chapter-8 Remainder and Factor Theorm

Example: $89 \div 9$

Divisor $\leftarrow 9\overline{)89}(9 \rightarrow$ quotient

81

(8)

Remainder   Dividend

② $x^2+2x \div x$

$\frac{x^{\cancel{2}}}{\cancel{x}} + \frac{2\cancel{x}}{\cancel{x}} = x+2$

$\frac{x^{\cancel{2}}}{\cancel{x}} = x$

$x\overline{)x^2+2x}(x+2$

$\frac{2\cancel{x}}{\cancel{x}} = 2.$

$\underline{-\cancel{x^2}}$

$2x$

$\underline{-2x}$

(0)

③ $x^2+2x+4 \div x+3$

$x+3\overline{)x^2+2x+4}(x-1$

$\underline{-x^2 \mp 3x}$

$-x+4$

$\frac{x^{\cancel{2}}}{\cancel{x}} = x$

$-x-3$

$\underline{(+)\quad(+)}$

$\frac{-x}{x} = -1$

(7)

Remainder

Remainder Theorm

Example 3: $x^2+2x+4 \div x+3$

let $f(x) = x^2+2x+4$

divisor $= x+3$

let $x+3=0$

$\boxed{x=-3}$

$f(-3) = (-3)^2+2(-3)+4$

$= 9-6+4$

$= 13-6$

$= 7 \rightarrow$ Remainder

Exercise - 8(A)

8A
I
Find, in each case, the remainder when

① $x^4 - 3x^2 + 2x + 1$ is divided by $(x-1)$

A) Given,

$f(x) = x^4 - 3x^2 + 2x + 1$

The divisor is $(x-1)$.

let $x - 1 = 0$

$\boxed{x = 1}$

$f(x) = (1)^4 - 3(1)^2 + 2(1) + 1$

$= 1 - 3 + 2 + 1$

$f(x) = 1$

∴ Remainder is 1.

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② $x^3 + 3x^2 - 12x + 4$ is divided by $x - 2$

A) Given,

$f(x) = x^3 + 3x^2 - 12x + 4$

The divisor is $(x-2)$

let $x - 2 = 0$

$\boxed{x = 2}$

$f(x) = (2)^3 + 3(2)^2 - 12(2) + 4$

$= 8 + 12 - 24 + 4$

$= 24 - 24$

$= 0.$

Note: If the remainder is zero, then the divisor is called factor of $f(x)$

iii) $x^4 + 1$ is divided by $x + 1$

A) Given,

$f(x) = x^4 + 1$

The divisor is $x + 1$

let $x+1=0 \Rightarrow \boxed{x=-1}$

$f(x)=(-1)^4+1$

$=1+1$

$=2$

II Show that

i) $x-2$ is a factor of $5x^2+15x-50$

A) Given, $f(x)=5x^2+15x-50$

The divisor is $x-2$

$\boxed{x=2}$

$\therefore f(x)=5(2)^2+15(2)-50$

$=5(4)+30-50$

$=20+30-50$

$=50-50$

$f(2)=0$

ii) $3x+2$ is a factor of $3x^2-x-2$

A) Given,

$f(x)=3x^2-x-2$

The divisor is $(3x+2)$

let $3x+2=0$

$3x=-2$

$x=-\frac{2}{3}$

$\therefore f\left(-\frac{2}{3}\right)=3\left(-\frac{2}{3}\right)^2-\left(-\frac{2}{3}\right)-2.$

$=\cancel{3}\times\frac{4}{\cancel{9}_3}+\frac{2}{3}-\frac{2}{1}$

$=$

$=\frac{4}{3}+\frac{2}{3}-\left(\frac{2}{1}\times\frac{3}{3}\right)$

$=\frac{4}{3}+\frac{2}{3}-\frac{6}{3}$

$=\frac{4+2-6}{3}=\frac{6-6}{3}=\frac{0}{3}=0$

$\therefore f(-\frac{2}{3}) = 0$ hence $3x+2$ is a factor of $f(x)$.

③ Use Remainder Theorm, to find which of the following is a factor of $2x^3+3x^2-5x-6$

i) $x+1$ ii) $2x-1$ iii) $x+2$

A) Given,

$$f(x) = 2x^3+3x^2-5x-6$$

The divisor is $x+1$.

let $x+1=0$

$$\boxed{x=-1}$$

$$\therefore f(x) = 2(-1)^3+3(-1)^2-5(-1)-6$$

$$= -2+3+5-6$$

$$= 8-8$$

$$= 0.$$

ii) $2x-1=0$

A) Given,

$$f(x) = 2x^3+3x^2-5x-6$$

The divisor is $2x-1$

let $2x-1=0$

$$2x = 1$$

$$x = \frac{1}{2}$$

$$\therefore f(x) = 2\left(\frac{1}{2}\right)^3+3\left(\frac{1}{2}\right)^2-5\left(\frac{1}{2}\right)-6$$

$$\therefore f\left(\frac{1}{2}\right) = 2\times\frac{1}{8}+3\times\frac{1}{4}-\frac{5}{2}-\frac{6}{1}$$

$= \frac{1}{4} + \frac{3}{4} - \frac{5}{2} - \frac{6}{1}$

$= \frac{1}{4} + \frac{3}{4} - \left(\frac{5}{2} \times \frac{2}{2}\right) - \left(\frac{6}{1} \times \frac{4}{4}\right)$

$= \frac{1}{4} + \frac{3}{4} - \frac{10}{4} - \frac{24}{4}$

$= \frac{1+3-10-24}{4}$

$= 4 - 34/4$

$= \frac{-\cancel{30}^{15}}{\cancel{4}_{2}}$

$= -\frac{15}{2}.$

(ii) $x+2$

Given;

$f(x) = 2x^3 + 3x^2 - 5x - 6$

The divisor is $x+2$

let $x+2=0$

$x = -2$

$f(-2) = 2(-2)^3 + 3(-2)^2 - 5\cancel{x}(-2) - 6$

$= 2(-8) + 12 + \cancel{8}10 - 6$

$= -16 + 12 + 10 - 6$

$= -16 - 6 + 12 + 10$

$= \cancel{-10+12+10}\ -22+22$

$= 0$

$\therefore f(-2) = 0$ hence $x+2$ is a factor of $f(x)$

Vernier Callipers

Aim: To deterime the diameter of a given object by using verneir callipers

Apparatus: Vernier callipers and object

Formula: $L.C = \dfrac{\text{Value of one main scale division}(x)}{\text{Total number of divisions on verneir}(n)}$

Procedure:

i) Find the least count and zero error of the verneir callipers

ii) Move the jaw J_2 away from the other jaw J_1 and place the object to be measured between the jaws J_1 and J_2. Move the jaw J_2 towards the jaw J_1 till it touches the object. Tighten the screw s to fix the verneir scale in its position.

iii) Note the main scale reading.

iv) Note that division p on verneir scale which coincides or is in line with any division of the main scale. Muitiply this verneir division p with the least count. This is the verneir scale ~~division~~ (or) reading i.e., Verneir scale reading $= p \times L.C$

v) Add the verneir scale reading to the main scale reading. This gives the observed length.

vi) Repeat it two times and record the observations

Observations:

Total number of divisions on verneir scale

$n =$

Value of one division on main scale

$x =$

Least count (L.C) =

Precautions:

- Motion of Verneir scale on main scale should be made smooth.
- The verneir constant and zero error should be carefully found and properly recorded.
- The body should be gripped between jaws firmly, but gently
- Observations should be taken at right angles at one place and taken at least at three different places.

Result:

Screw Gauge

Aim: To determine the thickness of the object usin screw gauge

Apparatus: Screw Gauge and object

Formula: $L \cdot C = \dfrac{\text{Pitch of the screw}}{\text{Total number of divisions on its circula scale}}$

Procedure:

i) Find the least count and the zero error (if any) of the screw gauge

ii) Turn the ratchet anticlockwise so as to obtain a gap between the stud A and the flat end B. Place the wire in the gap between the stud A and the flat end B. Then turn the ratchet clockwise so as to hold the given wire gently between the stud A and the flat end B of the screw.

iii) Note the main scale reading.

iv) Note that division p of the circular scale which coincides with the base line of the main scale. This circular division p when multiplied by the least count, gives the circular scale reading i.e., Circular scale reading $= p \times L \cdot C$

v) Add the circular scale reading to the main scale reading to obtain the total reading (i.e., the observed diameter of the wire).

vi) Repeat it by keeping the wire in perpendicular direction. Take two more observations at different places of the wire and write observation and record them

Observation:

Pitch of the screw =

Total number of divisions on the circular scale =

Least count of screw gauge (L.C)

$$= \frac{\text{Pitch}}{\text{Total number of divisions on circular scale}} =$$

Zero error =

Precautions:

- To avoid undue pressure always use the retchet R to rotate the screw
- The screw should move freely without friction.
- The zero error, with proper sign should be noted carefully and applied correctly.
- For the same set of observations, the screw should be moved in the same directions to avoid back-lash error of the screw.

- At each place the diameter in two perpendicular directions should be measured.
- The wire should be straight and free from any kinks
- Avoid error due to parallax.

Result

Simple Pendulum

Aim:- To Measure Time Period of a Simple Pendulum and g)

Apparatus: Support, Bob and String

Formula: $f = \frac{1}{T}$ or $T = \frac{1}{f}$

$$g = \frac{4\pi^2}{\text{Slope of } T^2 \text{ vs } l \text{ graph}}$$

Procedure:

i) To measure the time period of a simple pendulum, the bob is slightly displaced from its rest(mean) position O and is then released. It begins to move to and fron about its mean position O in a vertical plane along the string. The time t for 20 complete oscillations is measured with the help of a stop watch and then dividing t by 20, its time period t is calculated. The experiment is then released for different lengths of the pendulum.

ii) If a graph is plotted for the square of time period (T^2) taken on Y-axis against the length l taken on X-axis, it comes out to be a straight line inclined to the l-axis. This shows that T^2 is directly proportional to l. The slope of the straight line obtained in T^2 vs l graph can be obtained by taking two points P and Q on the straight line and drawing normals from these points on the x and Y axes. Then note the value of T^2 say T_1^2 and T_2^2 at a and b respectively, and also the value of l say l_1 and l_2 respectively at c and d. Then

$$\text{Slope} = \frac{PR}{QR} = \frac{ab}{cd} = \frac{T_1^2 - T_2^2}{l_1 - l_2}$$

This slope is found to be a constant at a place and is equal to $\frac{4\pi^2}{g}$ where g is the accerlation due to gravity at that place. Thus g can be determined at a place from these measurements by using the following reaction:

$$g = \frac{4\pi^2}{\text{Slope of } T^2 \text{ vs } l \text{ graph}}$$

Observations:

It can be noted that if the length of a pendulum is made four times, the period of oscillation gets doubled i.e., now it takes twice the time for one complete to and fro motion. Thus time period T is directly proportional to the square root of effective length l of the pendulum ($T \propto \sqrt{l}$) or the square of time period T^2 is directly proportional to the length l of the pendulum (i.e., $T^2 \propto l$) or $\frac{l}{T^2}$ is a constant.

Precautions:

• The amplitude of the vibrations should be kept small.
• The bob should move along a straight line and must not spin during vibration.
• Length of pendulum should be increased in steps of 10cm t bring appreciable change in time period
• Not the time as accurately as possible because a small error in measurement of T produces large error in the final result.

Result:

Aim: To Determine the weight of the metre rule by using known mass
(a) when the rular is pivoted at 0 cm mark.
(b) when the rular is pivoted at 40 cm mark.
(c) when the rular is pivoted at 75 cm mark.

Apparatus:
1) Metre rule
2) known mass
3) stand

Principle:
At equilibrium, moment of force clock wise = moment of force anti clock wise

Formula: $F_1 \times \perp d_1 = F_2 \times \perp d_2$

Procedure:

(a) when the rular is pivoted at 0 cm mark.
i) Hang the metre scale at 0 cm mark to the stand.
ii) Hang the known mass in anti-clockwise direction at an appropriate position such that the metre rule gets balanced
iii) Note the position of the known mass on the metre rule.
iv) If the known mass is of mass m_2 and the noted position of the known mass is

d_2 (in cm) then anticlockwise moment of force $= m_2 \times g \times d_2$

v) Since the mass of the metre rule is assumed to act at 50 cm mark, clockwise moment of force $= m_1 \times g \times 50$ where m_1 is mass of metre rule and $m_1 \times g$ is the weight of metre rule

vi) Equate anti-clockwise moment and clockwise moment of force

$$m_2 \times g \times d_2 = m_1 \times g \times 50$$

$$m_1 \times g = \frac{m_2 \times g \times \cancel{8} d_2}{\cancel{d_2} 50}$$

$\therefore$ weight of metre rule $= \frac{m_2 \times g \times \cancel{8} d_2}{50}$

b) when the rular is pivoted at 40 cm mark.

i) Hang the metre scale at 40 cm mark to the stand

ii) Hang the known mass at an appropriate position between 0 cm mark and 40 cm mark such that the metre rule gets balanced.

iii) Note the position of the known mass on the metre rule.

iv) If the known mass is of mass m_2 and the noted position of the known mass is d_2 (in cm) then anticlockwise moment of force $= m_2 \times g \times (40 - d_2)$

v) Since the mass of the metre rule is assumed to act at ~~an~~ 50 cm mark, clockwise moment of force $= m_1 \times g \times (50-40) = m_1 \times g \times 10$ where m_1 is the mass of the metre rule and $m_1 \times g$ is the weight of metre rule.

vi) Equate anti-clockwise moment and clockwise moment of force

$$m_2 \times g \times (40 - d_2) = m_1 \times g \times 10$$

$$\frac{m_2 \times g \times (40 - d_2)}{10} = m_1 \times g$$

$\therefore$ weight of the metre rule $= \frac{m_2 \times g \times (40 - d_2)}{10}$

c) when the rular is pivoted at 75 cm mark

i) Hang the metre scale at 75 cm mark to the stand

ii) Hang the known mass at an appropriate position between 75 cm mark and 100 cm mark such that the metre rule gets balanced

iii) Note the position of the known mass on the metre rule.

iv) If the known mass is of mass m_2 and the noted position of the known mass is d_2 (in cm) then clockwise moment of force $= m_2 \times g \times (d_2 - 75)$

v) Since the mass of the metre rule is assumed to act at 50 cm mark, anticlockwise moment of force $= m_1 \times g \times (75 - 50) = m_1 \times g \times 25$ where m_1 is the mass of the metre rule and $m_1 \times g$ is the weight of metre rule.

vi) Equate clockwise moment and anticlockwise moment of force

$$m_2 \times g \times (d_2 - 75) = m_1 \times g \times 25$$

$$\frac{m_2 \times g \times (d_2 - 75)}{25} = m_1 \times g$$

$\therefore$ weight of the metre rule $= \dfrac{m_2 \times g \times (d_2 - 75)}{25}$

Result:

Verification of Archimedes' Principle

Aim: To Verify Archimedes' Principle

Apparatus: Spring Balance, Solid, Eureka Can, Measuring Cylinder, Water

Principle:

Archimedes' principle states that when a body is immersed partially or completely in a liquid, it experiences an upthrust, which is equal to the weight of the liquid displaced by it.

This principle applies not only to liquids, but it applies equally well to gases also.

Formula: Weight of water displaced = Upthrust or loss in weight

Procedure:

Take a solid. Suspend it by a thin thread from the hook of a spring balance. Note its weight.

Now take a eureka can and fill it with water up to its spout. Arrange a measuring cylinder below the spout of the eureka can.

Now immerse the solid gently into water of the eureka can. This water displaced by it gets collected in the measuring cylinder. When water strops dripping through the spout, note the weight of the solid and the volume of water collected in the measuring cylinder.

The solid weighs 300 gf in air and 200 gf when it is completely immersed in water. This volume of water collected in the measuring cylinder is 100 ml i.e, $100\ cm^3$

$\therefore$ Loss in weight = 300 gf − 200 gf = 100 gf —— (i)

Volume of water displaced = Volume of solid

$= 100\ cm^3$

Since, density of water $= 1\ g\ cm^{-3}$

$\therefore$ Weight of water displaced = 100 gf —— (ii)

From equations (i) and (ii)

Weight of water displaced = Upthrust or loss in weight

Observation:

Thus the weight of water displaced by a solid is equal to the loss in weight of the solid. This verifies Archimedes' principle

Precautions:

- Spring balance should be stable and sensitive.
- While weighing, the metal ball should not touch the sides of the measuring cylinder.
- Always look at the level of the lowest point of the concave meniscus water while taking the reading.

Result:

Verification of Laws of Reflection

Aim: To verify laws of Reflection

Apparatus: Marker, white paper, drawing board, protractor, small plane mirror, stand, pins

Laws of Reflection

1) The angle of incidence i is equal to the angle of reflection r (ie., $\angle i = \angle r$)

2) The incident ray, the reflected ray and the normal at the point of incidence, lie in the same plane.

Procedure:

Fix a sheet of white paper on a drawing board and draw a line MM_1. On this line, take a point O and nearly at the needle of it. and draw a line OA such that $\angle MOA$ is less than 90°. Then draw a normal ON on line MM_1 at point O, and place a small plane mirror vertically by means of stand with its silvered surface on the line MM_1

Now fix two pins P and Q vertically at some distance apart on line OA, on the board. keeping eye on the other side of normal (see but on the same side of mirror), see clearly the images P' and Q' of the pins P and Q. Now fix a pin R such that the pin S is also in line with the pin R as well as the images P' and Q' of pins P and Q.

Draw small circles on paper around the position of the pins. Remove the pins and draw a line OB joining the point O to the pin points S and R, AO is the incident ray, OB is the reflected ray, ∠AON = r is the angle of relection. The angles AON and BON are measured and recorded in the observation table.

Observation:

We find that in each case, angle of incidence is equal to the angle of reflection. This verifies the first law of reflection.

The experiment is being performed on a flat drawing board, with mirror normal to the plane of board on which white sheet of paper is being fixed. Since the lower tips of all four pins lie on the same plane, therefore the incident ray, the reflected ray and normal at the point of incidence, all lie in one plane. This verifies the second law of reflection.

Precautions:

- A sharp pencil should be used for drawing the incident ray, reflected ray and the normal.
- The angle of incidence should lie between 30° and 60°.

- The distance between the pins should be at least 10 cm.
- The pins must be vertical.
- The mirror should be sufficiently thin.
- The plane of the mirror should be perpendicular to the plane of the paper.
- The directions of light ray should be indicated with the help of arrows.

Result :

Plot the magnetic lines of forces.

a) Aim:- To plot the magnetic lines of forces when the magnet is placed with its north pole pointing towards the north.

Apparatus: white paper, drawing board, pins, pencil, magnet, magnetic compass

Procedure:

Fix a sheet of white paper on a drawing board with the help of brass pins. Mark north-south direction in the middle of the paper by keeping a compass needle on it. Draw a line along this direction and place a bar magnet on the paper along this line with its north pole pointing towards north. Mark its outline with a fine pencil. Now place the compass needle close to the north pole of the magnet and looking from above, mark two pencil dots exactly in front of the two ends of the needle.

Then move the compass needle in such a way that one end of the needle coincides with the second pencil dot. Again looking from above mark the position of the other end of the needle with a dot. Repeat the process of moving the compass needle till the other end of the bar magnet is reached. Join different dots to get a continuous smooth curve. Thus one magnetic field line is traced.

Repeat the process from the same pole of magnet, but starting from a different point and trace out another magnetic field line. In this manner, draw Several magnetic field lines starting from different points near the same pole of the magnet. label each line with an arrow from the north pole towards the South pole of the magnet (or from south pole of compass needle to its north pole) to indicate the direction of magnetic field line at that place.

x (The magnetic field lines are shown in the figure) x These are due to the combined effect of (i) the magnetic field of magnet and ii) earth's magnetic field.

Observations:

(i) The magnetic field lines are curved in the vicinity of the magnet. They are mainly due to the magnetic field of the magnet which is stronger than the magnetic field of the earth in this region. As the distance from the magnet increases, the strength of the magnetic field due to the magnet decreases and at distant points, it becomes weaker than the earth's magnetic field. The magnetic field lines are therefore parallel to each other at distant points. Here they are mainly due to the earth's magnetic field.

ii) There are two points equidistant from the centre of the magnet marked as x in east and west directions where the magnetic field of the magnet and the horizontal component of the earth's magnetic field are equal in magnitude but in opposite directions such that they neutralize each other. These are neutral points. A compass needle when placed at these points, remains unaffected and the needle rests in any direction.

Precautions:

- The drawing board must not be distributed during the experiment.
- Care must be taken that magnetic materials are away from the board.
- The direction of the magnetic meridian must be drawn very carefully.
- The compass needle is gently tapped locating its 'N' pole.

Result:

b) Aim: To plot the magnetic lines of forces when the magnet is placed with its south pole pointing towards north.

Apparatus: white paper, drawing board, pins, pencil, magnet, magnetic compass

Procedure:

In this case, the bar magnet is placed on the paper along the magnetic meridian with its south pole pointing towards north and lines of magnetic field are traced following the same method as described above.

Observations:

i) The magnetic field lines are curved in the vicinity of the magnet and they are mainly due to the magnetic field of the magnet which is much stronger than the earth's magnetic field. As the distance from the magnet increases, the strength of the magnetic field due to the magnet decreases and at distant points, it becomes weaker than the earth's magnetic field. The magnetic field lines are nearly parallel to straight lines from south to north, at distant points from the magnet. They are mainly due to the earth's magnetic field.

ii) There are two points equidistant from the centre of the magnet marked as x in north and south directions where the magnetic field of the magnet and the horizontal compenent of the earth's magnetic's field are equal in magnitude but in opposite directions such that the two fields neutralize each other. At these points, the compass needle remains unaffected and the needle comes to rest pointing in any direction. These points are neutral points.

Precautions

- The drawing board must not be distributed during the experiment.
- Care must be taken that magnetic materials are away from the board.
- The direction of the magnetic meridian must be drawn very carefully.
- The compass needle is gently tapped locating its 'N' pole.

Result:

Verification of laws of refraction

Aim:- To verify laws of Refraction

Apparatus: Glass Block, drawing board, white papers, pins, protractor, pencil (or) marker

Laws of Refraction:

1) The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane

2) The ratio of the sine of the angle of incidence i to the sine of refraction r is constant for the pair of given media, i.e., mathematically

Procedure:

1) Place a rectangular glass block on a white sheet of paper fixed on a drawing board and draw its boundary line PQRS with a pencil.

2) Remove the block and on the boundary line PQ, take a point O nearly at its middle and then draw a normal NOM on the line PQ at the point O.

3) Draw a line AO inclined at an angle i to the normal NOM.

4) Replace the glass block exactly on its boundary line.

5) Fix two pins a and b vertically on the board about 5 cm apart, on the line AO.

6) Now looking from the other side RS of the block by keeping the eye close to the plane of the board, fix two more pins c and d such that the base of all the four pins a, b, c and d appear to be in a straight line as seen through the match.

7) Then remove the pins once one by one and mark dots at the position of each pin with a fine pencil. Remove the block and join the points c and d by a line BC to meet the boundary line RS at a point B. Join the points O and B by a straight line which gives the path of light ray inside the glass block.

Here AO represents the incident ray, OB the refracted ray through the block and BC the emergent ray. NOM is the normal at the point of incidence O, ∠AON is the angle of incidence i and ∠BOM is the angle of refraction r.

8) Measure the angles i and r. Read the values of sin i and sin r from the sine table and calculate the ratio sin i/sin r. This ratio is constant and it gives the refractive index of glass.

9) Repeat the steps (3) to (8) of the experiment for different values of angle of incidence i equal to $50°, 60°, 70°, 80°$ and in each case, find the ratio $\frac{\sin i}{\sin r}$ or $\frac{DE}{EG}$

Observations:-

We find that the ratio $\frac{\sin i}{\sin r}$ or $\frac{DE}{EG}$ comes out to be a constant for each value of angle i. This verifies the second law of refraction. The ratio so obtained is equal to the refractive index μ of glass, the material of the block. Thus, the refractive index μ of glass or of any other material in the form of a block can be determined.

Further, the incident ray AO, the normal NOM at the point of incidence O and the refracted ray OB are in the plane of paper (i.e., in the same plane). This verifies the first law of refraction.

Precautions:

- Arrow heads should be marked to show the direction of the light ray.
- The parallax should be removed when the light rays travels from one medium to another medium.
- The glass slab should be thin.

Result:

Determination of focal length of convex lens.

a) Aim: To Determine focal length of convex lens by i) distant object method.

Apparatus: white wall (screen), distant object (tree), covex lens, metre rule

Principle:

A beam of parallel rays from a distant object incident on a convex lens gets converged in the focal plane of the lens.

Procedure:

In an open space, against a white (or light coloured) wall, place a metre rule horizontally with its 0 cm end touching the wall and its other end towards the illuminated object which is at a very large distance (such as a tree). Holding the given lens vertically on the metre rule, focus the object on the wall by moving the lens to and fro along the length of the metre rule. Since the light rays incident from a distant object are nearly parallel, so the image of it formed on the wall is almost in the focal plane of the lens. The distance of the lens from the wall on the metre rule directly gives the approximate focal length of the lens. The approximate focal length of the lens is 48 cm.

Precautions:

• Tip of the object and image needle should be at the same height as the centre of the lens.
• Parallax error should be removed from tip to tip.
• The base of the lens stand and white screen should be in the line with the measuring scale.
• Record the readings when sharp image is forme-d.

Result:

b) Aim: To determine focal length of convex lens by ii) plane mirror method.

Apparatus: convex lens, mirror, vertical stand, pin, clamp

Procedure:

i) Place the lens L on a plane mirror MM' kept on the horizontal surface of the vertical stand and arrange the pin P horizontally in the clamp so that its tip is vertically above the centre O of the lens L.

ii) Adjust the height of the pin till it has no parallax with its inverted image as seen from vertically above the pin. To check for parallax, keep the eye vertically above the tip of the pin P at a distance nearly 25 cm from it and move it sideways. If the tip of the pin and its image shift together, then there is no parallax.

iii) Measure the distance x of the pin P from the lens and the distance y of the pin from the mirror, using a metre rule and a plumb line. Calculate the average of the two distances. This gives the focal length of the lens, i.e., $f = \frac{x+y}{2}$

Precautions:

• Tip of the object and image needle should be at the same height as the centre of the lens.
• Parallax error should be removed from tip to tip.
• The base of the lens stand and white screen should be in the line with the measuring scale.
• Record the readings when sharp image is forme-d.

Result:

c) Aim: To determine the focal length of a convex lens by plotting graphs between u and v and between $\frac{1}{u}$ and $\frac{1}{v}$

Apparatus: An optical bench with three uprights (central fixed, two outer uprights with lateral movement), a convex lens with lens holder, two optical needles and a half meter scale.

Formula: The relation between u, and f, v for a convex lens is

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$, where f = focal length of convex lens, u = distance of object needle from lens, v = distance of image needle from lens.

Note: According to sign-convention, the value of u is always negative and the values of v and f are always negative

Procedure:

1) Mount object needle, lens and image needle uprights on the optical bench.

2) Tip of the object needle, image needle and optical centre of lens must be in straight line parallel to optical bench.

3) Place the object needle on left side of lens so as to get its inverted image of it.

4) Now place image needle on right side of lens and remove the parallax between image of object and image needle.

5) Note down the position of object needle, lens and image needle.

6) For more reading move object needle slightly and again remove parallax between image of object needle and image needle keeping lens position fixed and note down the positions, image needle and lens.

7) In this way take at least five readings.

Calculations of focal length by graphical methods.

1) u-v Graph. Select a suitable but a same scale to represent u along X-axis and v along Y-axis. According to sign convection, in this case, u is negative and v is positive. Plot the various points for different sets of values of u and v from observation table. The graph comes out to be a rectangular hyperbola.

Draw a line OA making an angle 45° with either axis (i.e., bisecting ∠YOX') and meeting the curve a point A. Draw AB and AC perpendicular on x' and Y axis respectively.

The values of u and v will be same for point A. So the coordinates of Point A must be $(-2f, 2f)$, because for a convex lens, when $u = -2f$, $v = 2f$.

Hence,

$$|OB| = |OC| = 2f \quad \text{or} \quad OC = 2f, OB = -2f$$

$$\therefore f = \frac{OB}{2} \text{ and also } f = \frac{OC}{2}$$

$\therefore$ Mean value of f = ____ cm

From lens formula applied at point A

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

As $u = -v$, $\frac{1}{f} = \frac{2}{u}$ or $\frac{2}{v}$ and $f = \frac{u}{2}$ or $\frac{v}{2}$

Hence, half the value of either coordinate of A (i.e., distance OB) gives the focal length of the convex lens.

$$f = \frac{OB}{2} = \text{\_\_\_\_ cm}$$

$\therefore$ Mean value of f = ____ cm.

Precautions:

- Tip of the object and image needle should be at the same height as the centre of the lens.
- Parallax error should be removed from tip to tip.

- The base of the lens stand and white screen should be in the line with the measuring scale.
- Record the readings when sharp image is formed.

Result

Determination of angle of minimum deviation of Light through glass prism.

Aim: To determine angle of minimum deviation of light through glass prism.

Apparatus: Diagram, monochromatic light, pins, scale, etc.

Procedure:

A monochromatic ray of light OP strikes the face AB of the prism at an angle of incidence i_1. It suffers refraction from air (rarer medium) to glass (denser medium) at the face AB, so the ray bends towards the normal PN making an angle of refraction r_1 and travels along PQ inside the prism. Thus, PQ is the refracted ray. The refracted ray PQ now strikes the face AC of the prism at an angle of incidence i_2. It suffers refraction from glass (denser medium) to air (rarer medium) at the face AC, so the ray bends away from the normal NQ and emerges out of the prism as QR at an angle of emergence i_2. Thus QR is the emergent ray.

Thus in passing through a prism, a ray of light suffers refraction at two inclined faces AB and AC of the prism. In each refraction, the ray bends towards the base of the prism. At the first face AB of the prism the ray OP, instead of going along OPM, has bent at P along PQ, so it suffers a deviation by an $\angle MPQ$ equal to δ_1. At the second face AC, the ray PQ has bent at Q along QR which appears to be coming along MQR, so it suffers a deviation by an $\angle MPQ$ equal to δ_2.

In the absence of the prism, the incident ray OP would have travelled along ~~PQ~~PML. The emergent ray QR appears to be coming ~~from~~ along MQR. Thus, the prism has produced a total deviation by an $\angle LMQ$, which is the angle between the direction of incident ray (OP produced forward) and the emergent ray (QR produced backward). It is called angle of deviation and is denoted by the greek alphabet δ (delta)

$$\angle LMQ = \angle MPQ + \angle MQP$$

$\therefore$ Angle of deviation $\delta = \angle MPQ + \angle MQP$

$$= \delta_1 + \delta_2$$

Since, $\angle MPN = i_1$ (angle of incidence), and $\angle MQN = i_2$ (angle of emergence).

Therefore $\angle MPQ = \delta_1 = (i_1 - r_1)$

$$\angle MQP = \delta_2 = (i_2 - r_2)$$

$\therefore$ From equation i) $\delta = (i_1 - r_1) + (i_2 - r_2)$

$$\boxed{\delta = (i_1 + i_2) - (r_1 + r_2)}$$

Also for equilateral triangle

$$\angle APN = \angle AQN = 90^\circ$$

$\therefore \angle PNQ + \angle PAQ = 180^\circ$

But $\angle PAQ = A$

$\angle PNQ = 180^\circ - A$ $\longrightarrow$ (ii)

But in triangle PNQ

$\angle PNQ = 180 - (r_1 + r_2)$

$\therefore$ From equations (ii) and (iii)

$[180^\circ - (r_1 + r_2)] = 180^\circ - A$

or $r_1 + r_2 = A$

Hence from equations (4.9) and (4.10),

$\delta = (i_1 + i_2) - A$

or $\boxed{i_1 + i_2 = A + \delta}$

Observation:

It is experimentally observed that as the angle of incidence increases, the angle of deviation first decreases, reaches to a minimum value for a certain angle of incidence and then on further increasing the angle of incidence, the angle of deviation begins to increase.

The angle of deviation δ is noted for each angle of incidence i and then a graph is drawn for δ vs i. It is called the i-δ curve in which the minimum value of angle of deviation is marked as δ_{min}

It is found that the angle of deviation becomes minimum ($= \delta_{min}$) when the angle of incidence is equal to the angle of emergence i.e., when $i_1 = i_2$ or when $r_1 = r_2$. If ΔABC is equilateral (or equiangular), for $r_1 = r_2$, the ray PQ will be parallel to be base BC.

~~It is found~~ ~~that~~ the position of a prism with respect to the incident ray at which the incident ray suffers minimum deviation is called the position of minimum deviation. Thus, in the position of minimum deviation, the refracted ray inside the prism is parallel to its base if the prism is equilateral (or the principal section of the prism forms an isosceles triangle).

Precautions:

- The prism should not be distributed during the course of the experiment
- The angle of incidence should not be less than 300, as the ray may get totally reflected inside the prism.
- The pins must have sharp tips and be positioned in a perfectly vertical around 10 cm apart from each other.
- The position of pins must be marked clearly by encircling the pin pricks.
- Arrow heads should be marked to show the direction of the light rays.

Result:

Determination of Specific heat of metal by method of mixtures.

Aim: To determine Specific heat of metal by method of mixtures

Apparatus: A hypsometer/calorimeter, stirrer, a lid and outer jacket, given metal in powder form or in small pieces, balance, weight box, two half degree thermometer, cold water, clamp stand.

Formula: ~~Ih~~ In hypsometer, the solid is heated uniformly above room temperature up to a fixed temperature and then solid is added to cold water in calorimeter.

Heat lost by solid = Heat gain by the water and calorimeter.

Procedure:

1) Put two thermometer A and B in a beaker containing water and note their. Take one of them, say A to be standard and find the correction to be applied to the other, say B.

2) Put thermometer B in the copper tube of hypsometer containing the power of given solid. Put sufficient water in hypsometer and place it on a burner.

3) Weigh the caloriemeter with stirrer and lid over it by the physical balance. Record it.

4) Fill about half of caloriemeter with water at about temperature 5 to 8°c below room temperature. Now, weigh it again and record it.

5) Heat the hypsometer about 10 minutes till the temperature of solid remains steady.

6) Note the temperature of water in the caloriemeter. Now, transfer the solid from hypsometer to the caloriemeter quickly. Stir the contents and record the final temperature of the mixture.

7) Remove the thermometer A from caloriemeter and weigh the caloriemeter with its contents and lid.

Observations:

Reading of thermometer A = T_A = ____ °c
Reading of thermometer B = T_B = ____ °c
Correction applied in B. with respect to A ($T_A - T_B$) = ____ °c,

Mass of caloriemeter and stirrer m = ____ g
Water equivalent of caloriemeter w = m × 0.095 = ____ g
Specific heat of copper caloriemeter = 0.095 cal/g.
Mass of caloriemeter + stirrer + lid = m_1 = ____ g
Mass of caloriemeter + stirrer + lid + cold water = m_2 = ____ g

steady temperature of hot solid = T_s = ____ °C.
Corrected temperature of hot solid $T = T_s - (T_A - T_B)$ = ____ °C.

Temperature of cold water = t = ____ °C.
Temperature of mixture = θ = ____ °C.
Mass of caloriemeter, stirrer, lid, cold water and solid = m_3 = ____ g

According to principle of caloriemeter, heat lost = heat gained

$$(m_3 - m_2) \times C \times (T - \theta) = [w + (m_2 - m_1)(\theta - t)]$$

$$C = \frac{[w + (m_2 - m_1)(\theta - t)]}{[(m_3 - m_2)(T - \theta)]} = \text{\_\_\_\_ cal/g°C.}$$

Precautions:

- Solid should be appropriate size.
- Before transferring the solid into the measuring cylinder, the its temperature must remain constant.
- The solid should be transferred immediately and gently to measuring cylinder so that its temperature may not fall.
- The mixture should be stirred well but gently.
- Half degree thermometer should be set properly before its use.
- Thermometers use should be sensitive.

Result:

Verification of Ohm's law

Aim: To Verify Ohm's law

Apparatus: Battery, Rheostat, Ammeter, Voltmeter, wire, Resistance, key.

Electric circuit:

The ~~r~~ rheostat, Rh, ammeter A, resistance wire R and key K are connected in series with the battery B, taking care that the +ve marked terminal of ammeter A is towards the positive terminal of the battery. The Voltmeter V is then connected in parallel across the resistance wire R keeping its +ve marked terminal towards the positive terminal of the battery.

The battery (B) sends current in the circuit. The current in the circuit is changed by the ~~Rh~~ rheostat (Rh) and the ammeter (A) measures the current. The key K is used to start and stop the current in the circuit. The wire R is the unknown resistance. The voltmeter (V) measures the potential difference across the ends of the resistance wire R.

Procedure:

As the key K is closed, current flows in the circuit. The Rheostat Rh is adjusted to get the minimum (non-zero) reading in the ammeter A and voltmeter V. The ammeter reading I and the voltmeter reading V are noted. The sliding terminal of the rheostat is then moved to increase the current gradually and each time the value of the current I flowing in the circuit and the potential difference V across the resistance wire R are recorded by noting the readings of the ammeter A and voltmeter V respectively. In this way, different set of the values of I and the V are recorded in the table given below. Then for each set of values of I and V, the ratio $\frac{V}{I}$ is calculated.

Observations:

It is noted that ~~the~~ for each observation, the ratio $\frac{V}{I}$ is almost constant so its average value gives the resistance R of the wire.

V–I graph: A glass is plotted for V against I by taking V on Y-axis and I on X-axis which is found to be a straight line. This verifies the Ohm's law.

Slope of V–I graph: To find the slope of the straight line obtained on V–I graph, take two points P and Q on straight line. From the points P and Q, draw normals PA and QB on the Y-axis; and PC and QD on the X-axis. Read the potential V_A at A and V_B at B and find the difference $V_A - V_B = \Delta V$. Similarly read the ~~difference~~ current I_C at C, and I_D at D, and find the difference $I_C - I_D = \Delta I$

Then find the slope $= \frac{\Delta V}{\Delta I}$

The slope of the straight line on V-I graph i.e., $\left(\frac{\Delta V}{\Delta I}\right)$ gives the resistance R of the conductor (or wire), i.e.,

$$R = \frac{\Delta I}{\Delta V} = \text{slope of V vs I graph}$$

Obviously, greater is the slope of V-I graph, greater is the resistance of the conductor.

Precautions:

- The terminals of voltmeter and ammeter should be connected as per the signs shown in the circuit diagram.
- Clean the ends of the connecting wires with send paper before making the connections.
- Remove the key, when the readings are not being taken.
- The range of the voltmeter, should be more than the e.m.f of cell.
- The connections should be tight.
- Do not allow current to pass for a very long time.

Result: