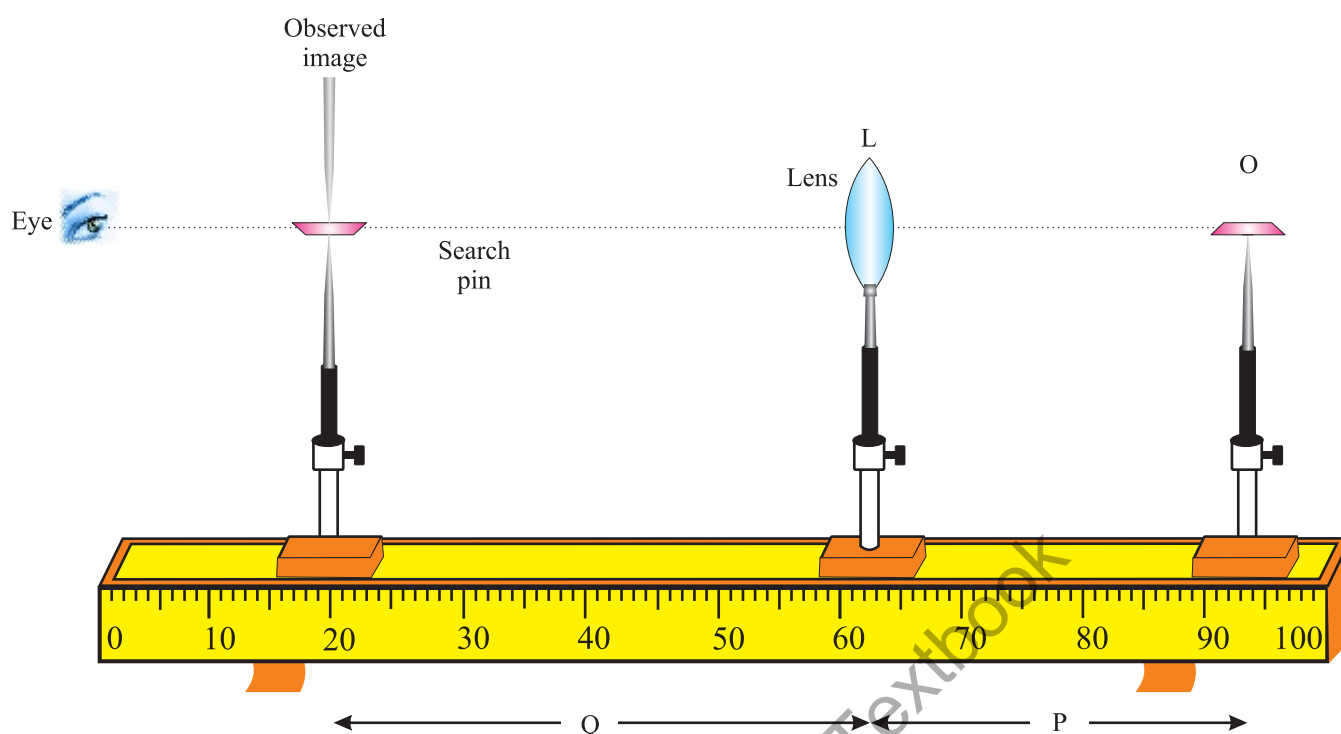


Fig. 12.5.3



Materials Required

A convex lens installed in a lens holder with base, two needle uprights and optical bench



Procedure

1. Get an image of a window or any distant object through the given convex lens on the opposite wall of the laboratory.
2. Measure the distance between the lens and the image. This distance is the approximate focal length (f_a) of the lens.
3. Place the lens upright in the middle of the optical bench.
4. Fix a piece of paper on one of the needle uprights. Label this needle as the object needle O. Place this needle upright in front of the lens at a distance of more than one focal length.
5. Place the second needle upright on the other side of the lens and label it as image needle I.
6. Look for the image of the object needle from the other side of the lens. This image will be inverted.
7. Adjust the position of the image needle to

Think

"Why should the object needle be placed at more than one focal length away from the lens?"

remove the parallax between the image and image needle, by moving this image needle back and forth.

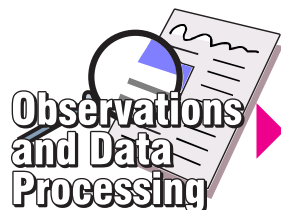
8. Note the positions of the object needle upright, image needle upright and lens upright.
9. Calculate the distance between the object needle and lens i.e. $p = OL$ and the distance between the image needle and the lens i.e. $q = IL$.
10. Calculate the focal length of the given lens using the formula
11. Take three readings by increasing the object distance in regular steps without changing the position of the lens.



CAUTIONS

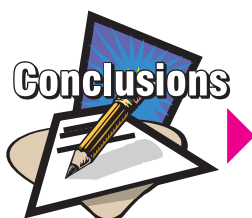
- The lens should be cleaned with a cotton cloth or with a tissue paper.
- All the upright needles should be vertical.
- Parallax should be removed carefully for each reading.

Approximate Focal Length. $= f_g = \dots\dots\dots \text{cm.}$



No. of Obs.	Position of			Distance		Focal length
	Object needle O (cm)	Lens L (cm)	Image needle I (cm)	p (cm)	q (cm)	
1						
2						
3						

Mean focal length = $\dots\dots\dots \text{cm}$



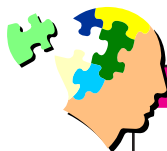


1. By measuring approximate focal length of different convex lenses, investigate, how the focal length of a lens is related to its thickness?

2. How can you make a set of rays coming from a single point to form a parallel beam of light?

3. Take three more readings in the above experiment and draw a graph between (pq) along y-axis and $(p+q)$ along x-axis. Find the slope or gradient of the graph. What does this slope represent?

4. Explain the difference between a real image and virtual image.



BRAIN TEASER

1. If object needle is replaced by a lighted candle, what arrangement would be needed to obtain its image?
2. Would you be able to obtain the image of the candle on a screen if it is placed within the focal length of the lens? Explain with the help of a ray diagram.
3. If half of a convex lens is covered by an opaque object, what shape of image would be obtained on the screen?

Experiment 12.6

(a)

Set up a Microscope.

Date _____

Background Information

A microscope is a device used to see very small objects such as bacteria and tiny cells that cannot be seen with naked eye. The microscope shows a magnified image of the object under observation. A microscope consists of two lenses

(1) Objective:

The lens close to the object is known as objective. It has very small focal length. It produces a highly magnified real image of the object.

(2) Eyepiece:

The eyepiece is the lens of the microscope close to the eye. Its focal length is relatively large. The eyepiece produces a magnified and virtual image of the real image already formed by the objective as shown in Fig. 12.6a.2.

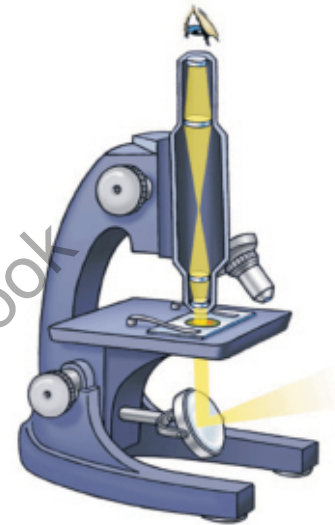


Fig.12.6a.1:
A sectional view of
Lab. Microscope



DO YOU KNOW?

When you look into some microscopes, you can see a set of cross-hairs or a ruled scale to measure sizes of features on your specimen, such a scale is called a *reticule*.

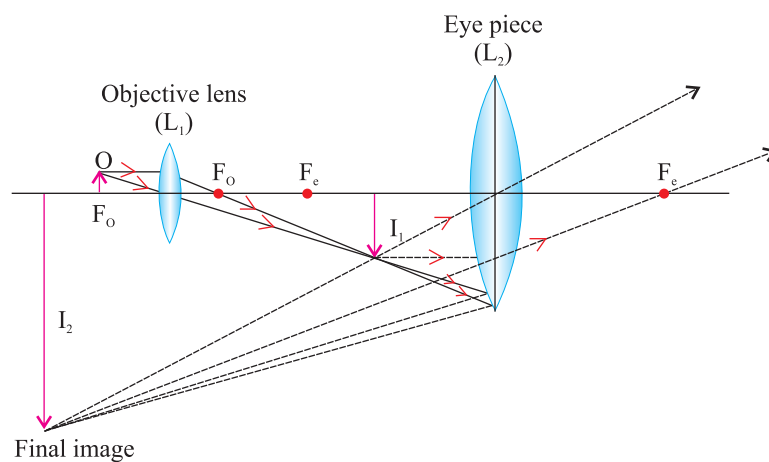


Fig.12.6a.2



Materials Required

Optical bench, a lens of focal length 10 cm (eye-piece), a lens of focal length 5 cm (objective), a meter rod and two upright needles



Procedure

1. Find approximate focal lengths of both the lenses. Record these focal lengths as f_o and f_e ($f_o < f_e$).
2. Install the lenses in their uprights (universal lens holders).
3. Place a needle upright near one end of the optical bench. This is the object OO' .
4. Place the lens with shorter focal length (objective lens) in front of the object needle at a distance slightly greater than its focal length.
5. Use second needle to locate position of a real image II' of the object OO' by removing parallax.
6. Measure distance from the objective lens to the image needle.
7. Now remove the image needle from the optical bench.
8. Place the second lens of larger focal length (eyepiece lens) on the optical bench just beyond the image position.
9. Look through this eyepiece to observe an inverted but magnified final image II of the needle.

Think

"Why the objective lens of microscope has short focal length and not a long one?"

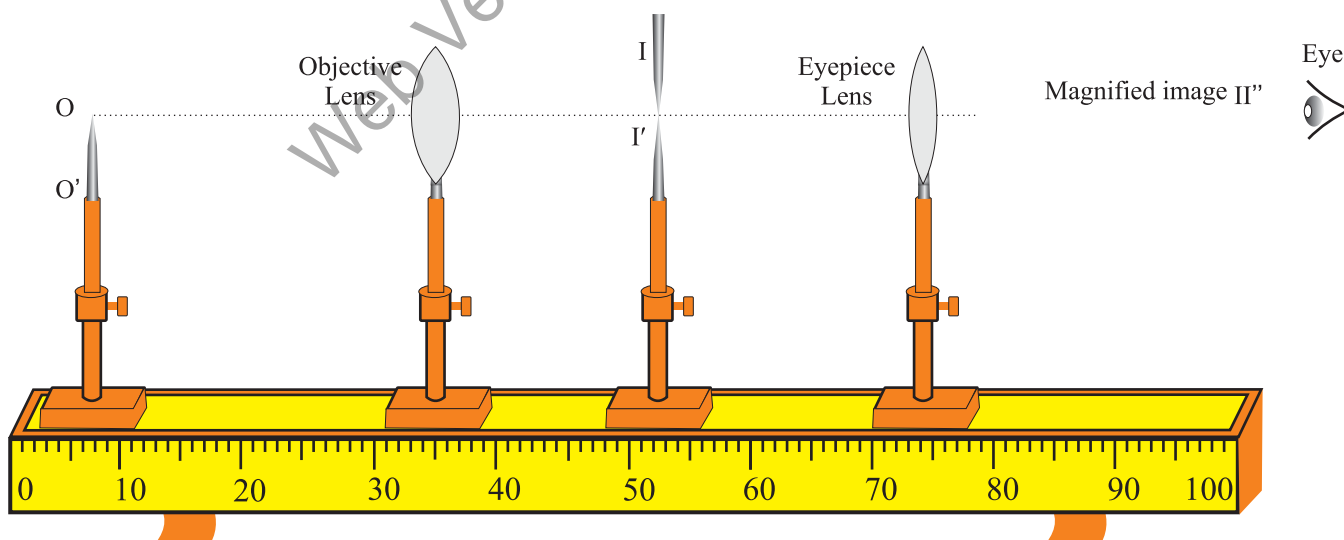


Fig. 12.6a.4



1. Identify a simple microscope in the laboratory. What is another name of this device?

2. Is it possible to make an optical microscope so strong that the atoms that make up everything would be visible?

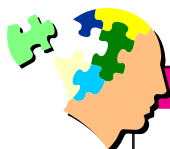
3. You are provided with a lens of shorter focal length than that you used earlier as an eyepiece. How the magnification of a given microscope will be changed?



DO YOU KNOW?



This is large 18cm screen of an electronic microscope which projects a clear image of a small specimen.



BRAIN TEASER

What effect in the working of a microscope is observed if plano-convex lenses are used instead of double convex lenses?

Experiment 12.6

(b)

Set up a Telescope.

Date _____

Background Information

A telescope is a device used to see the objects which are located at very large distances and cannot be seen clearly with naked eye. A telescope consists of two lenses.

(1) Objective:

It is the convex lens directed towards the distant object. It has large focal length ' f_o ' and a large aperture. It produces an inverted, diminished and real image of



DO YOU KNOW?

Galileo in 1609 constructed a telescope which provides an **erect image** of an object with the help of only two lenses. The eyepiece is a concave lens. **Galilean's telescope** is used to see the object on earth.

(2) Eyepiece:

The eyepiece of the telescope is also a convex lens close to the eye. It has short focal length ' f_e '. It magnifies the diminished image formed by the objective.

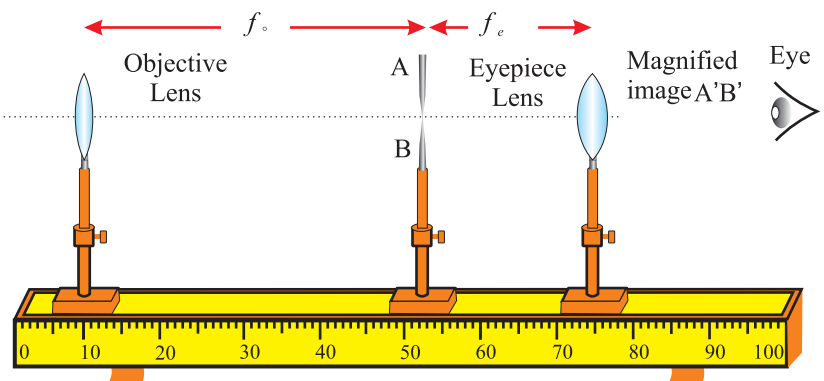
Construction

The objective is mounted on one end of a wide tube while the eyepiece is mounted on the end of a narrow tube which can slide into the wide tube. Thus the distance between the eyepiece and the objective can be changed.

Length of telescope

Distance between objective lens and eyepiece is called length of telescope. Length of telescope is $L = f_o + f_e$

Distant Object





Materials Required

Optical bench, a lens of focal length 5cm or less, a lens of focal length 20cm or greater (objective), two lens holders, a metre rod, two upright needles, a distant marked object.



Procedure

1. Find the approximate focal lengths of both the lenses. Record these focal lengths.
2. Install the lens with larger focal length (objective) in the upright and place it near one end of the optical bench.
3. Make a vertical arrow mark on the distant wall of the laboratory in front of objective about 5 m away.
4. Use the objective lens to observe an inverted and diminished image AB of the arrow mark from the other side of the lens.
5. Locate this image AB with the help of image needle upright.
6. Note the position of image AB, it will be nearly at the focal length f_o of the objective lens.
7. Now remove the image needle and place the lens upright with shorter focal length (eyepiece) just behind the image AB.
8. Locate the position of eyepiece for final image A'B'.
9. Final image A'B' is obtained when eyepiece is at f_e from the former image AB.
10. The final image A'B' will be inverted and magnified.

CAUTION

While mounting or installing on the uprights, the optical centers of the both lenses and the tip of the image needle should be in line and at the same height.

Think

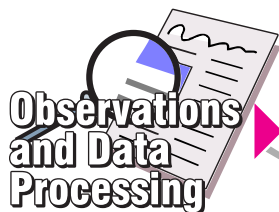
"Why has the eyepiece lens of telescope short focal length and not a long one?"



DO YOU KNOW?



The Hubble Space telescope orbits around the earth. It can take pictures of very distant galaxies clearly.



Observations and Data Processing

Approximate focal length of Objective = f_o = _____ cm.



Post Lab Activities

1. Find the length of telescope in the above experiment?

2. Replace the objective with another lens of larger focal length. What will be new length of the telescope? Compare the lengths of telescope in both the cases?

2. Determine the magnifying powers of the telescope in both the cases?



BRAIN TEASERS!

1. What changes are required to reduce the length of a telescope?
2. What is the difference between a telescope and a binoculars?

Web Version of PCTB Textbook

Experiment 14.1

Verify Ohm's Law (using wire as conductor).

Date _____

Background Information

Every conductor has some resistance. When a potential difference is applied across a conductor current starts flowing through it. The amount of current flowing through a conductor depends upon the potential difference applied as well as the resistance of the conductor.

Ohm's Law states that, "The current I passing through a conductor is directly proportional to the potential difference V across it, provided its temperature and physical state is not changed".

Mathematically,

$$V \propto I$$

$$V = IR$$

where constant R is called the resistance of the conductor.

Electric current flows easily through materials called conductors such as copper, aluminium and iron. For current to flow, there must be a closed loop of conducting materials which includes electric cell, bulb or resistance, switch and connecting wires. This loop is called a circuit and its parts such as cell, resistance and switch are called components. All components have at least two connection points called terminals.

Energy is used up when current flows in the circuit. The cell provides energy to enable the current to flow around a circuit. Potential difference across a component specifies the energy lost as the current flows through it. It is measured in volt.

CAUTIONS

1. Clean the ends of connecting wires with sandpaper.
2. All connections should be tight.
3. The voltmeter and ammeter should be connected in the circuit such that their positive ends are connected to the positive terminal of the power supply.
4. Note the zero errors of the voltmeter and ammeter, if any, before starting the experiment.
5. Always keep the key open while making connections of the circuit.
6. Always set the rheostat slider at the middle position before starting the apparatus.

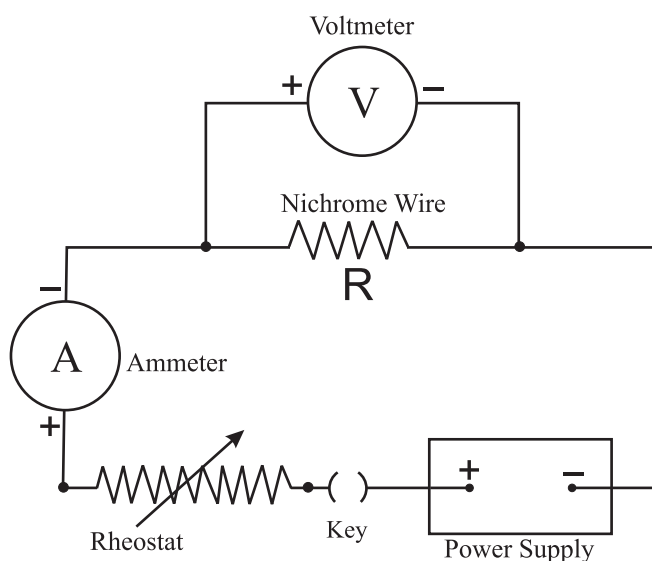


Fig. 14.1



Materials Required

Nichrome wire (of resistance not less than 10), voltmeter (0 – 15 V), ammeter (0 – 0.6 A), rheostat (50 ohm), power supply (0 – 12V, 1A), key, connecting wires and sand paper.



Procedure



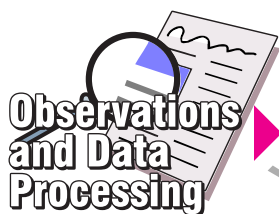
DO YOU KNOW?

Insulators are materials that resist the flow of current. They protect us from harmful effects and prevent current leakage. Insulators includes rubber, plastic, dry wood, cotton, paper, clay etc.

Think

Why should the slider of the rheostat be kept in the middle?

1. Draw the circuit diagram as shown in Fig.14.1.1.
2. Make connections according to the circuit diagram. Nichrome wire is used as a conductor.
3. Before starting the experiment, bring the slider of the rheostat to its middle.
4. Turn the power supply ON. Slowly rotate its knob till the voltmeter shows a reading of 6 volts.
5. Close the key. A current should flow through the circuit as indicated by the ammeter.
6. Adjust the rheostat so that the current in the circuit remains within the range of ammeter.
7. Note the readings of voltmeter (V) and ammeter (I).
8. Determine the resistance R of nichrome wire for each reading by using the formula
9. Take four more readings by changing the resistance of the rheostat.



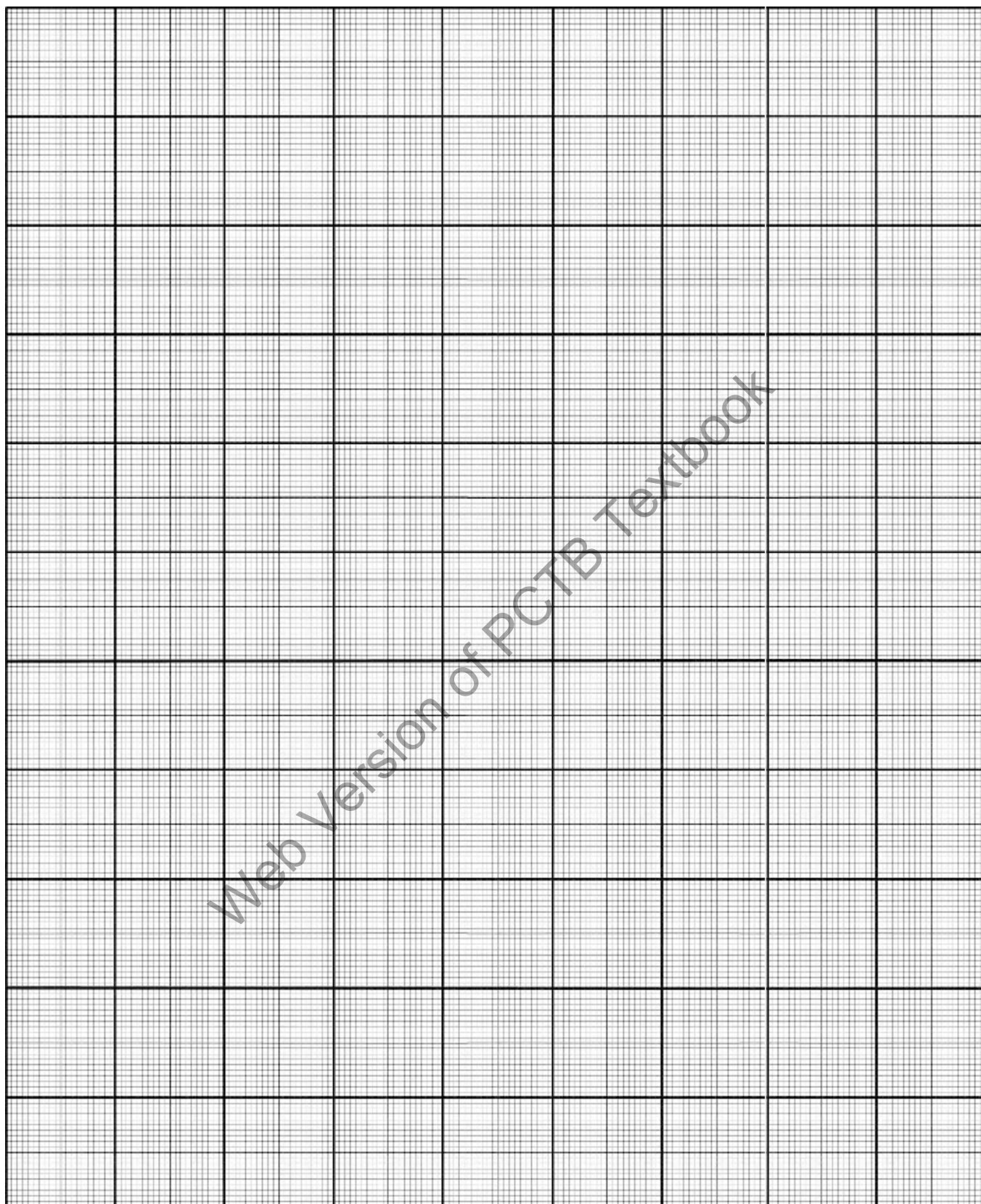
Observations and Data Processing

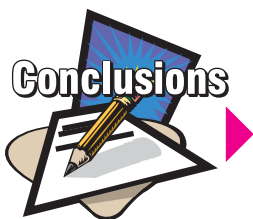
No. of Obs.	Voltmeter reading V (V)	Ammeter reading I (A)	Resistance of conductor
1			
2			
3			
4			
5			

Mean resistance $R = \text{-----} \Omega$.

Graph

Draw a graph for V versus I .





Conclusions



Post Lab Activities



DO YOU KNOW?

Most of the devices like fluorescent tube, energy saver, electrical bulb and electrolytes do not obey Ohm's law. Only a conductor at constant temperature obeys Ohm's law.

1. A switch can act both as a conductor and as an insulator. Comment on the statement..

2. Determine the value of resistance R of the conductor from graph drawn for nichrome wire

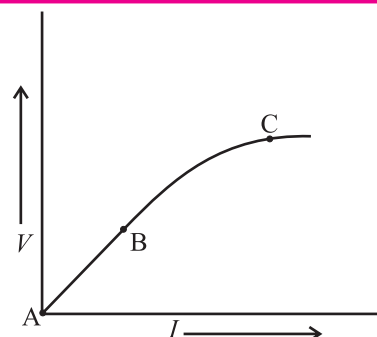
3. Connect a 6V bulb in the circuit in place of nichrome wire. Take five reading of V & I . Draw V versus I graph. Does it verify Ohm's Law? Give reason

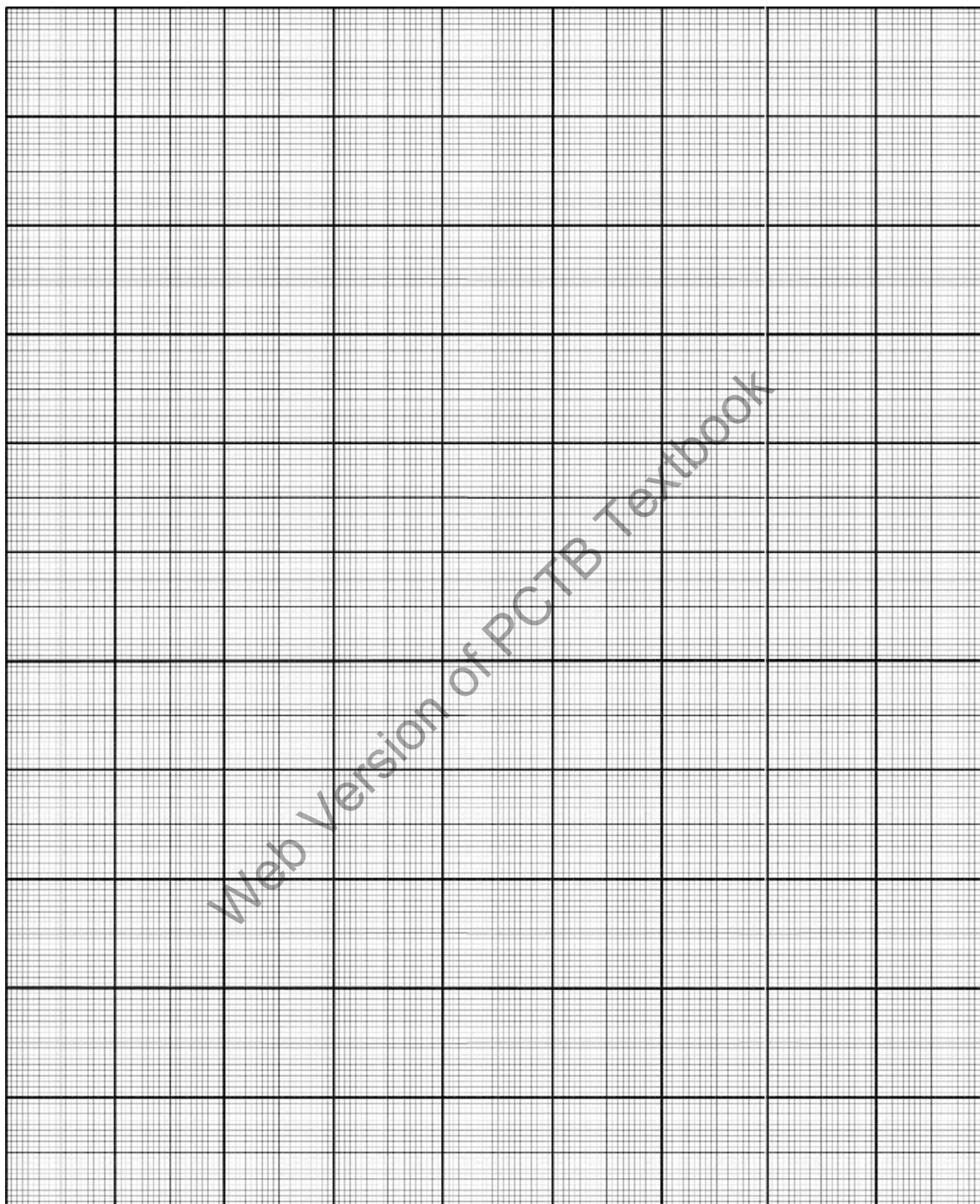
4. Repeat the above experiment by using nichrome wire of double the length. Draw its $V-I$ graphs on the same graph paper. What do the two different straight lines show with reference to the slope? Can you tell which of the two wires has greater resistance?



BRAIN TEASER

1. What does this graph indicate?
 - (i) From A to B
 - (ii) From B to C
 - (iii) Name the device which follows this graph.





Experiment 14.2

Study resistors in series circuit.

Date _____

Background Information

CAUTIONS

- Connect the key to the positive of the power supply.
- Connect ammeter and voltmeter according to their polarity, i.e. the positive terminal of the meter should be towards the positive terminal of the power supply.
- Open the key after every reading and close it again before taking the next reading.



DO YOU KNOW?

The bulbs connected in series have to share the voltage of the power supply, so such bulbs glow dimly.

When two or more resistors are joined together, one after the other, the circuit is called series combination of resistors. In such a combination there is only one path for the current to flow. Fig. 14.2.1 shows the resistors R_1 , R_2 and R_3 connected in series. This type of combination has the following characteristics:

- In a series combination, the current is the same through each resistor.
- The total potential drop across the series combination is equal to the sum of the potential drops across all the resistors connected in series. For n resistors, the potential difference V across the combination is

$$V = V_1 + V_2 + V_3 + \dots + V_n$$

- The equivalent resistance R_e is equal to the sum of the resistances R_1 , R_2 , R_3 , and R_n connected in series.

$$R_e = R_1 + R_2 + R_3 + \dots + R_n$$

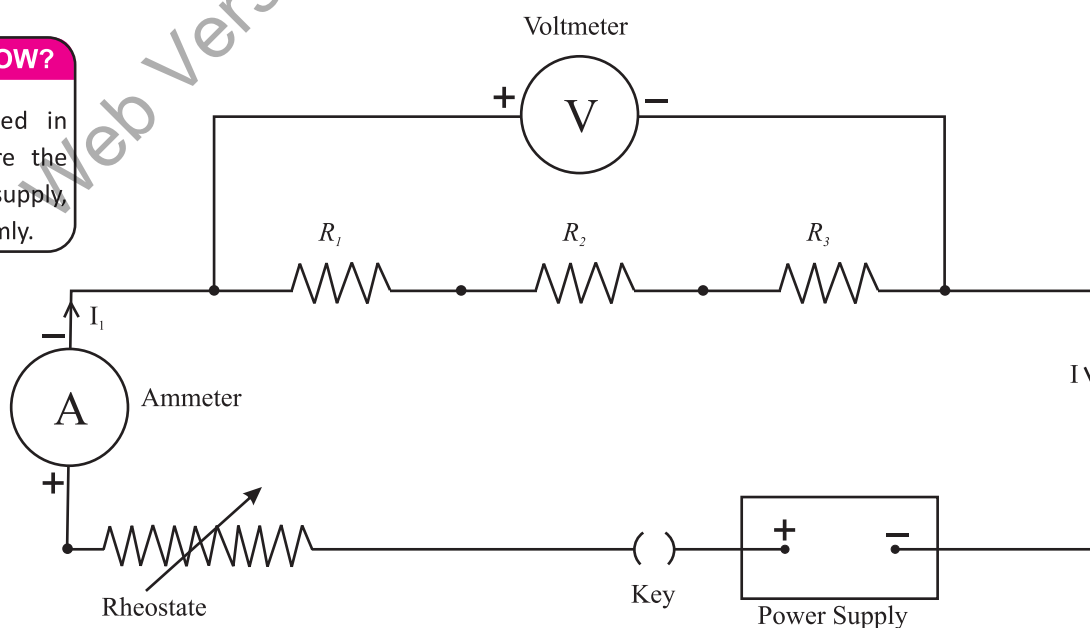


Fig. 14.2.1



Materials Required

Standard resistors of 8.2Ω , 10Ω and 12Ω of 5 watt each, variable power supply (0-12V/2A), voltmeter (3V, 15V), ammeter (0.6A, 3A), key, rheostat (0-50 ohm), connecting wires and sandpaper.



Procedure

1. Make a circuit as shown in Fig. 14.2.2. Keep the key open.
2. Connect the voltmeter across resistor R_1 .
3. Set the slider of the rheostat in the middle.
4. Turn the power supply ON and adjust it to about 6 volt output.
5. Close the key. Adjust the rheostat so that voltmeter and ammeter show readings which can be read accurately.
6. Note the reading V_1 of voltmeter and I of ammeter and record them in the table 14.2.1.
7. Open the key and connect the voltmeter across resistor R_2 .

Think

An ammeter has a very low resistance. How should it be connected to a circuit components?

Think

Voltmeter has a very high resistance. How should it be connected to a bulb?

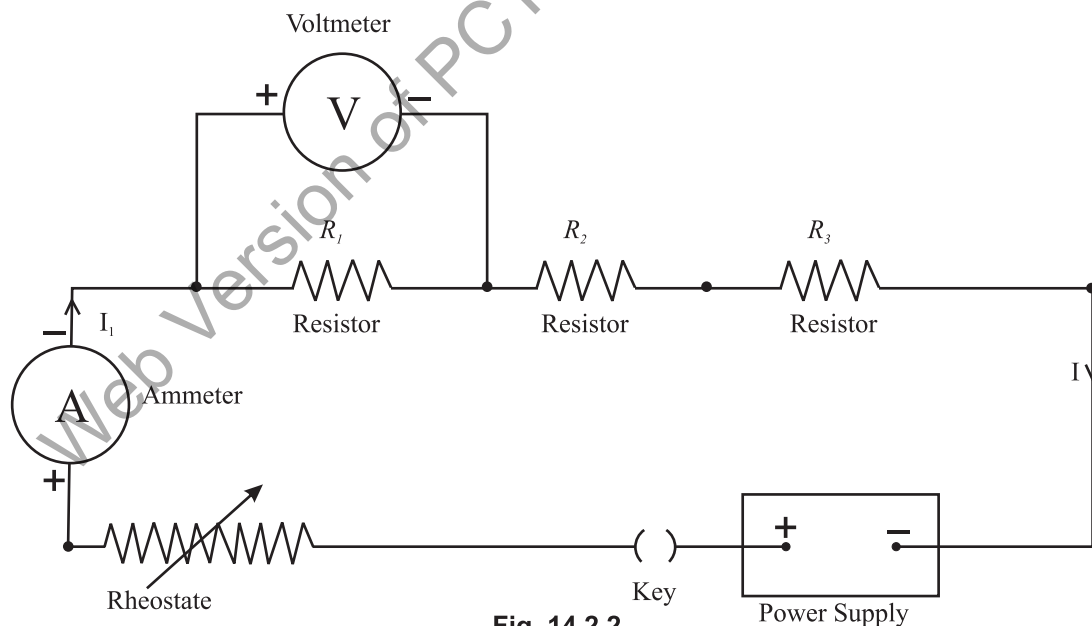


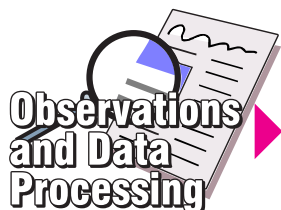
Fig. 14.2.2

8. Without changing the current in the circuit, close the key again.
9. Note the reading V_2 for the same current I .
10. Repeat steps 7, 8 and 9 for the resistor R_3 .
11. Now connect the voltmeter across all the resistors connected in series.

Think

Why does the current in the circuit not change when the voltmeter is connected across any resistor?

12. Note the reading V' of the total potential difference across the three resistors for the same current I in the circuit.
13. Take two more readings for V_1 , V_2 , V_3 and I by changing the current of the circuit with the help of rheostat and record them in table 14.2.1.

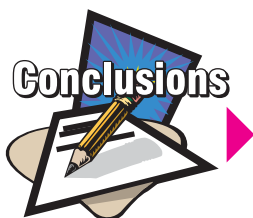


No. of Obs.	Ammeter reading I	Voltmeter readings				Sum of Potential Drops $V = V_1 + V_2 + V_3$ (V)	Difference $V - V'$ (V)
		V_1 (V)	V_2 (V)	V_3 (V)	V'		
1							
2							
3							

Table 14.2.1

No. of Obs.	Resistance	Resistance	Resistance	Sum of resistances $R_c = R_1 + R_2 + R_3$	Observed Equivalent resistance	Difference $R - R_c$
	(Ω)	(Ω)	(Ω)	(Ω)	(Ω)	(Ω)
1						
2						
3						

Table 14.2.2



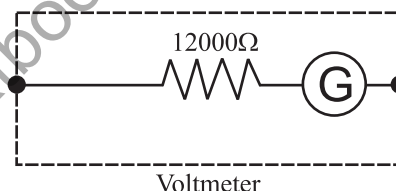
1.
2.
3.



1. Festive lights used for building decorations are made by connecting many small bulbs in series. If one of the bulbs gets fused, would the others continue to glow? Explain the reason

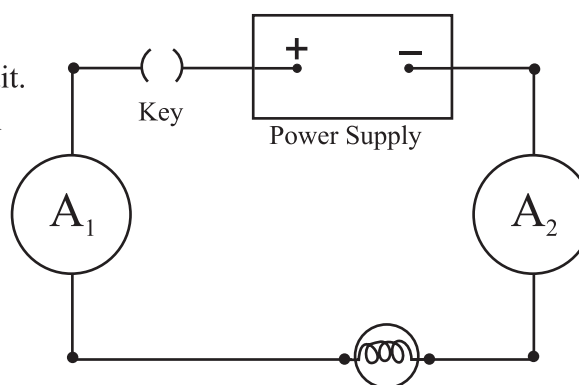
2. Select any two suitable resistors of known values and join them in series by using the apparatus given in experiment No.14.2.2 to make an electric circuit. Find the equivalent resistance of the resistors experimentally and then compare it with its value calculated theoretically.

3. A high resistance of 12000Ω is connected in series with a galvanometer to form a voltmeter. If the resistance of the voltmeter is 12150Ω , what is the resistance of the galvanometer?



4. Why is the resistance of a long wire greater than that of a shorter one of the same thickness and material?

5. Consider the given circuit. Ammeter A_1 shows $0.5A$ current. What is the current passing through the bulb and what reading is shown by ammeter A_2 ?



BRAIN TEASER

Six bulbs are connected in series in a circuit. If two more bulbs are added in series with them, what will be the effect on the brightness of the bulbs now? How will be the current affected? Give reason.

Experiment 14.3

Study resistors in a parallel circuit.

Date _____

Background Information

CAUTIONS

- Connect the key to the positive of the power supply.
- Connect ammeter and voltmeter according to their polarity, i.e. the positive terminal of the meter should be towards the positive terminal of the power supply.
- Open the key after every reading and close it again before taking the next reading.

When two or more resistors are joined in such a way that one end of all the resistors is connected to one point and all the other ends to another point then this combination is called parallel circuit.

Fig. 14.3.1 shows resistors R_1 , R_2 and R_3 connected in parallel. A parallel circuit provides different paths for the flow of current. It has the following characteristics.

- Potential difference across all the resistors connected in parallel is the same.
- The sum of the currents through all the resistors connected in parallel is equal to the total current entering the combination.

$$I = I_1 + I_2 + I_3$$

- The equivalent resistance of R_1 , R_2 and R_3 connected in parallel is given by R_e where

If n resistors R_1 , R_2 , R_n are connected in parallel, their equivalent resistance R_e is given by

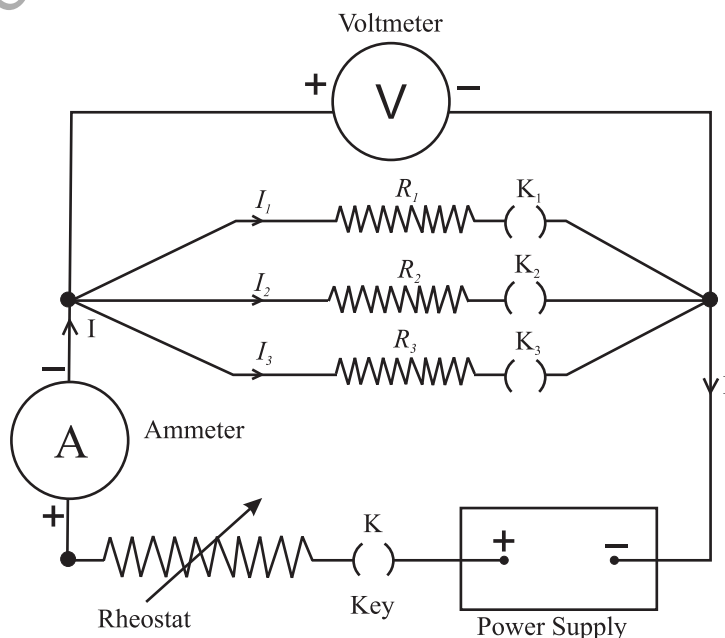


Fig. 14.3.1



DO YOU KNOW?

Standard wire resistors of 5.6, 6.8, 8.2, 10, 12, 18, 22, 27 and 39 ohms are easily available



Materials Required

Wire wound standard resistors of 22Ω , 27Ω , and 33Ω each of 5 watt rating, voltmeter (3V, 15V), ammeter (0.6A, 3A), variable power supply (0-12V/1A) connecting wires, 4 one way keys and rheostat (0 – 50 Ω).



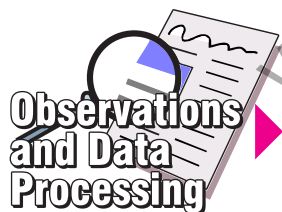
Procedure

1. Assemble the circuit as shown in Fig. 14.3.1. Keep all the keys open.
2. Set the rheostat at the middle.
3. Turn the power supply ON. Adjust it to about 6 volts output and close the key K.
4. To determine the value of R_1 , close the key K_1 . Adjust the rheostat such that the readings of ammeter is accurately readable. Note the values of V and I_1 in table 14.3.1. Determine the value of R_1 using the relation and record this value in Table 14.3.2.
5. Open key K_1 and close key K_2 . Adjust the rheostat again to bring the voltmeter reading to the same value V and determine the value of R_2 .
6. Similarly open key K_2 and close key K_3 to find the values of I_3 and R_3 .
7. Now close all the keys. Adjust the rheostat to obtain the same value of V as in steps 4 to 6. Note the values of V and I' .
8. Take two more sets of readings of V and I (step 7) by changing the voltage V each time with the adjustment of rheostat.
9. Repeat step 4 to note the current I_2 and determine the value of R_2 .



DO YOU KNOW?

Resistors in parallel have effective resistances which is smaller than that of the smallest resistor in the circuit.



Observations and Data Processing

No. of Obs.	Voltmeter reading V (V)	Ammeter readings through				Sum of the currents $I = I_1 + I_2 + I_3$	Difference (A)
		R_1	R_2	R_3	R_c		
		I_1 (A)	I_2 (A)	I_3 (A)	I' (A)	$V = V_1 + V_2 + V_3$ (A)	$I - I'$ (A)
1							
2							
3							

Table 14.3.1



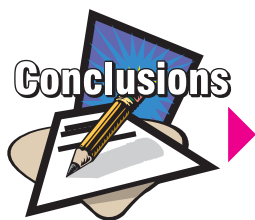
DO YOU KNOW?

When a low resistance is connected in parallel with a galvanometer, it is called a shunt.

No. of Obs.	Resistance (Ω)	Resistance (Ω)	Resistance (Ω)	Sum Reciprocal of resistances	Equivalent Resistance R_e	Observed Equivalen resistance (Ω)	Difference $R_e - R$ (Ω)
1							
2							
3							

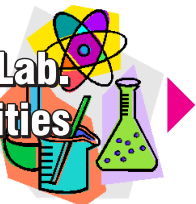
Table 14.3.2

Conclusions



-
-
-

Post Lab Activities



- Resistances of values 1, 100 and 1000 are connected in parallel. What is the equivalent resistance of the combination? What conclusion do you draw from this example?

.....
.....



DO YOU KNOW?

When current passes through a resistor, it is heated up and sometimes it also burns up. In order to avoid this mishap, resistors are designed to dissipate power without overheating. This power is indicated by the wattage of the resistor. The wattage depends upon the size and material of the resistor.

- An ammeter is formed by shunting a galvanometer with a low resistance. If the resistance of the galvanometer is 50 ohm and that of the shunt is 0.0001 ohms, what is the resistance of the ammeter?

.....
.....

- A current of 2mA is passing through a resistance of 1k Ω (Fig.14.3.2a).

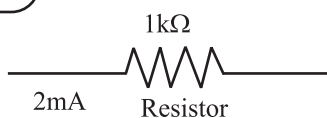


Fig. 14.3.3(a)

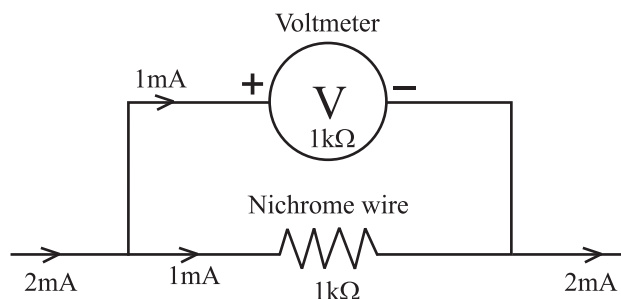


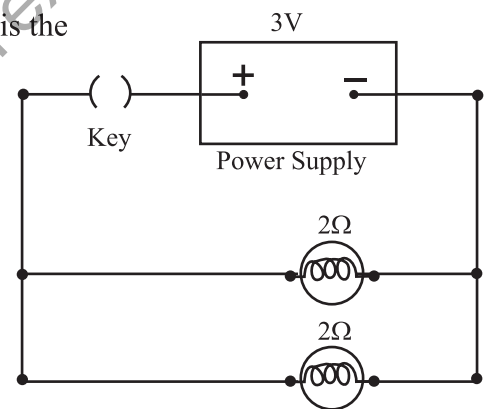
Fig. 14.3.3(b)

What is the potential difference across it? A voltmeter of $1k\Omega$ is connected across this resistance to measure the potential difference (Fig.143.2b). What potential drop will be indicated by the voltmeter? What conclusion do you draw from this example?

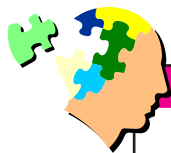
4. What arrangement, parallel or series, would you use to connect the lights in a room? Explain your reason.
-
-

5. Why the main fuse wire is connected in series with the electric meter in an household electric circuit?
-
-

6. Consider the given circuit. What is the potential difference across the two bulbs and current passing through each bulb?
-
-
-



1. Design an experiment to find the equivalent resistance of three resistors such that one resistor is connected in series with the parallel combination of other two. Compare it with theoretically calculated result.
-
-



BRAIN TEASER

1. What will happen if the electrical appliances are connected in series in a household electrical circuit?
2. What will happen to a circuit if a student by mistake interchanges the positions of ammeter and voltmeter?

Experiment 14.4

Find the resistance of galvanometer by half deflection method.

Date _____

Background Information

Consider a parallel combination of a galvanometer of resistance R_G and a resistance R_s . The resistance R_s is usually known as shunt resistance. This parallel combination is connected into a circuit carrying current I as shown in Fig. 14.4.1. As the current I enters into the parallel combination, it divides into two parts I_G and I_s .

In Fig. 14.4.1

Potential drop across the galvanometer $= I_G R_G$

Potential drop across the shunt $= I_s R_s$

As the galvanometer and the shunt are connected in parallel, so

$$I_s R_s = I_G R_G \quad \text{or}$$

and the total current

$$I = I_G + I_s$$

Substituting the value of I_s

CAUTIONS

- By means of a fine sandpaper, remove the insulation from the ends of the connecting wires.
- Be sure that all connections are tight.
- Initially the key K_1 should be open. Take out a high value of the resistance R (of the order of thousands of ohms) and then close the key K_1 .
- The value of R should be much greater than the resistance of the galvanometer. This is to ensure that value of the total current I does not appreciably change when shunt is connected to the

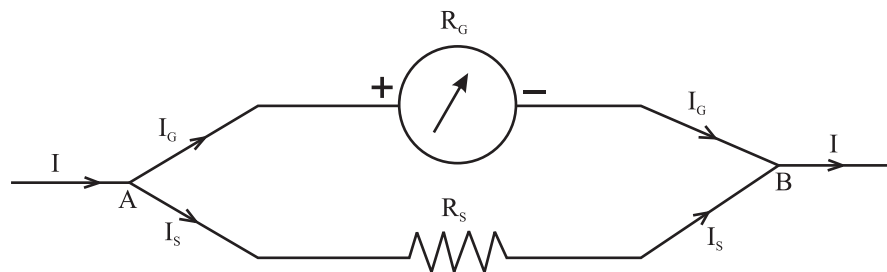


Fig. 14.4.1

As the galvanometer shows half deflection, so

Therefore,

$$\frac{1}{2} = I \times \frac{R_s}{R_s + R_G}$$

$$\text{or } 2R_s = R_s + R_G$$

$$\text{or } R_G = R_s$$



Materials Required

Galvanometer, dry cell, high resistance box (0-10kΩ), low resistance box (0-500Ω), 2 one-way keys and connecting wires.



DO YOU KNOW?

An ordinary galvanometer has a coil and a permanent magnet. When the current passes through the coil, a magnetic field is generated which interacts with the magnetic field of the magnet as a result of which the coil rotates. A digital meter has no coil and no magnet. It does not work upon the magnetic effect of current. It is based on the working of a digital circuit known as Analog to Digital Converter (ADC).

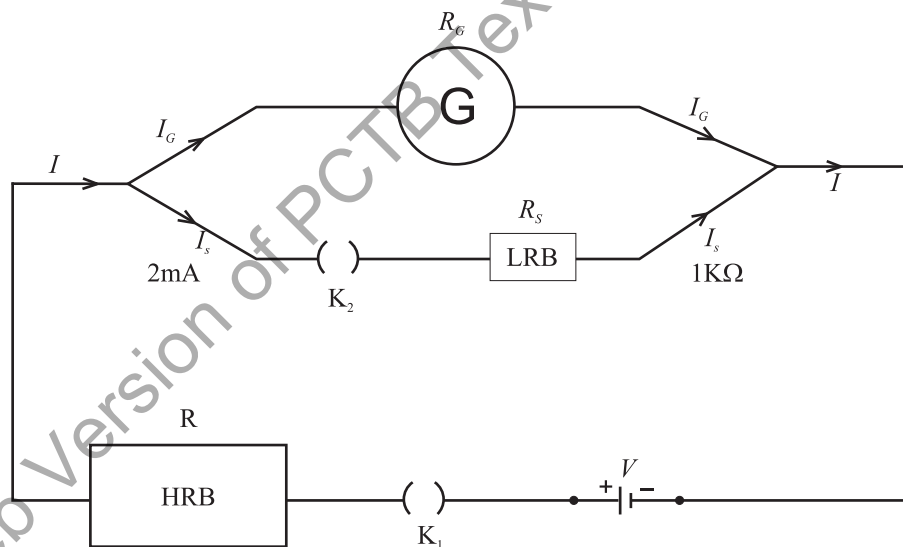


Fig. 14.4.2

1. Assemble the circuit as shown in Fig. 14.2.2. Keep the key K_1 open and K_2 closed.
2. Take a high resistance R from the resistance box (HRB).
3. Close the key K_1 and open the key K_2 .
4. Adjust the resistance R , so that the galvanometer shows a high even number deflection. Now the whole current I is passing through the galvanometer.



Procedure

Think

Why a high resistance is taken out from the resistance box before closing the key K_1 ?



5. Close the key K_2 . The deflection will become zero.
6. Adjust the shunt resistance R_s so that the deflection in the galvanometer is exactly the half?
7. Repeat the experiment by changing the resistance R for another even value of . In this way take three more readings and record them.

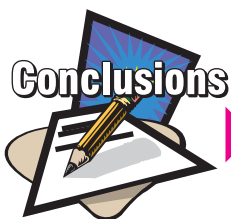
Think

Why does the deflection become zero on closing the key K_2



No. of Obs.	High Resistance R (Ω)	Deflection θ (Ω)	Shunt Resistance R_s (Ω)	Deflection	Resistance of Galvanometer $R_G = R_s$ (Ω)
1					
2					
3					

Mean value of $R_G = \dots\dots\dots \Omega$



.....



1. Determine the resistance of the galvanometer by adjusting shunt resistance so that the deflection θ is reduced to .

.....

2. Resistance of the galvanometer is due to a coil fixed inside it. Why do not we directly measure its resistance like an ordinary resistor?

.....



BRAIN TEASER

1. What will happen to the reading of an ordinary galvanometer if a strong magnet is brought near it?
2. Can you measure the resistance of a voltmeter by half deflection method?

Experiment 15.1

Trace the magnetic field due to a bar magnet.

Date _____

Background Information

A substance which has a tendency to attract certain materials like iron, nickel, cobalt etc. is called a magnet.

The materials which are attracted by the magnets are called magnetic materials. The region or space around a magnet where it shows its effect of attraction on magnetic materials or another magnet is called magnetic field.

Magnetic field is usually represented by drawing arrow lines indicating the direction of the magnetic force. These lines are called magnetic lines of force. Magnetic lines of force are traced by a compass needle.

A magnet has two poles; north pole and south pole. The magnetic lines of force emerge from North pole and enter into the South pole. Closer lines mean a stronger magnetic field.

CAUTIONS

- Gently tap the drawing board near the compass needle before marking the dots.
- Board and magnet should not be displaced from their position.
- No other magnet or magnetic material should be placed near the apparatus during the experiment.
- Draw arrowheads to show the direction of magnetic lines of force.
- Join the marked points with free

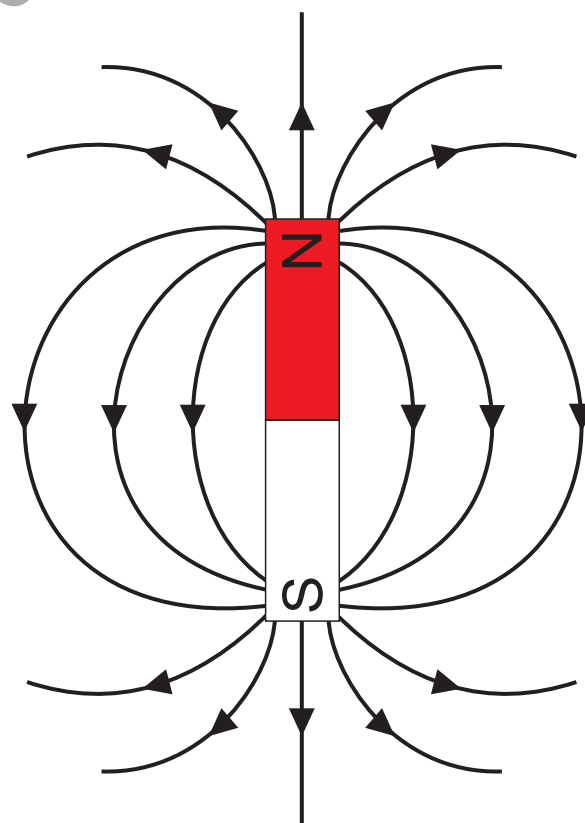
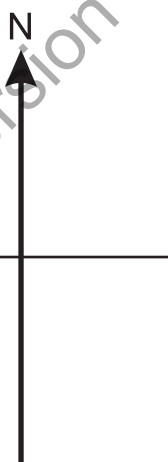


Fig. 15.1.1



Materials Required

Bar magnet, compass needle, drawing board, sheet of paper, cello tape, and piece of chalk.



Procedure

1. Fix the paper sheet on the drawing board with the help of cello tape.
2. Draw a line at the centre of the sheet.
3. Place the compass needle on this line.
4. Adjust the orientation of the drawing board such that the ends of the compass needle point along the line. Mark N for north and S for south.
5. Mark the boundary of the board on the table top with a piece of chalk.
6. Place the magnet on the line with its north pole pointing towards geographical north. Draw the boundary of the magnet with a pencil.
7. Put a dot on the paper near to north pole of the magnet.
8. Place the compass needle near the dot such that its south end points toward the dot. Put the next dot at the north end.
9. Repeat the process till it reaches the south pole of the bar magnet.
10. Draw a free hand line by joining all the dots. The line will originate from north pole and terminate at south pole. Mark arrow heads on this line from north towards south.
11. Similarly draw a number of lines on both sides of the bar magnet.
12. The drawn lines show the magnetic field of the bar magnet.

Think

Why is the compass needle is adjusted along the drawn line?

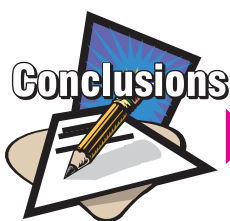


DO YOU KNOW?

A freely suspended magnet always points in north-south direction. This is called directive property. This property was put to use by sailors to point out the directions. Initially, this freely suspended stone was called leading stone. Later the name was changed to lodestone.

Think

Why is it necessary to draw the boundary of the drawing board?



Conclusions



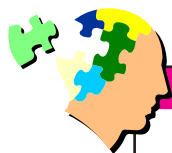
Post Lab Activities

1. Place two bar magnets parallel to each other at 8 cm apart with their north poles pointing in the same direction. Plot the magnetic field lines in the space between the magnets and outside the magnets. Where is the field stronger?

2. Draw the magnetic field of a U-magnet.

3. Why does a compass needle align itself up with the magnetic field?

4. Give three examples of domestic appliances in which permanent magnets are used.



BRAIN TEASER

1. A boy was placing the bar magnet near the fire. Why it is not advisable?
2. A magnet is surrounded by an iron sheet. How does this sheet protect the surroundings from magnetic effect?
3. A magnet is cut into two pieces from the middle. Will North and South Pole be separated?

Experiment 15.2

Trace a magnetic field due to current in a circular coil.

Date _____

Background Information

Magnetic field due to current in a wire

The magnetic field due to a current carrying wire is shown in Fig. 15.2.1.

The magnetic lines of force are in the form of concentric circles around the current carrying wire. The direction of these magnetic lines of force at any point is indicated by right hand grasp rule as shown in Fig 15.2.2.

The magnetic effect of current increases if a circular coil is used instead of a straight wire. A circular coil consists of several turns of insulated copper wire closely wound together.

A current carrying circular wire (or coil) behaves as a short bar magnet.

The strength or intensity of a coil's magnetic field depends on the following of factors.

- The number of turns of wire in the coil.
- The amount of current flowing through the coil.

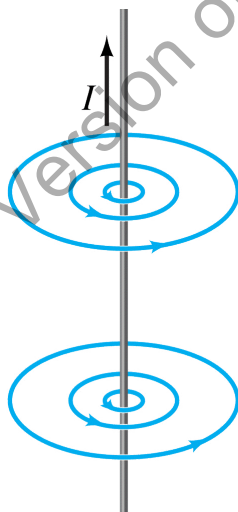


Fig. 15.2.1

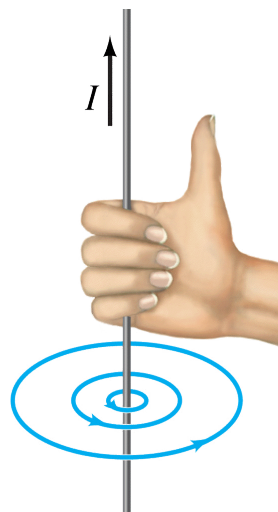


Fig. 15.2.2

Materials Required

Circular coil of insulated copper wire having large number of turns fixed in a wooden board, a sheet of paper, cello tape, compass needle, power supply (0 — 12V), ammeter (0-0.6A), rheostat (0-50), key, sandpaper and connecting wires.

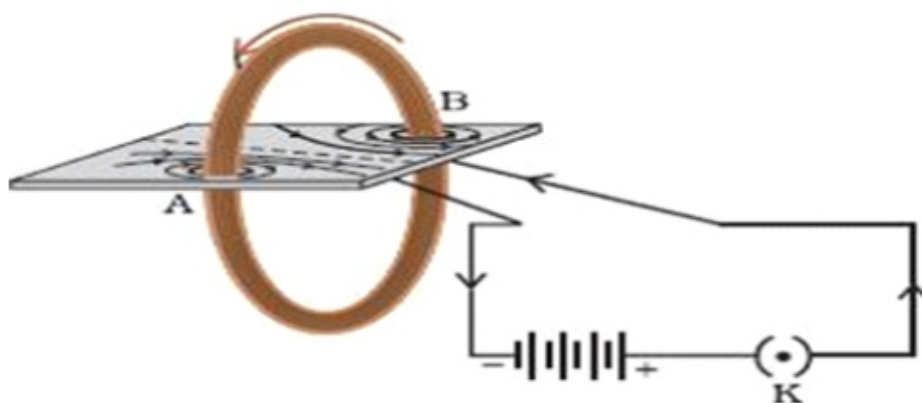


Fig. 15.2.3



Procedure

1. Take a wooden board fitted with a vertical circular coil.
2. Cut a slot in the paper and pass it through the coil. Fix it on the board with cello tape.
3. Draw a line on the paper along the axis of the coil.
4. Set the coil in the magnetic meridian i.e. along the N-S direction using compass needle.
5. Connect power supply, ammeter, rheostat and key in series with the coil.
6. Set the rheostat slider in the middle.
7. Turn the power supply ON and close the key.
8. Observe the reading on the ammeter. Adjust its current to 0.5A with the help of rheostat. Keep the current constant at this value.
9. Place the compass needle near one side of the coil at A.
10. Trace a magnetic line of force by marking the end points of the needle and moving it along the marked points.
11. Similarly, draw more lines by placing the compass needle starting from points A, B, C, ... F as shown in Fig. 14.2.3 (b). The $\odot$ shows the cross section of the wire of the coil with current outward and $\otimes$ shows the current inward.
12. Join the marked points with free hand and indicate the direction of the lines with arrow-heads.

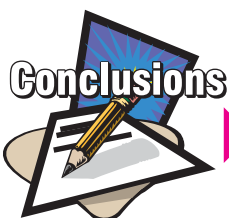


BRAIN TEASER

Two current carrying straight wires are held parallel to each other then. "They will attract if the current in both the wires is in the same direction." This is due to the combined magnetic field around the wires.



Think
Why is the magnetic field line at the center of the coil straight?



Conclusions

.....



- Reverse the direction of current and trace the magnetic field again. How does it differ from the previous one?

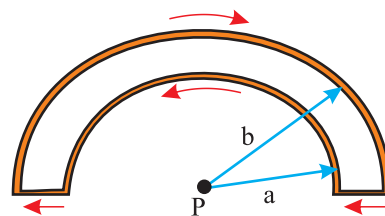


Fig. 15.2.4

CAUTIONS

- Remove all the magnetic materials away from the apparatus.
- The compass needle should be gently tapped before marking the end positions.
- Direction of each line drawn is indicated by an arrow head.

- A loop of wire is in the shape of two concentric semicircles as shown in Fig. 15.2.4.

The inner circle has radius a and the outer circle has radius b . A current I flows clockwise through the outer wire and counterclockwise through the inner wire.

What is the direction of the magnetic field at the common center P of the semi-circles?



BRAIN TEASER

What change in the pattern of magnetic field will be observed if the shape of coil is made rectangular rather than circular?

Experiment 16.1

Set up and study OR, AND, NOT, NOR and NAND gates

Date _____

Background Information

A computer computes and processes information or data by taking logical decisions. Fundamental logical decisions performed by a computer are OR, AND and NOT operations. NOR and NAND are derived operations. These logic operations are implemented by electric circuits known as gates. Thus we have got OR, AND, NOT gates.

All computer systems are based on a branch of Mathematics called Boolean algebra. In Boolean algebra a variable can have only two values, that is, 1 or 0. An electric switch also has two states. In closed (ON) state it represents 1, and in open (OFF) state it represents 0. Therefore, a switch can represent a Boolean variable and used as an input to a logic system. Similarly, a bulb or Light emitting diode (LED) can be used as an output variable. When a bulb or an LED is glowing, it is taken as 1, and when it is not glowing it is taken as 0. The states 0 and 1 are also called Low and High states.

In the study of a logic system, the state of the output is observed for different combinations of inputs, and is recorded in a tabular form. This table is called the Truth Table of that logic system. All logic systems are defined by their specific Truth Tables.

Plastic strip

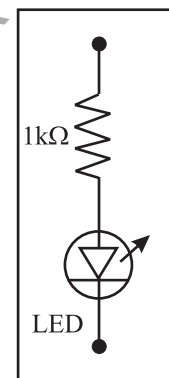
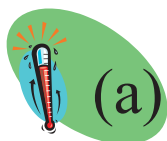


Fig. 16.1.1 Diode

Materials Required

A Module fitted with LED and 1 k Ω resistance connected in series as shown in Fig. 16.1.2 one way keys, power supply or 6V DC battery and connecting wires.



(a)

Set up and study of OR gate

An OR gate can be formed by combining two switches in parallel.

A	B	Q
0	0	0

Table 16.1.1: Truth Table for OR gate

Symbol of OR gate

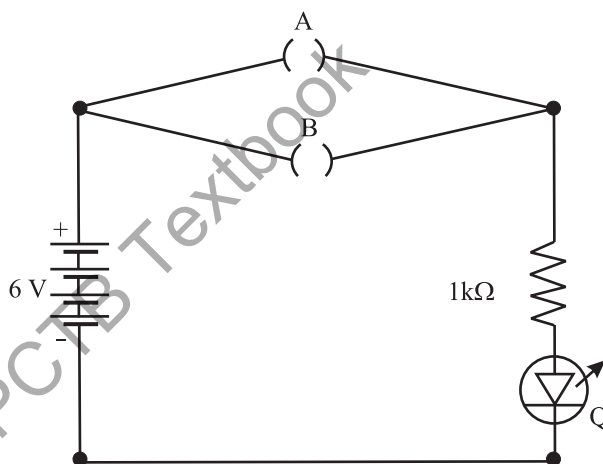
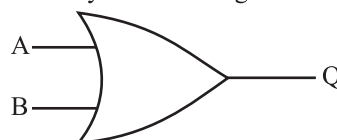
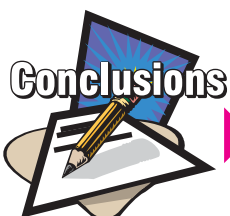


Fig. 16.1.2: OR gate circuit

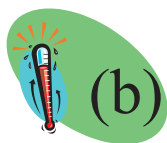


Procedure

1. Set up the circuit for OR gate as shown in Fig. 16.1.2. Keys A and B are two input variables and the LED is the output variable Q. Keep keys A and B open. In this state the LED is not glowing which shows that the output of this gate is 0. This state is recorded in the Table 16.1.1 as A=0, B=0 and Q=0. This is the initial state of this circuit.
2. Keep key A open and close the key B. Observe the state of LED. Record your observation in the Table.
3. Now open key B and close key A. Record your observation in the Table.
4. Finally, close both keys A and B and record the observation.
5. When Table 16.1.1 is complete, it describes all the possible states of the OR gate. This table is then called the Truth Table of OR gate with two input variables.



Conclusions



Set up and study of AND gate

An AND gate can be formed by combining two switches in series.

A	B	Q

Table 16.1.2: Truth Table for AND gate

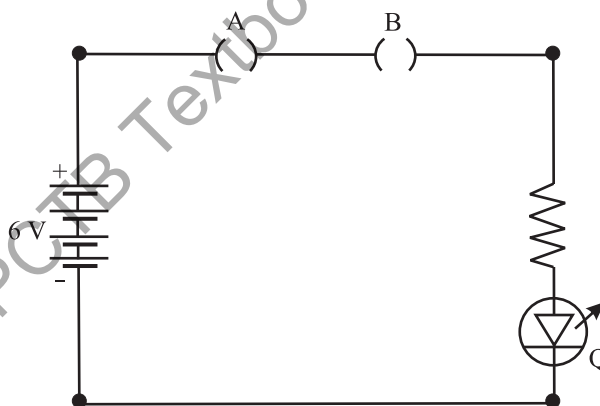
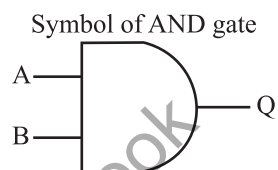
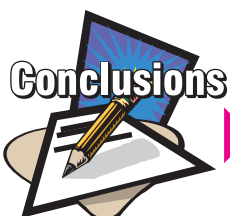


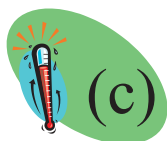
Fig. 16.1.3: AND gate circuit



Set up the circuit for AND gate as shown in Fig. 16.1.3. Keep both keys A and B open. Repeat the steps 1 to 4 given for the OR gate. Record your observations in Table 16.1.2 to obtain the Truth Table for AND gate.



.....

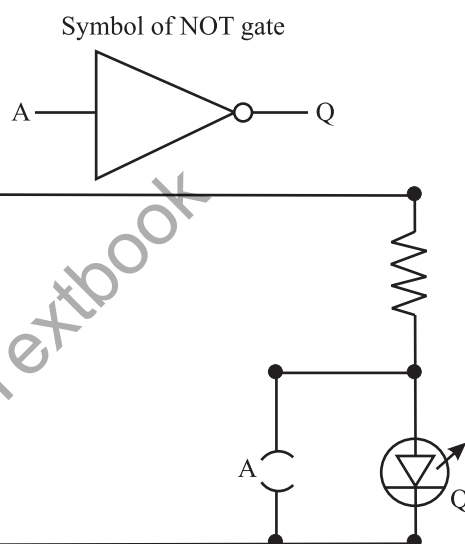


Set up and study of NOT gate

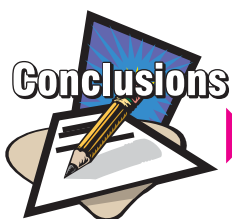
A single switch can be used as a NOT gate as shown in Fig 16.1.4.

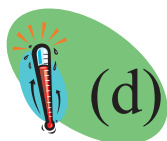
A	Q

Table 16.1.3: Truth Table for NOT gate



1. Set up the circuit as shown in Fig. 16.1.4. Keep key A open and note the state of LED. Record your observation in Table 16.1.3.
2. Now close key A and again note the state of LED. Record your observation in table 16.1.3. This table is the Truth Table for NOT gate.





(d)

Set up and study of NOR gate

A NOR gate is a combination of OR and NOT gates.

A	B	Q

Table 16.1.4: Truth Table for NOR gate

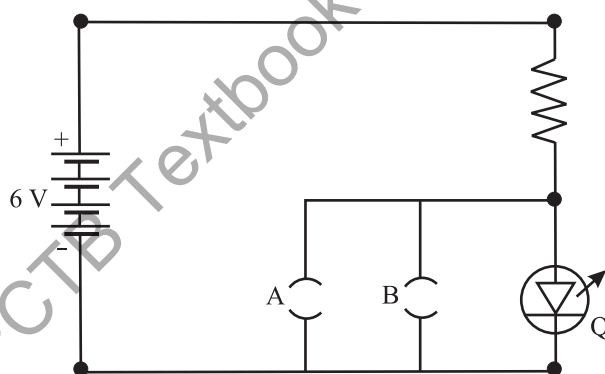
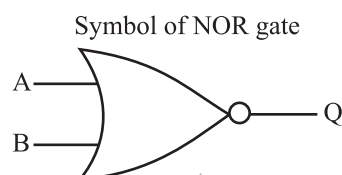
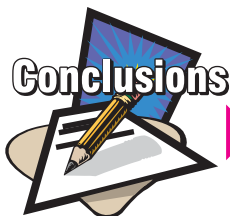


Fig. 16.1.5: NOR gate circuit



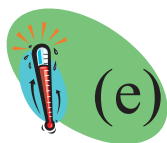
Procedure

Set up the circuit as shown in Fig. 16.1.5. Keep both keys A and B open. Repeat steps 1 to 4 given for OR gate. Record your observations in table 16.1.4.



Conclusions

.....



(e)

Set up and study of NAND gate

A NAND gate is a combination of AND and NOT gates.

A	B	Q

Table 16.1.5: Truth Table for NAND gate

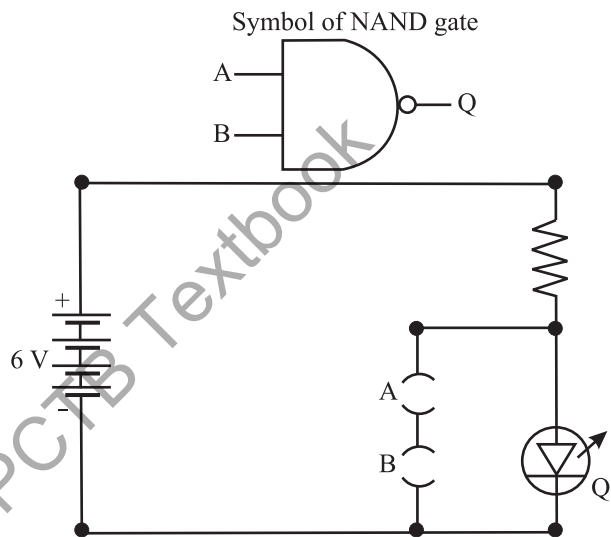
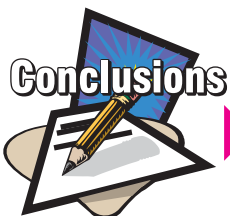


Fig. 16.1.6: NAND gate circuit



Procedure

Set up the circuit as shown in Fig 16.1.6. Keep keys A and B open. Repeat steps 1 to 4 given for OR gate. Record your observations in table 16.1.5.



Conclusions

.....



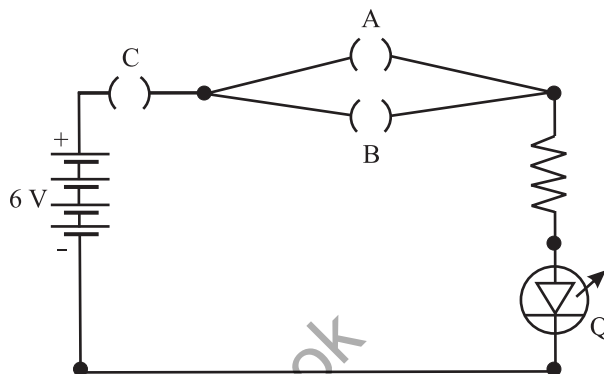
Develop the truth tables for the following circuits.



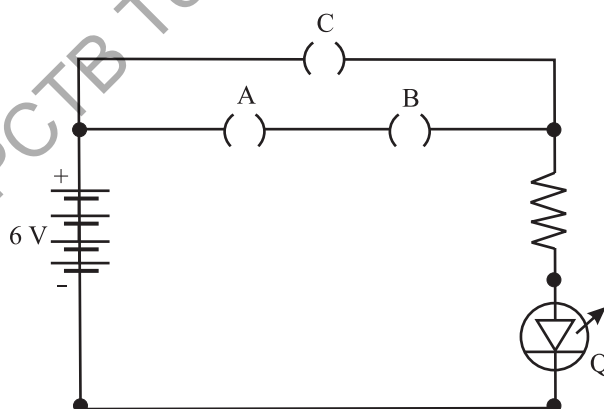
DO YOU KNOW?

If a logic system has n inputs then it will have 2^n possible states.

(a)



(b)



BRAIN TEASER

Write down a truth table for a three input AND gate. How many possible states does this system have?

Experiment 16.2

Set up a NAND gate burglar Alarm.

Date _____

Background Information

A NAND gate can be used as a burglar alarm if LED module is replaced by a buzzer module as shown in the Fig.16.2.1. In this burglar alarm, the keys A and B are secretly installed switches in the two doors of the protected area. When the doors of the protected area are closed, both switches are also closed, so that both inputs of the NAND gate are high. Therefore, the output of the NAND gate is low and the buzzer remains silent. When any one of the doors is opened, it opens the switch also. The corresponding input of the NAND turns Low. The output of the NAND therefore, goes High, and turns the buzzer ON, which gives out an alarming sound.

Materials Required

Buzzer module, two one way keys, power supply or 6V DC battery, connecting wires.

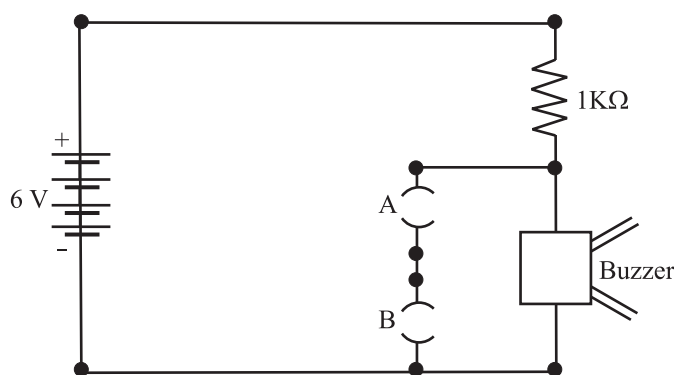
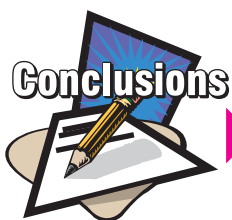


Fig. 16.2.1 NAND GATE Burglar Alarm

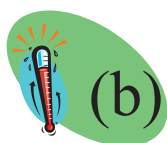


1. Set up the circuit as shown in Fig. 16.2.1. Keep keys A and B closed. In an actual set up, keys A and B are secretly installed switches in the doors of the protected area.
2. Now open any one of the keys. This is equivalent to opening of the door by an intruder.



DO YOU KNOW?

The thermal switch consists of bimetallic strip which bends as heating occurs and breaks the electrical contact.



Set up a NOT gate Fire Alarm.



A NOT gate can be used as a fire alarm. If in Fig. 16.1.1 the key A is replaced by a bimetallic thermal switch and the LED module is replaced by a buzzer module as shown in the Fig.16.2.2. The thermal switch acts as a NOT gate. The thermal switch is installed in the protected area. At room temperature the thermal switch remains closed, so that the input of NOT gate is High. Therefore, the output of the NOT gate is low and the buzzer remains silent. When the thermal switch receives heat due to fire, it opens. The input of the NOT gate turns low. Consequently, the output of the NOT gate goes High, and turns the buzzer ON, which gives out an alarming sound.



Buzzer module, power supply or 6V DC battery pack, connecting wires, thermal switch fitted on base with terminals

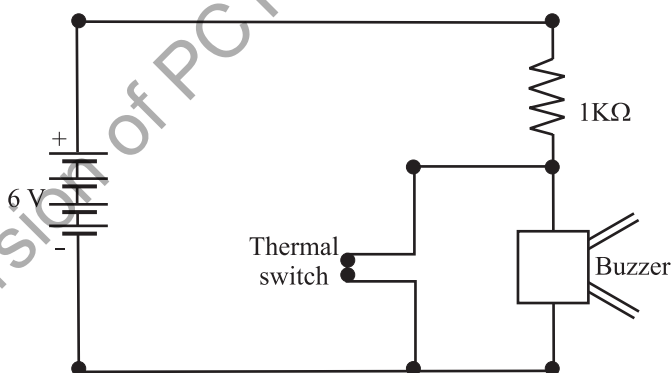
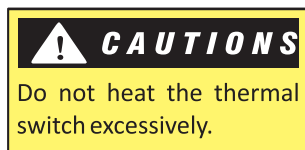
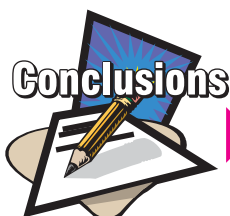


Fig. 16.2.2 NOT GATE Fire Alarm



1. Set up the circuit as shown in Fig. 16.2.2. In an actual set up, the thermal switch (key A) is installed in the protected area.
2. Now heat the thermal switch with the help of a spirit lamp. The thermal switch opens. This is equivalent to a fire in the protected area.





DO YOU KNOW?

Large hydraulic presses used for making motor car parts use logic gates as safety devices. As long as a hand of a worker is between the hammer and the anvil of the press, any one of the many beams of light is interrupted and the AND gate connected to them gives a Low output which keeps the press inoperative. The press operates only when there is no obstruction between the press and all light beams. Only then the output of the AND gate goes High. Now the operator can operate the press safely.

