TO THE STUDENTS

Physics is generally defined as the study of matter and motion. In fact, neither this nor any other one sentence statement adequately covers the whole definition of physics. But tenth grade physics course is designed to give students an understanding of important facts, laws and basic concepts of physics together with the theoretical application of theoretical knowledge to solving problems .

The purpose of laboratory studies is to carry out operations and make measurements that will give us information about the physical world in which we live. This manual will serve you as the basis for physics laboratory experiences that establish an appreciation for the value and satisfactions of experimental science and that help install a qualitative, quantitative and critical approach to understanding the physical world around us.

In this physics course, you will be working with your teacher and other students to develop the basic knowledge and skills which will help to understand more about physics and to apply in your daily life. You will learn how to demonstrate an interest in the creativity and innovation discover in physics.

Experiments have been grouped by topic to fit conveniently into most lecture schedules. This means that you must study each experiment before coming to the laboratory, referring if necessary to your Grade 10 Physics Textbook for the theory and calculations involved in this experiment.

After learning this experimental physics course you will develop and practice higher order thinking skills. Moreover, you will be able to participate actively in all experiments through the **5 C's**, which are **collaboration, communication, critical thinking and problem solving, creativity and innovation and citizenship, as 21st century skills for learning**.

EXPERIMENT 1
VERNIER CALIPERS

Aim of Experiment

- To measure the dimensions of the wooden block
- To find the volume of the wooden block

Apparatus

- vernier calipers, rectangular wooden blocks

Theory

Description of Apparatus

Vernier caliper is an instrument which is used for measuring lengths up to the second decimal place of a centimetre as shown in Figure 1. It consists of a fixed jaw and a sliding jaw. The scale on the fixed jaw is called the main scale and the scale on the sliding jaw is called the vernier scale. A vernier caliper also has outside and inside jaws. The outside jaws are usually used to measure short lengths, like the diametre of a test-tube (or) a ball bearing. The inside jaws can be used for measuring the internal diametres of tubes, cylinders etc. The sliding tail can be used for measuring the internal depth of the beakers, cups etc.

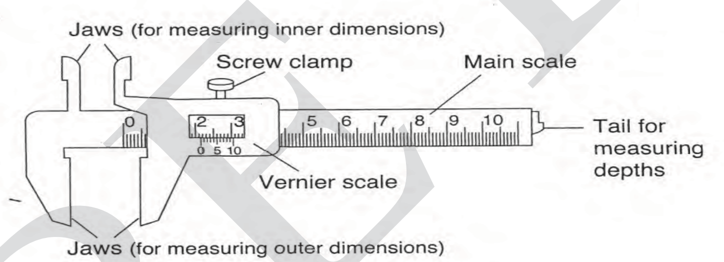


Figure 1 Vernier calipers

Least count

Least count (LC) of the vernier calipers is difference between the value of one main scale division and the value of one vernier scale division.

LC = the value of one main scale division – the value of one vernier scale division.

The reading taken when the two jaws of a vernier caliper just touch is called zero reading.

How to read a vernier caliper

(i) Grip the object gently using the outside jaws.

(ii) Read the mark on the main scale just before the zero mark on the vernier scale. It reads 3.1 cm in Figure 2.

(iii) Look on the vernier scale for the vernier mark which exactly coincide with 4 vernier scale divisions on the main scale. This gives a reading of 0.04 cm to be added to the main scale.

(iv) Final reading = main scale reading + vernier scale reading
= 3.1 cm + 0.04 cm = 3.14 cm

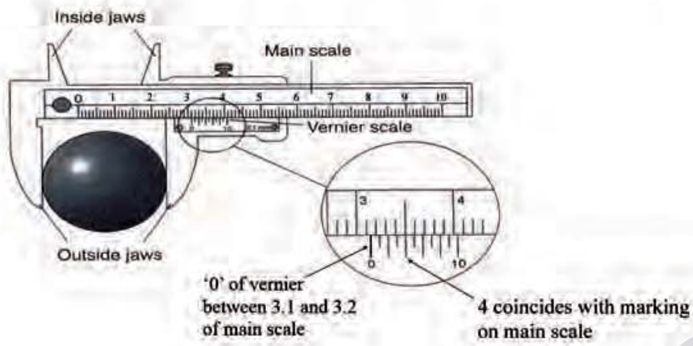


Figure 2 Instructions on reading of vernier calipers

Zero reading

For some vernier calipers, the zero mark of the vernier scale does not coincide with the zero mark of the main scale when the two jaws just touch. This is because of the manufacturing fault (or) the long-time use of the instrument. The zero reading must be considered in the measurements with vernier calipers in order to avoid errors.

The zero reading is the sum of the main scale reading and the vernier scale reading while the jaws of the vernier caliper are just touching.

Expression For Volume of Rectangular Block

The following formula will be used to obtain the volume of a given rectangular wooden block.

$$\text{Volume} = \text{length} \times \text{breadth} \times \text{height}$$

$$V = l \times b \times h \qquad (1)$$

Procedure

1. Find the least count of the given vernier calipers.
2. Read the zero reading and enter the result in Table 1.
3. Place and grip the rectangular wooden block, length-wise in the jaws of the vernier caliper.
4. Take the readings using the method described and enter the results in Table 2.
5. Take two more such measurements following the same procedure for different positions. Find the average value of the three readings.
6. Obtain the length of the rectangular wooden block by subtracting the zero reading from the average value.
7. Repeat the above procedure to obtain the breadth and the height of the wooden block.
8. Using equation (1) calculate the volume of the given rectangular wooden block.

To find the least count

In Figure 1 the vernier scale is a short scale 9 mm long and divided into 10 equal parts so that the difference in length between one vernier division and one main scale division is 0.01 cm. This difference in length is called the ***least count***.

vernier scale 10 divisions = main scale 9 divisions = 0.9 cm

1 division = 0.09 cm

LC = 0.1 cm – 0.09 cm = 0.01 cm

Least count of the vernier caliper, LC = ------------ cm

Linear scale reading **a (cm)**	Vernier scale which coincides with the linear scale **b (division)**	Vernier scale reading **c = b × LC (cm)**	Zero reading **z = a +c (cm)**
1.			
2.			
3.			

Average value of the zero reading, z_{av} = --------------- cm

dimensions of block	Main scale reading **a (cm)**	Vernier scale which coincides with the main scale **b (division)**	Vernier scale reading **c = b×LC (cm)**	The value of the measurement **d = a + c (cm)**
Length (*l*)	1.			
	2.			
	3.			
Average value l_{av} = --------------- cm				
Breadth (*b*)	1.			
	2.			
	3.			
Average value b_{av} = --------------- cm				
Height (*h*)	1.			
	2.			
	3.			
Average value h_{av} = --------------- cm				

Length of wooden block (ℓ) $= (\ell_{av} - z_{av}) =$ ----------------

Breadth of wooden block (b) $= (b_{av} - z_{av}) =$ ----------------

Height of wooden block (h) $= (h_{av} - z_{av}) =$ ----------------

Result

- The volume of the given rectangular wooden block, $V = l \times b \times h$

  = -----------

Precautions

- Jaws must be tightly closed.
- When taking the main scale and vernier scale readings, the object must be gently gripped between the two jaws.
- To take accurate readings by avoiding parallax errors.

Discussion

1. Discuss the difference between measurement of length of an object using vernier caliper and metre rule.

Questions

1. What is the accuracy of vernier calipers?
2. How can you measure the inner volume of a cylindrical cup?

EXPERIMENT 2

MEASUREMENT OF AVERAGE SPEED

Aim of Experiment

- To measure the time interval for a certain distance travelled of moving marble on the horizontal track
- To calculate its average speed

Apparatus

- stop watch / timer, marble/ glass ball, measuring tape, track rails

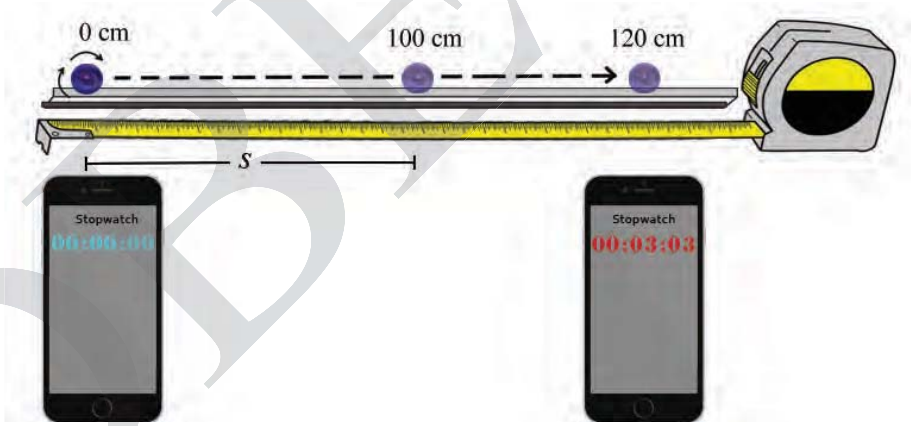
Theory

Distance (or) distance travelled by the body is the length of the path along which the body moves. Distance has no specific direction. It has only magnitude; and therefore, it is a scalar. The average speed of a moving body can be defined as follows;
Average speed is the ratio of distance travelled to time taken.

$$\text{average speed} = \frac{\text{distance}}{\text{time taken}}$$

$$\bar{v} = \frac{s}{t}$$

In this experiment, we will be required to measure short time intervals. Stopwatches are commonly used in the laboratory for measuring time intervals accurately.



Procedure

1. Mark four points on the horizontal track rail with suitable length. (e.g. 100 cm, 120 cm, 140 cm, 160 cm)
2. Place the marble at a certain point. (e.g. 0 cm)
3. Push the marble gently; start the stopwatch at the starting point (0 cm) and stop at the finishing point. (100 cm, 120 cm, 140 cm, 160 cm)
4. Repeat the experiment at least three times and note down all the data.

Sr No	Distance travelled (cm)	Time taken (s)	average speed (cm s^{-1})
1.	100 120 140 160		
2.	100 120 140 160		
3.	100 120 140 160		

average speed = --------- cm s^{-1}

Result

- The average speed of moving mable is ----------.

Precautions

- When starting and stopping the stopwatch, the eye must be in line with the marks.
- At initial point, the magnitude of the force exerted on the marble should not be large.

Discussions

1. Discuss the variable physical quantities in this experiment.
2. What will happen the measurement of time if the force exerted on the marble is large?

Questions

1. Convert your answer of average speed in SI unit.
2. Can the moving marble has the acceleration?

EXPERIMENT 3
SIMPLE PENDULUM

Aim of Experiment

- To investigate the relation between period and length of a simple pendulum

Apparatus

- a metal bob of known diametre, a thread, a cork-pad, stand, stopwatch, metre rule, graph paper

Theory

In mechanics, a simple pendulum is a small heavy body suspended by a light inextensible string. A simple pendulum constructed for use in the laboratory is shown in Figure 1.

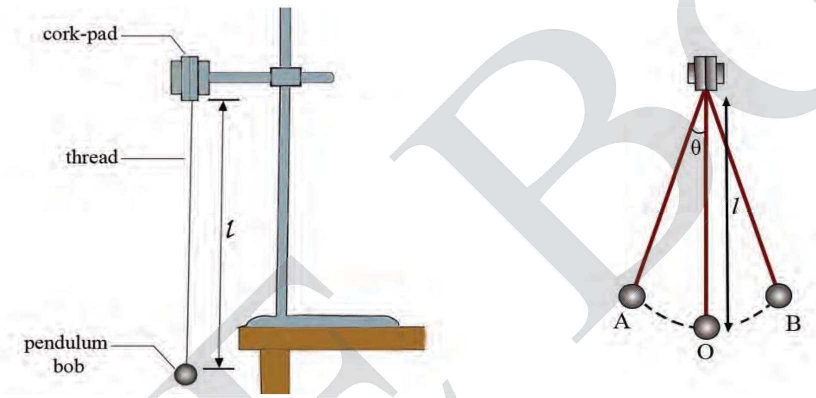


Figure 1 Simple pendulum

A small brass (or) lead sphere B is called the bob and it is attached to a thread. The upper end of the thread is held firmly on a cork. The cork remains fixed between a clamp. The whole set-up is supported by a stand.

One complete to and fro movement of the pendulum is called an oscillation (or) a vibration. The time taken for one complete oscillation is called the time period. The distance from the point of suspension to the centre of gravity of the bob is the effective length of the pendulum and is represented by the letter *l* in Figure 1.

The effective length of pendulum = radius of the bob + length of the thread.

For a simple pendulum, the relationship between the time period *T* and effective length of the pendulum is

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad (1)$$

where g is the gravitational acceleration. In order to verify equation (1), we may rewrite it as follows:

$$T^2 = \frac{4\pi^2 l}{g} \quad \text{(or)} \quad \frac{l}{T^2} = \frac{g}{4\pi^2} \qquad (2)$$

The factors 4 and π^2 on the right hand side of equation (2) are constant and since the acceleration due to gravity g is constant for the place where the experiment is carried out, $\frac{l}{T^2}$ must also be constant.

Two important points become obvious when analyzing equation (2).

(1) The length of the pendulum, is directly proportional to the square of period T. $\frac{l}{T^2}$ is a constant.

(2) Since mass m does not appear in equation (1), the period T does not depend on m.

Procedure

1. Tie the pendulum bob (known radius) on one end of a thread. Measure the effective length (20 cm, 40 cm, 60 cm, 80 cm). Clamp the other end firmly at a cork.
2. Give a small displacement of about 5 degree to the pendulum bob and then allow it to oscillate. An example of one complete swing (or) oscillation is when the bob moves through O $\rightarrow$ A $\rightarrow$ O $\rightarrow$ B $\rightarrow$ O.
3. Measure the time for 20 oscillations t by using a stopwatch. Record your reading t and calculate the period T.
4. Repeat the experiment for other effective lengths.
5. Calculate the values of $\frac{l}{T^2}$.
6. Draw the graph T^2 (y-axis) versus l (x-axis). Examine the nature of the graph.

Effective Length l (cm)	Time taken for 20 oscillations t (s)	Period $T = \frac{t}{20}$ (s)	T^2 (s^2)	$\frac{l}{T^2}$ (cm s^{-2})
20				
40				
60				
80				

Result

1. The nature of graph T^2 versus l is --------- .
2. The square of the period T is -------- proportional to the effective length l of pendulum.

Precautions

- The pendulum must be displaced through an angle θ about 5°.
- The initial displacement of the pendulum should not be large.
- The position of the swing must be determined precisely.
- When starting and stopping the stopwatch, the eye should be in line with the marks.

- The number of oscillations should be at least 20 for measuring the time period.
- They can be further reduced by starting and stopping the timing when the pendulum is at O, because this is where it is moving fastest.

Discussions

1. Discuss how the period of pendulum depends on the effective length of pendulum.
2. Discuss why the pendulum should be swung for a large number of oscillations when finding the time period.

Questions

1. Can the bob have acceleration during the oscillation?
2. What is the effective length?

EXPERIMENT 4
CONSTRUCTION OF A HYDROMETER

Aim of Experiment

- To construct a hydrometer with a test tube
- To measure the relative density of liquid (brine) using the constructed hydrometer

Apparatus

- lead shot (or) small steel balls, thin test tube 12 cm long, graph paper, containers, liquid

Theory

Hydrometer is an instrument for measuring the density (or) relative density of liquids. The construction of hydrometer is based on the Archimedes' principle. Hydrometer can be constructed by using test tube and lead shots (or) small steel balls to float vertically in liquid. Overall density of test tube hydrometer is less than the density of water. When a hydrometer floats in a liquid, the weight of liquid displaced by the hydrometer is equal to the weight of hydrometer.

The hydrometer is floating in water

Weight of hydrometer = Weight of water displaced

$$mg = A\,h_w \rho_{water}\, g$$

The hydrometer is floating in liquid (brine)

Weight of hydrometer = Weight of brine displaced

$$mg = A\,h_b \rho_{brine}\, g$$

$$A\,h_w \rho_{water}\, g = A\,h_b \rho_{brine}\, g$$

$$\frac{\rho_{brine}}{\rho_{water}} = \frac{h_w}{h_b}$$

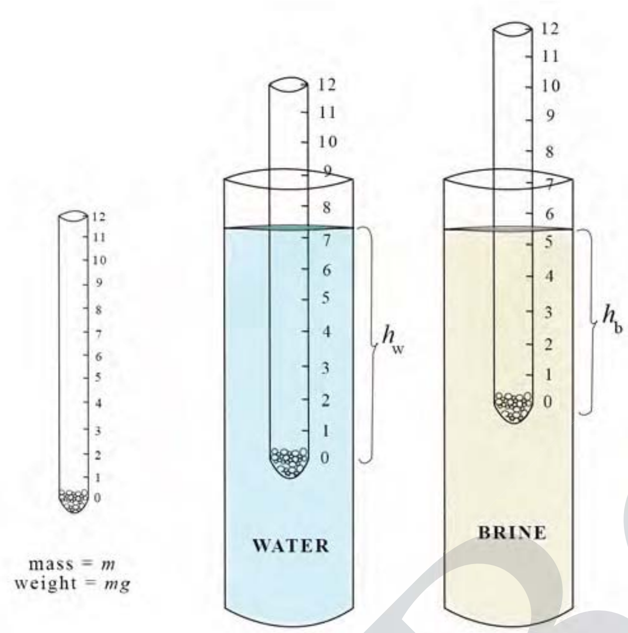
$$\text{Relative density of Liquid (brine)} = \frac{\text{density of liquid (brine)}}{\text{density of water}}$$

$$\frac{\rho_{brine}}{\rho_{water}} = \frac{h_w}{h_b}$$

$$= \frac{\text{immersed length in water}}{\text{immersed length in liquid (brine)}}$$

Procedure

1. Mark and paste the centimeter scale grid line with zero at the bottom and marking upwards inside wall of the test tube.
2. Place the constructed hydrometer weighted with lead shot (or) small steel balls in water and record the immersed length.
3. Repeat this procedure in liquid (brine) and record the immersed length.



Immersed length of constructed hydrometer in water h_w (cm)	Immersed length of constructed hydrometer in brine h_b(cm)	Relative density of brine $\frac{h_w}{h_b}$
1. 2. 3.		

average relative density of brine = ------------.

Precautions

- The test tube hydrometer must not be in contact with the wall of the container.
- The hydrometer must be vertical position when recording the data.
- When recording the length of liquid, the eye should be in line with the marks.

Result

- The relative density of brine = -------------------- .

Discussions

1. How are the immersed length of hydrometer and density of liquid related?
2. Can the experiment be used to determine the relative densities of other solutions?

Questions

1. Give the name of forces acting on hydrometer floating in liquid.
2. Find the net force on the hydrometer floating in liquid in equilibrium condition.

EXPERIMENT 5
WORK DONE BY ELASTIC FORCE

Aim of Experiment
- To measure the length of spring (or) rubber band without load and with load
- To determine the work done by elastic force

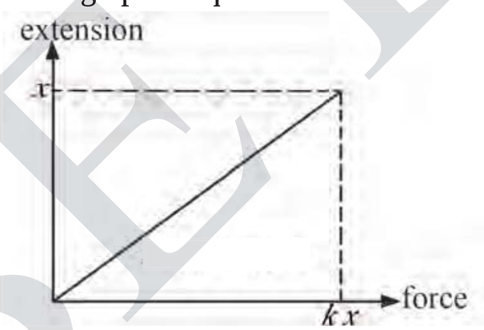
Apparatus
- retort stand, ruler, graph paper, syringe (25 ml), cup, spring balance, weight box, rubber band

Theory
When a spring (or) rubber band is stretched, the force that causes the spring (or) rubber band to retain their original form is called elastic force.
The elastic force (F) is directly proportional to extension of spring (or) rubber band (x).

$$F \propto x$$

$$F = k\,x \qquad k = \text{force constant (or) spring constant}$$

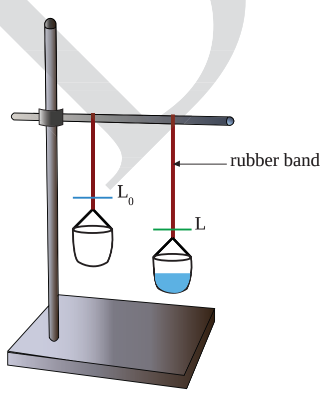
The nature of graph (extension versus elastic force) is straight line. The work done by the elastic force is the energy stored in the stretched spring (or) the stretched rubber band $(\frac{1}{2}k\,x^2)$.
Area under the extension versus force graph is equal to the work done by the elastic force.



Work done = area under the graph

$$\text{Work done} = \frac{1}{2}\ \text{base} \times \text{height}$$

Procedure (1) Rubber Band Method

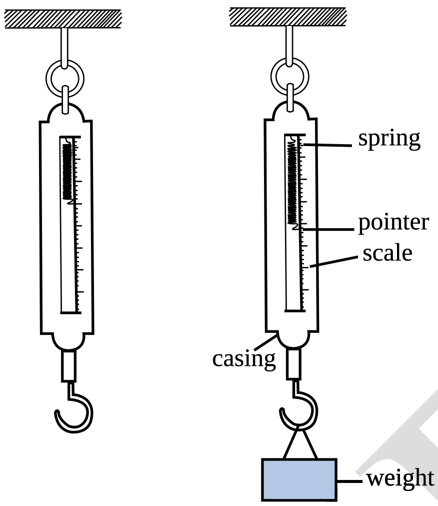


The experiment is set up as shown in the figure.
1. Record the index of the initial position (without load).
2. Add five millilitre of water (5 g) in the hanging cup and record the index of new position of stretching rubber band.
3. Repeat this procedure for 10 g, 15 g, 20 g of water and record respective index.
4. Draw the extension (y-axis) versus weight (x-axis) graph.

The index of the initial position of rubber band = L_0 = -------

Sr No	Mass of added water m (g)	Weight mg (dyne)	Index position L (cm)	Extension $L - L_0$(cm)
1.	5 g			
2.	10 g			
3.	15 g			
4.	20 g			

Procedure (2) Spring Balance Method



1. Record the length of spring without hanging weight.
2. Hang the weight on the spring and record the length of spring.
3. Repeat this procedure for suitable weight and record respective lengths.
4. Draw the extension (y-axis) versus weight (x-axis) graph.

The length of spring without hanging weight = L_0 = -------

Mass m (g)	Weight $m\,g$ (dyne)	The length of spring with weight L (cm)	Extension $L - L_0$ (cm)
10 g			
20 g			
30 g			
40 g			

Calculate area under the graph. It will give work done in ergs.

Result

- The work done by the elastic force of rubber band = ---------- .
- The work done by the elastic force of spring = ---------- .

Precautions

- There is no spill of water.
- The eye must be level with index while recording.
- Since the large force exerted will permanently damage the spring, hanging weight should not be very large.

Discussion

1. How can unknown mass of an object be found with this experiment from the graph?

Questions

1. How can you determine the units of k ?
2. What will happen to spring (or) rubber band if the hanging mass is very large?
3. Convert the results of work done ergs to joules.

EXPERIMENT 6
REFLECTION BY A PLANE MIRROR

Aim of Experiment

- To prove that image distance equals object distance in plane mirror
- To measure the angle of incidence and angle of reflection

Apparatus

- protractor, ruler, paper, mirror strip, clip, colour pencils, plane mirror (7 cm by 15 cm), drawing board

Theory

When rays of light are incident on the plane mirror, some of the light is reflected and it follows a part as shown in Figure 1. The two rays are known as incident ray (OP) and reflected ray (PQ). The line is drawn perpendicularly to the plane mirror at the point of incidence is normal. An angle between the incident ray and the normal is angle of incidence. An angle between the reflected ray and the normal is angle of reflection. The law of reflection states that the angle of incedence is equal to the angle of reflection.

Procedure (1) Line method

1. Draw the mirror surface line on the paper. On it place the mirror strip upright vertically.
2. Mark an object point infront of a mirror at a certain distance and draw a line to represent the incident ray.
3. Line up the edge of the ruler with the image of the incident ray and draw the reflected line.
4. Take away the mirror and draw the normal at the point of incidence on the mirror surface line.
5. Measure the angle of incidence and angle of reflection.
6. Repeat two times of the above procedure for step 2 to 5 by drawing other incident rays.
7. Draw the three reflected rays produced backwards to meet at a point(image point).
8. Measure the perpendicular distances of object point and image point from the mirror line.
9. Check whether these two distances are equal (or) not.

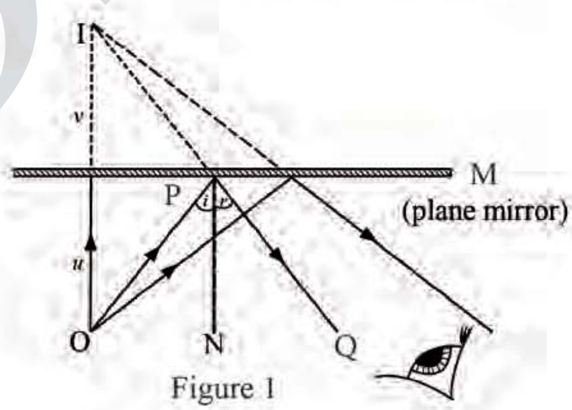


Figure 1

Procedure (2) Pin Method

1. Draw the surface line on the paper and place the mirror strip upright on the surface line.
2. Mark the object point and draw a line represented the incident ray.
3. Place the two object pins (P , Q) on the incident ray and put two search pins (R , S) in straight line with the image (P′, Q′). The images (P′, Q′) and two search pins (R , S) should be on the same straight line.
4. Remove the mirror and all pins.
5. Draw the reflected rays passing through the search pin points and normal line.
6. Measure the angle of incidence and angle of reflection.
7. Check whether angle of incidence and angle of reflection are equal (or) not.

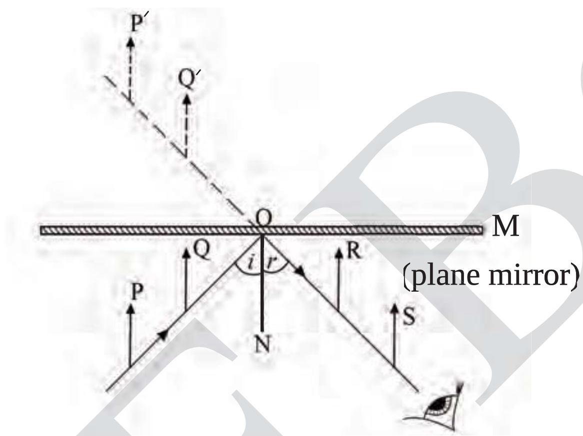


Figure 2

Precautions

- The observer's eye must be in the plane of rays and not too close with the mirror.
- The hard-sharp pencil must be used to give measurement of angle accurately.
- Parallax error must be avoided.
- Search pins R and S must not close one another.

Result

- For procedure (1) object distance = image distance = ----------- cm
- For procedure (2) angle of incidence = angle of reflection = -----------

Discussions

1. Deduce the properties of image in plane mirror.
2. Perform and discuss the lateral inversion in plane mirror.

Questions

1. Can the image in the plane mirror be formed on screen?
2. Can the reflected ray actually pass through the image in plane mirror?

EXPERIMENT 7
THE CONCAVE MIRROR

Aim of Experiment

- To determine the focal length of a concave mirror by using the conjugate foci method

Apparatus

- optical bench, search pins, concave mirror fixed on stand, white paper (screen), metre stick

Theory

A concave mirror can produce a real image of a distant object (at infinity) as shown in Figure 1. The position of image is considered as a focus of concave mirror and hence, the distance from the mirror to this image is approximately equal to focal length of the concave mirror. Therefore, it has a real focus. Hence, the focal length of a concave mirror is positive.

Further, a concave mirror can produce both types of images real as well as virtual, depending upon the object position. The position, nature and size of the image may be predicted by drawing ray diagrams. If the object is placed at the center of curvature of the concave mirror, its image is formed at the center of curvature as shown in Figure 2. The set of points on the principal axis of a concave mirror where the position of the object and the image can be interchanged are called conjugate foci.

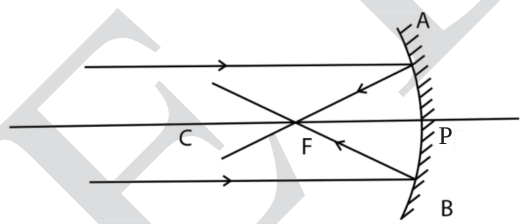


Figure 1 The real, inverted and diminished image of distant object is formed at focus

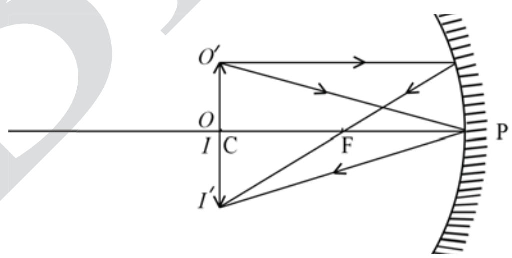


Figure 2 The real, inverted and same size image of the object at C is formed at C

Procedure

1. Hold the mirror towards distant object, a tree (or) a building and adjust a white paper (screen) in front of it to get a sharp image on the screen.
2. Measure the distance between the mirror and the screen.
3. Repeat the above procedure three times.

The distance between the mirror and the screen (1) ------- cm
(2) ------- cm
(3) ------- cm

The average approximate focal length of concave mirror = -------- cm

4. Place the mirror on the optical bench and put the object pin twice the approximate focal length in front of the mirror.
5. Adjust the position of the object pin, so that the image in the mirror was no parallax with object pin (Object pin is also used as search pin and object pin and its image in the mirror are coincided each other).
6. Measure the distance of the pin from the mirror.
7. Repeat that experiment three times.
8. The distance of the pin from the mirror (1) -------- cm
(2) -------- cm
(3) -------- cm

The average distance of the pin from the concave mirror = -------- cm

The radius of the curvature of the concave mirror R = -------- cm

The focal length of a concave mirror, $f = \frac{R}{2}$ = -------- cm

9. Compare the focal length obtained from conjucate foci method and the focal approximate length.

Result

- The focal length of a concave mirror found to be ---------.

Precautions

- The parallax error must be avoided.
- The mirror and the pin must be upright.

Discussions

1. If the incident rays are parallel, where is the object located? Where is its image formed? Can this image be focus on the screen?
2. Are the approximate focal length and the result equal?

Questions

1. If the object is placed at the focus of the concave mirror, where is its image formed ? Draw an appropriate ray diagram.
2. Under what condition will the concave mirror produce virtual image?

EXPERIMENT 8

MAGNETIC FIELD

Aim of Experiment

- To plot the magnetic lines of force of a bar magnet

Apparatus

- bar magnet, plotting compass, plain paper

Theory

A magnet exerts a force on magnetic objects nearby. The region around a magnet where this magnetic effect can be detected is called a magnetic field. The direction of the magnetic field at any point is the direction indicated by the north pole of a small plotting compass.

Procedure

1. Place the bar magnet at the centre of the piece of paper .
2. Mark a dot Y near north pole as shown in the Figure 1. Then place the compass on Y and mark X at north pole. That process is repeated until the mark reach south pole. Starting near one pole of the magnet, the positions of the ends, N and S, of the compass needle are marked by pencil dots X and Y. The compass is then moved until one end is exactly over X and the new position of the other end is marked with third dot.

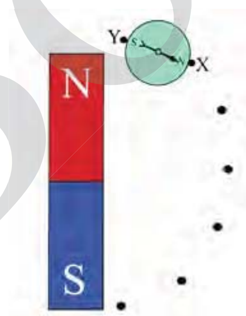
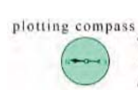


Figure 1

3. Repeat the process of marking another dots. Join the series of dots and this will give the plot of the field lines of the magnetic field.

Result

- A typical field pattern (neglecting the effect of the Earth's field) for the case of a bar magnet is obtained.



Precautions

- Check that the plotting compass is in good working order.
- Ensure that there is no strong magnetic field (other than the Earth's magnetic field) around the plotting compass.

Discussion

1. Draw the combine magnetic field due to two magnets when a pair of unlike poles together, then a pair of like poles together. Locate the neutral point in later case. Indicate the region stronger magnetic field strength and that of weaker magnetic field strength.

Figure 2 A pair of unlike poles together

Figure 3 A pair of like poles together

Questions

1. What is meant by a magnetic field ?
2. Can the copper block be exerted the magnetic force due to magnet ?

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