Applied Physics B

Lab Manual

Applied Physics – B

Syllabus

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units:** T24001028 (Applied Physics B)

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Distinguish between fundamental and derived physical quantity. *TSO 1b.* Estimate the errors in the measurement of given physical quantity. *TSO 1c.* Derive dimensional formula of given physical quantity. *TSO 1d.* Apply dimensional analysis for inter conversion of units. *TSO 1e.* Establish relation among physical quantities using dimensional analysis. *TSO 1f.* Use dimensional analysis to check the correctness of a given equation.	**Unit-1.0 Unit and Measurements** 08 class 1.1 Physical quantities, fundamentals and derived units and system of units 1.2 Accuracy, precision and errors (systematic and random) in measurements, Method of estimation of errors (absolute and relative) in measurement, propagation of errors, significant figures 1.3 Dimensions and dimensional formulae of physical quantities, Principle of homogeneity of dimension in an equation 1.4 Applications of dimensions: conversion from one system of units to other, corrections of equations and derivation of simple equations.	CO1
TSO 2a. Explain the various terms related to SHM. *TSO 2b.* Distinguish between mechanical and electromagnetic waves with examples. *TSO 2c.* Differentiate between longitudinal and transverse waves with examples. *TSO 2d.* Find the relation between the terms used to describe wave motion. *TSO 2e.* Explain the principle of Superposition of waves	**Unit-2.0 Simple Harmonic and Wave Motion** 05 class 2.1 Periodic and Oscillatory Motion 2.2 Simple Harmonic Motion (SHM): Displacement, velocity, acceleration, time period, frequency and their interrelation 2.3 Types of waves: Mechanical and Electromagnetic, Transverse and longitudinal waves, wave velocity, frequency and wave length and their relationship, wave equation, amplitude, phase, phase difference, Superposition of waves	CO2
TSO 3a. Derive an expression for electric field experienced by electric charge in the vicinity of another electric charge(s). *TSO 3b.* Differentiate between electric potential and potential difference. *TSO 3c.* Apply Gauss' law to find the electric field intensity due to charge bodies. *TSO 3d.* Describe factors affecting the capacitance of a given capacitor. *TSO 3e.* Find the expression for magnetic field caused by current carrying circular wire at the center. *TSO 3f.* Explain Faraday's law of electromagnetic	**Unit-3.0 Electrostatics, Electromagnetism and Electric Current** 12 class 3.1 Electric Charge, Coulomb's law, Electric field, Electric lines of force and their properties, Electric flux, Electric potential and potential difference, Electric dipole 3.2 Gauss' law, electric field intensity due to straight charged conductor, charged plane sheet and charged sphere 3.3 Dielectric, Capacitance of capacitor (parallel plate), Factor affecting capacitance of capacitors 3.4 Magnetic field and its units, Biot Savart Law Magnetic field due to current caring wire: straight and circular wire, Lorentz force (force on moving charge in magnetic field)	CO3

Syllabus

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
induction and Lenz's with applications. *TSO 3g.* Explain the terms required to describe the AC current	3.5 Magnetic flux, Faraday's law of electromagnetic induction, Lenz's law, Self and Mutual induction, eddy current, motional emf 3.6 DC and AC currents, Average, rms and Peak value of AC current	
TSO 4a. Distinguish material on the basis of band gap. *TSO 4b.* Explain the various terms related to movement of charge carrier inside the semiconductors. *TSO 4c.* Explain the formation of depletion layer in a given pin junction. *TSO 4d.* Use V-I characteristic of explain the working of given p-n junction device.	**Unit-4.0 Semiconductor Physics** 08 class 4.1 Energy band and band gap, insulator, semi-conductor, conductor 4.2 Intrinsic and Extrinsic semiconductors, Drift velocity, drift and diffusion current, Mobility, current density, law of mass action. 4.3 Depletion layer and barrier Potential, p-n junction and V-I characteristics, Half wave and full wave rectifier 4.4 Photocells, Solar cells; working principle and engineering applications.	CO4
TSO 5a. Apply the concept of photoelectric effect to explain the of photonic devices. *TSO 5b.* Explain Laser, components of laser and its various engineering applications. *TSO 5c.* Explain propagation of light in optical fiber and applications of optical fiber. *TSO 5d.* Describe the properties of nanomaterials and its various applications.	**Unit-5.0 Modern Physics** 12 class 5.1 Photoelectric effect; threshold frequency, work function, Stopping Potential, Einstein's photoelectric equation. 5.2 Lasers: Energy levels, ionization and excitation potentials; spontaneous and stimulated emission; population inversion, pumping methods, types of lasers): He Ne Laser, p-n junction diode laser, engineering and medical applications of lasers. 5.3 Optical fibers: Total internal reflection, acceptance angle and numerical aperture, Optical fiber types, applications in telecommunication, medical and sensors. 5.4 Nanotechnology: Properties (optical, magnetic and dielectric properties) of Nanomaterials and its application	CO5

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400102B

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Use Vernier caliper to measure the known and unknown dimensions of a given small object. *LSO 1.2.* Estimate the mean absolute error up to two significant figures.	1.	Vernier caliper	CO1
LSO 2.1. Use screw gauge to measure the diameter/ thickness of a given object. *LSO 2.2.* Estimate the mean absolute, relative and percentage errors up to three significant figures.	2.	Screw gauge	CO1
LSO 3.1. Use Spherometer to measure radius of curvature of given convex and concave mirror/surface.	3.	Spherometer	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 3.2. Estimate errors in the measurement.			
LSO 4.1. Measure the variation of Time period with Mass of a given spring Oscillator. *LSO 4.2.* Determine the spring constant of a given spring.	4.	Spring Oscillator	CO2
LSO 5.1. Determine the time period of oscillation of given bar pendulum.	5.	Bar Pendulum	CO2
LSO 6.1. Determine the V-I characteristics of a given p-n junction device.	6.	p-n junction diode	CO4
LSO 7.1. Determine the capacitance of a given parallel plate capacitor.	7.	Parallel Plate capacitor	CO3
LSO 8.1. Determine the inverse square law relation between the distance of photocell and light source v/s intensity of light source.	8.	Photo-electric cell	CO5
LSO 9.1. Determine the Numerical Aperture (NA) of a given step index optical fiber.	9.	Numerical Aperture of an optical fiber.	CO5
LSO 10.1. Measure wavelength of a He-Ne/diode laser by using a plane diffraction grating.	10.	He-Ne/diode laser	CO5
LSO 11.1. Determine the V-I characteristics of given solar cell under various illumination condition	11.	Solar cell (virtual experiment)	CO4
LSO 12.1. Determine the V-I characteristics of a given p-n junction device under various temperature conditions.	12.	p-n junction diode (virtual experiment)	CO4
LSO 13.1. Plot the graph between KE of Photo electron v/s frequency of incident light *LSO 13.2.* Determine the value of Plank's Constant (*h*) from the graph between KE v/s frequency of incident light. *LSO 13.3.* Determine the variation of stopping potential w.r.t frequency of incident photon	13.	Photo electric effect (virtual lab experiment)	CO5
LSO 14.1. Determine the wavelength of different spectral lines of Hydrogen spectra	14	Emission Spectra of Hydrogen (virtual lab experiment)	CO5
LSO 15.1. Find the variation in magnitude and direction of emf induced in a coil due to change in magnetic flux.	15	Electromagnetic induction (virtual lab experiment)	CO4

L) **Suggested Term Work and Self Learning: S2400102B** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. **Assignments**: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs such as,

1. Check the correctness of given equations, using dimensional analysis.
2. Find phase difference between particles executing SHM with different initial conditions.
3. Determine the magnitude and direction of the net electrostatics force acting on any one charge, when 'n' point charges of charge q are placed at the vertices of given polygon with sides 'a' cm.
4. Find the electric field intensity at point due to different type of distribution of charges.

Applied Physics Lab - 1

Experiment No(1)

Aim :- To measure Length, radius of a given cylinder, a test tube and a beaker using a vernier caliper and find volume of each object.

or,

To measure internal diameter and depth of a given Calorimeter/beaker using vernier Caliper and hence find its volume.

Apparatus required :- A vernier Caliper, a Cylinder (Calorimeter), a test tube and a beaker.

Formula used :- volume of a cylinderical container (cylinder, test tube or beaker)

$$V = \frac{\pi D^2 l}{4}$$

where, D = internal diameter of the Calorimeter/beaker.

L = depth of Calorimeter/beaker.

Diagram :-

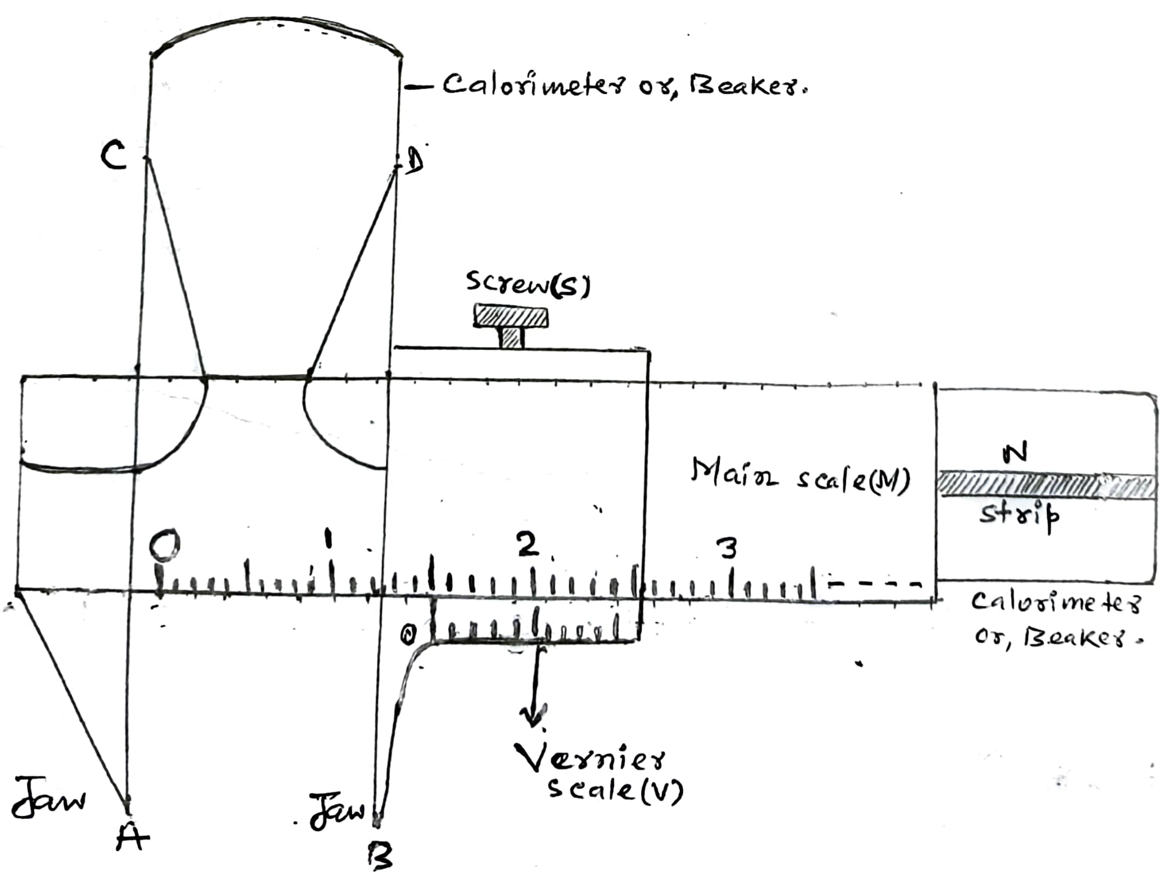


Fig: Vernier Caliper

Measurement of internal diameter :

Procedure : (1) To measure the internal diameter of the given beaker or, Calorimeter, the upper jaws "C" and "D" are inserted inside the beaker or, Calorimeter and the position of the movable jaws are so adjusted such that the two jaws "C" and "D" just might touch the wall of the beaker or, Calorimeter and the screw "S" is tightly fixed in this position.

(2) The main scale reading and the vernier scale division coinciding with some main scale division are determined. From these values, internal diameter of the beaker or, Calorimeter ... calculated.

(3) Now, the internal diameter is measured in the mutually perpendicular direction.

(4) These observations are repeated at least three times at three different positions of the beaker or, calorimeter. The mean value(D) of the internal diameters is calculated.

Measurement of internal depth :

(1) To measure the internal depth of the beaker or, calorimeter, the edge of main scale of the vernier Calipers on the peripheral edge of the beaker or, Calorimeter is put in such a way that the strip N might go inside the beaker or, Calorimeter along the Length as shown in the fig. (diagram).

(2) The movable jaw BD was slided till the end of the strip "N" just might touch the bottom of the beaker or, Calorimeter perpendicularly. It was noted that the edge of the main scale should remain in contact with the peripheral edge of the beaker or, Calorimeter.

(3) The main scale reading and the vernier scale division coinciding with some main scale division are determined. From these values internal depth of the beaker or calorimeter is calculated.

(4) These observations are repeated at least three times at three different positions of the beaker or, calorimeter. The mean

Observations:

Least Count: is found

Value of one small main scale division (1 M.S.D) = 1 mm,

$10\ V.S.D = 9\ M.S.D.$

$1\ V.S.D = \frac{9}{10}\ M.S.D. = \frac{9}{10}\ mm$

Least Count $= 1\ M.S.D. - 1\ V.S.D = 1\ mm - \frac{9}{10}\ m$

$= \frac{10\ mm - 9\ mm}{10} = \frac{1}{10}\ mm = 0.1\ mm = 0.01\ cm.$

2nd method for Least Count:

$$\text{Least Count} = \frac{\text{Value of one small division on the main scale}}{\text{Total divisions on vernier scale}}$$

$= \frac{1\ mm}{10}$

$= 0.1\ mm = 0.01\ cm.$

Thus, Least Count = 0.01 cm.

ie, $L = 0.01\ cm.$

Zero error: No error.

Table for diameter of the beaker: $D = (m + n \times LC)$

SL. No.	Main scale reading m (cm)	Vernier scale reading: No. of Co-inciding divisions (n)	Vernier scale reading: Value $V = n \times L.C$ (cm)	Total value $D = m + V$ (cm) $D = m + n \times LC$
1.	4.5	6	6×0.01 = 0.06	4.5 + 0.06 = 4.56
2.	4.5	6	6×0.01 = 0.06	4.5+0.06 = 4.56
3.	4.5	6	6×0.01 = 0.06	4.5 + 0.06 = 4.56
4.	4.5	8	8×0.01 = 0.08	4.5+0.08 = 4.58

Table for depth of the beaker

Sl. No	Main scale readings m (cm)	Vernier scale reading		Total value $h = m + n \times LC$ $h = (m + v)$ in cm.
		No. of co-inciding divisions (n)	Value $= n \times L.C$ (cm)	
1.	7.1	9	$9 \times 0.01 = 0.09$	$7.1 + 0.09 = 7.19$
2.	7.2	3	$3 \times 0.01 = 0.03$	$7.2 + 0.03 = 7.23$
3.	7.1	9	$9 \times 0.01 = 0.09$	$7.1 + 0.09 = 7.19$
4.	7.1	9	$9 \times 0.01 = 0.09$	$7.1 + 0.09 = 7.19$

Mean value of observed diameter, $D = \frac{4.56 + 4.56 + 4.56 + 4.58}{4}$

$= \frac{18.26}{4} = 4.565 \Rightarrow D = 4.56$ cm

Mean value of observed depth (ie height),

$h = \frac{7.19 + 7.23 + 7.19 + 7.19}{4} = \frac{28.8}{4} = 7.2$

$h = 7.2$ cm

Now, volume of the beaker $V = \frac{1}{4} \pi D^2 h$

$V = \frac{1}{4} \times 3.14 \times (4.56)^2 \times 7.2 \text{ cm}^3 = \frac{1}{4} \times 3.14 \times 20.8 \times 7.2 \text{ cm}^3$

$V = \frac{1}{4} \times 470.1 \text{ cm}^3 \Rightarrow V = 117.53 \text{ cm}^3$

Thus, Result :— The diameter of beaker, $D = 4.56$ cm $= 4.6$ cm
height of the beaker, $h = 7.2$ cm
and volume of the beaker $= 117.53 \text{ cm}^3$

Applied Physics-I, Experiment No 1(a)

Aim:- To measure internal diameter of a hollow cylinder.

or, To measure diameter (or, radius) of a given cylinder (or, a beaker, or, a calorimeter or, a solid sphere etc) using a vernier caliper

Apparatus required:- A vernier calliper, given cylinderical body etc.

Diagram:-

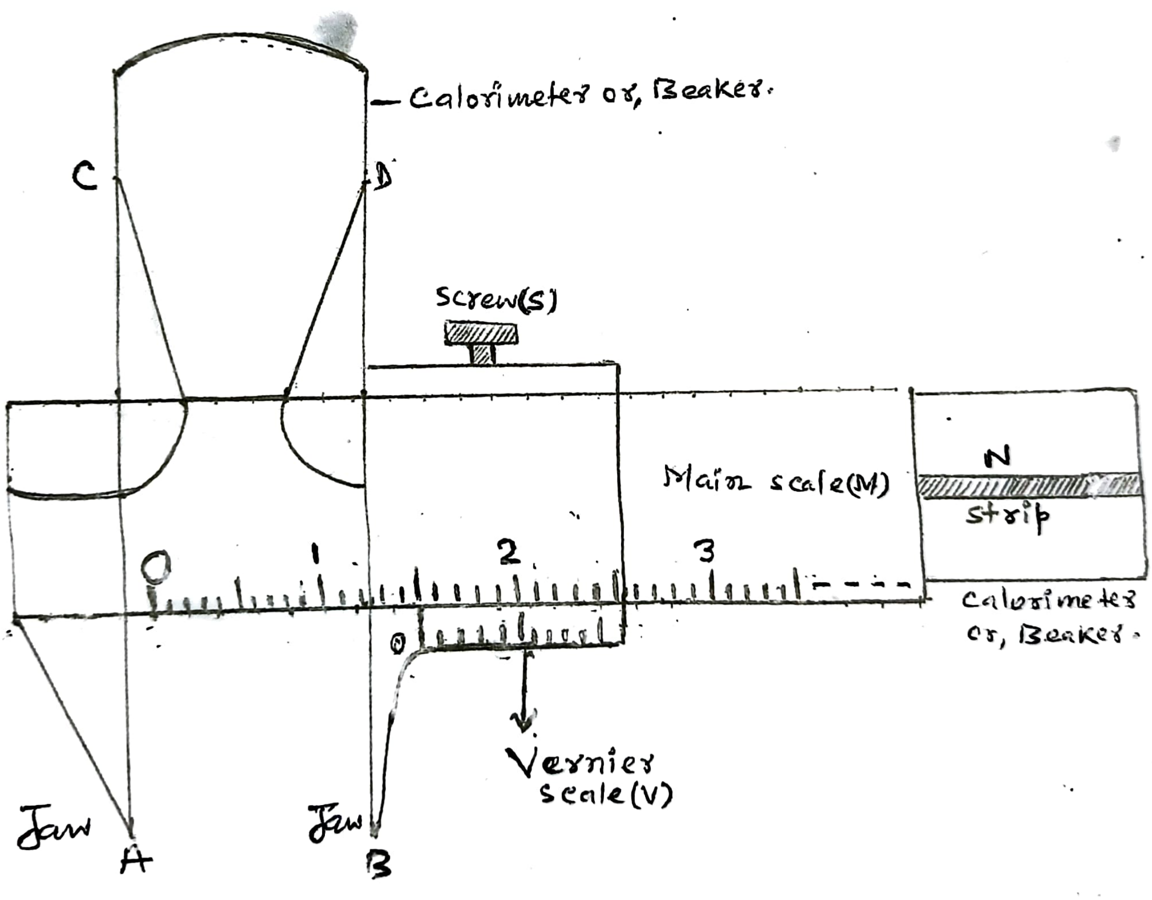


Fig: Vernier Caliper

Measurement of internal diameter the cylinder :-

Procedure :- (i) The vernier calliper is made free from errors ie it is made zero error.

(ii) Least Count of the vernier calliper is determind

(iii) The cylinder is held fixed in the jaws C and D. and readings are noted down on the main scale and vernier scale.

(iv) Three readings are taken and their average value is calculated which is considered the correct value of the internal diameter.

Error zero error (ie no error).

Observations :- Least Count is found.

$$\text{Least Count (L.C.)} = \frac{\text{Value of one small division on the main scale}}{\text{total no. of divisions on the vernier scale}}$$

$$= \frac{1\,mm}{10} = 0.1\,mm = \frac{0.1}{10}\,cm = 0.01\,cm$$

ie, Least Count, LC $= 0.01\,cm$.

Observation table for the internal diameter of the cylinder :-

Diameter, $D = (m + n \times LC)$, where, m = main scale reading, n = no. of coinciding divisions of vernier scale with the main scale divisions and LC = Least Count.

S.No	Main scale readings (m) in cm.	Vernier scale reading: No. of coinciding divisions (n) in cm	Vernier scale reading: Value of $n \times LC$ in cm	Value of diameter $D = m + n \times LC$. in cm.
1.	4.5	6	6×0.01 = 0.06	4.5 + 0.06 = 4.56
2.	4.5	6	6×0.01 = 0.06	4.5 + 0.06 = 4.56
3.	4.5	6	6×0.01 = 0.06	4.5 + 0.06 = 4.56

Average value of observed diameter, $D = \frac{4.56+4.56+4.56}{3}$

ie average value (or, correct value) of internal diameter of the given cylinder $D = 4.56\,cm$.

Aim : To measure Length of a given cylinder (or, a test tube, or, a beaker) usig Vernier Caliper and find volume of the given cylinder.

Apparatus required : A vernier caliper and a given cylinderical body such as a beaker.

Formula used :

Volume of the cylinderical body (beaker)

$$V = \pi r^2 h = \pi \left(\frac{D}{2}\right)^2 \times h$$

where, D = diameter of the beaker

h = height of the beaker or, depth of the beaker.

Diagram :

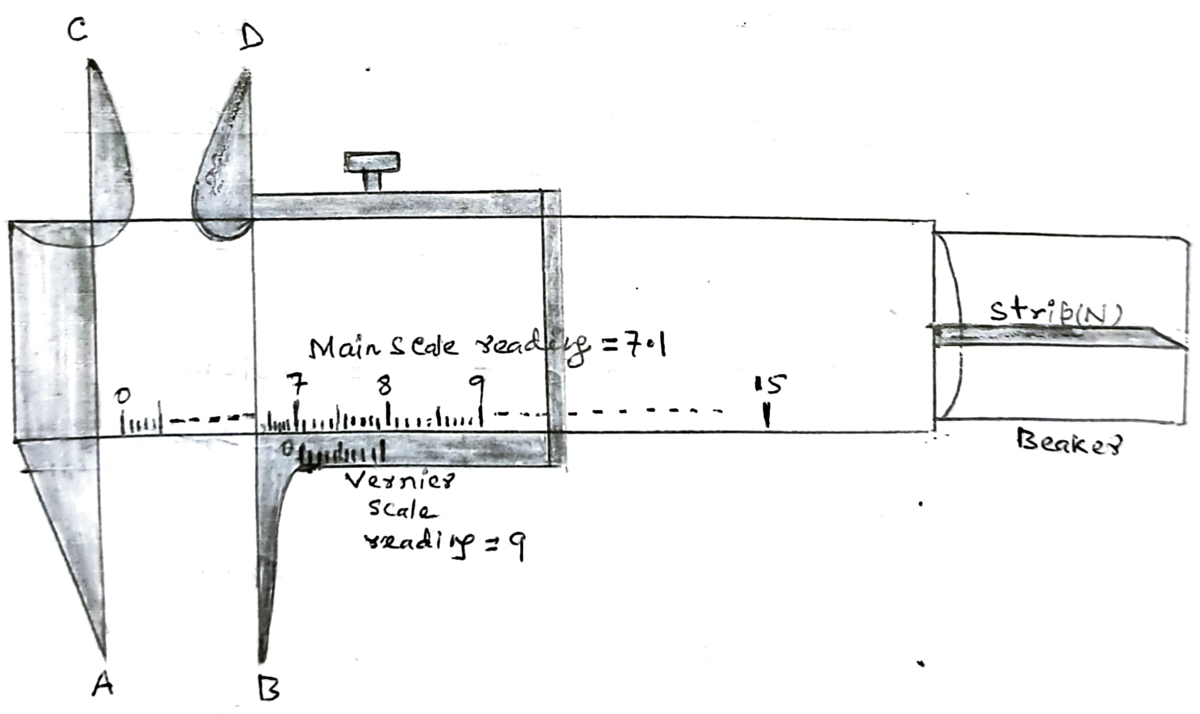


Fig: Vernier Callipers measuring Length of a beaker

Measurement of depth of the beaker:-

Procedure:- (i) The vernier Calliper is made free from errors ie it is made zero error.

(ii) Least Count of vernier Calliper is determined.

(iii) The strip "N" of the vernier Calliper is put inside the beaker in such a way that its ~~first~~ just touches the bottom of the beaker and readings are noted down on the main scale and vernier scale.

(iv) Three reading are taken and their average value is calculated which is Considered the Correct value of the internal depth (or, length or, height) of the beaker.

Error:- Zero error ie no error in the given instrument.

Observations:- Least Count is determined.

$$\text{Least Count (LC)} = \frac{\text{Value of one small division on the main scale}}{\text{Total no. of divisions on the vernier scale}}$$

$$= \frac{1\,mm}{10} = 0.1\,mm = \frac{0.1}{10}\,cm = 0.01\,cm.$$

ie, Least Count, LC $= 0.01\,cm$.

Observation table for the Length (or internal depth) of the given beaker:-

Internal depth (height) of the beaker,

$$h = (m + n \times lc),$$

where, m = main scal reading, n = No. of Coinciding divisions of the vernier scale with main scale divisions and $l.c$ = Least Count.

Applied Physics - I, Experiment No 2.(a)

Aim :- To measure diameter of a given wire (or, nail) using screw guage.

Apparatus required :- screw guage, a thin wire a nail, magnifying glass etc.

Diagram :-

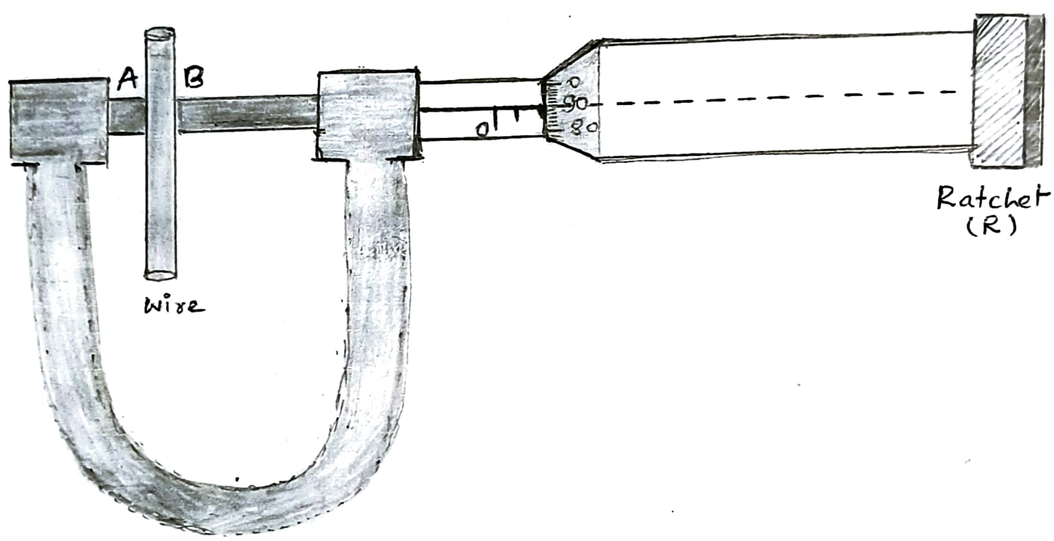


Fig: Screw guage measuring diameter of the wire

Procedure:- (i) The screw guage is made free from errors ie it is made zero error.

(ii) Pitch and Least Count of the screw guage are determined.

(iii) The wire (or, nail) is placed between stud A and flat end B.

(iv) With the help of ratchet, its head is rotated until the wire is held firmly but not tightly.

(v) The readings are noted down on the Linear scale (or, pitch scale axis called Linear Scale Reading, LSR) and the head scale division which coincides with the pitch scale axis (ie, called Head Scale Coincides, H.S.C or, circular scale reading.)

(vi) Three readings are taken and their average value is calculated which is considered the correct value of the diameter of the wire.

Error: Zero error ie the instrument is made free from errors.

Observations:- Least Count is determined.

$$\text{Least Count, LC} = \frac{\text{Pitch}(p)}{\text{Total no. of circular scale divisions (CSD) } N}$$

where, pitch, p = 1mm = distance between two successive the readings on the Linear Scale of the screw.

and N = 100 divisions (on the circular scale)

$$\therefore LC = \frac{1\,mm}{100} = 0.01\,mm = \frac{0.01}{10} = 0.001\,cm.$$

ie, $LC = 0.001\,cm.$

Observation table for the diameter of the given wire :-

S.No	Linear scale Reading (L.S.R.) in mm	Circular scale divisions (C.D.S) coinciding with Main base Line (n) in mm	Circular Scale reading (C.S.R) $= n \times LC$ in mm	Observed diameter, $d = L.S.R + C.S.R$ in mm	
1.	2	88	$88 \times 0.01 = 0.88$	$2 + 0.88 = 2.88$	
2.	2	90	$90 \times 0.01 = 0.90$	$2 + 0.90 = 2.90$	
3.	2	89	$89 \times 0.01 = 0.89$	$2 + 0.89 = 2.89$	

Calculation :- Mean diameter $= \frac{d_1 + d_2 + d_3}{3}$ mm

i.e. Mean diameter (true diameter) $= \frac{2.88 + 2.90 + 2.89}{3}$ mm

Thus, result $= \frac{8.67}{3}$ mm $= 2.89$ mm $= 0.289$ cm Ans.

Experiment (2) (b)

Aim :- To determine diameter of a solid ball (or, a solid sphere) using a screw guage (or, Micrometer screw guage).

Apparatus required :- Screw guage (or, Micrometer screw guage), metallic sphere

Least Count : $LC = \frac{\text{One small division on main scale}}{\text{Total no. of divisions on ...... scale}} = \frac{\text{pitch}(p)}{N}$

where, $p = 1mm$, $N = 100$, $LC = \frac{1}{100}mm = 0.01mm = 0.001cm$

Error :- Zero error ie the instrument is made free from errors.

Diagram :-

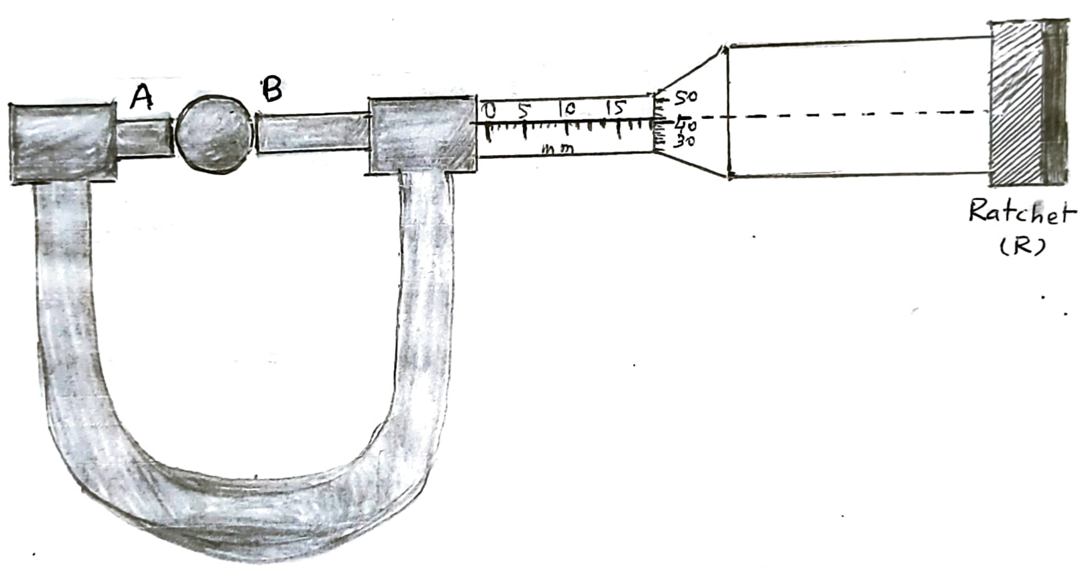


Fig: Screw guage measuring the diameter of a solid ball.

Procedure :- (i) The screw guage is made free from errors ie it is made zero error.

(ii) Pitch and Least Count of the screw guage are determined.

(iii) The solid ball is placed between stud "A" and flat end "B".

(iv) With the help of ratchet, its head is rotated untill the solid ball is held firmly but not tightly.

(v) The readings are noted down on the Linear scale or, main scale (Called Linear (Main) Scale readings M.S.R) and the head scale division which coincides with the pitch scale axis called circular scale readings.

(vi) Three readings are taken and their average value is calculated which is considered the correct value of the diameter of the solid ball.

Observation table for the diameter of the solid ball.

S.No.	Linear Scale Reading (or, Main scale Reading) = L.S.R. in mm	Circular Scale divisions co-inciding with main base Line = n	Circular Scale Reading, C.S.R = n×L.C in mm.	Observed diameter $d = (L.S.R + n \times L.C)$ in mm.
1.	18	42	$42 \times 0.01 = 0.42$	$d_1 = (18 + 42 \times 0.01) = 18.42$ mm.
2.	18.5	41	$41 \times 0.01 = 0.41$	$d_2 = (18.5 + 41 \times 0.01) = 18.91$ mm.
3.	18	41	$41 \times 0.01 = 0.41$	$d_3 = (18 + 41 \times 0.01) = 18.41$ mm.

Mean diameter $= \frac{(d_1 + d_2 + d_3)}{3} = \frac{(18.42 + 18.91 + 18.41)\text{ mm}}{3}$

$= \frac{55.74}{3}$ mm $= 18.58$ mm.

Thus, true diameter of the solid sphere, $d = 18.58\text{mm} = \frac{18.58}{100}$

$= 0.1858$ cm

$= 0.19$ Cm

$= 0.20$ Cm (about)

Experiment No(2)(C)

Aim :– To measure thickness of a given sheet using screw guage.

Apparatus required :– Screw guage, given sheet, magnifying glass.

Least Count, L.C. $= \dfrac{\text{One small division on main scale}}{\text{Total no. of divisions on circular scale}} = \dfrac{\text{pitch}(p)}{N}$

Where, pitch $(p) = 1\,mm$ and $N = 100$ $\therefore LC = \dfrac{p}{N} = \dfrac{1\,mm}{100} = 0.01\,mm$

Diagram :–

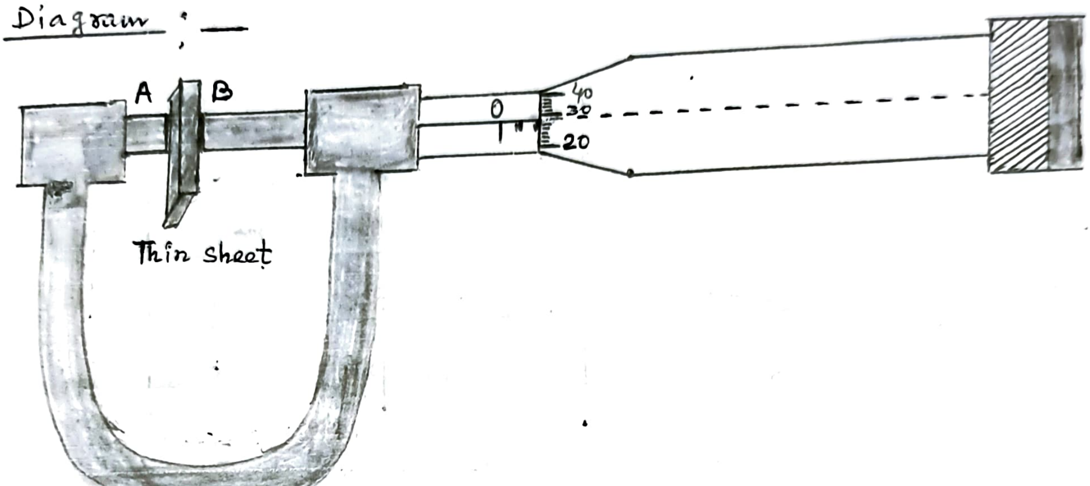


Fig: Screw guage measuring the thickness of a thin sheet.

Procedure :– (i) The screw guage is made free from errors ie it is made zero error.

(ii) Pitch and the Least Count of the screw guge are determined.

(iii) The thin sheet is placed between stud "A" and flat end "B".

(iv) With the help of ratchet, its head is rotated untill the thin sheet is held firmly but not tightly.

(v) The readings are noted down on the Linear Scale or, main scale (Called Linear Scale Readings (L.S.R.) or, Main Scale Reading (M.S.R) and head Scale division (or, circular scale division) Coincides with pitch scale axis (Called circular scale Reading, C.S.R.).

(vi) Three readings are taken and their average value is calculated which is considered the correct value of thickness of the thin sheet.

Observation table for the thickness of thin sheet :-

S.NO	Linear Scale Reading (L.S.R) in mm	Circular Scale Division (C.S.D) Coinciding with the main base line $= n$	Circular Scale Reading (C.S.R.) $= n \times L.C$	observed thickness $t = (LSR + n \times LC)$ in mm.
1.	2 mm	29	29×0.01 mm	$= (2 + 29 \times 0.01)$ mm $= 2.29$ mm
2.	2 mm	30	30×0.01 mm	$= (2 + 30 \times 0.01)$ mm $= 2.30$ mm
3.	2 mm	25	25×0.01 mm	$= (2 + 25 \times 0.01)$ $= 2.25$ mm

$$\text{Mean thickness} = \frac{(t_1 + t_2 + t_3)}{3} = \frac{(2.29 + 2.30 + 2.25)\,mm}{3} = \frac{6.84\,mm}{3}$$

$$= 2.28\ mm$$

Thus, true value of thickness of given thin sheet $= 2.28$ mm

Experiment No (3)

Aim :- To determine the radius of curvature of a Convex mirror (or, Convex surface) by using a spherometer.

Apparatus required :- A spherometer, Convex mirror (or, Convex surface), a big size plane glass, a glass slab, scale, white paper sheet, paper strip etc.

Pitch of Spherometer :- The vertical distance moved by the Central Screw in one complete rotation of the circular disc scale. The pitch of the spherometer screw is 1 mm.

Least Count of Spherometer :-

$$\text{Least Count (L.C.)} = \frac{\text{(Pitch of the spherometer)}}{\text{(Number of divisions on the circular scale)}}$$

$$= \frac{1\ mm}{100} = 0.01\ mm = \frac{0.01}{10}\ cm = 0.001\ cm$$

Principle or, theory or, Formula used to determine the radius of curvature of spherical surface :-

Radius of curvature, $R = \left(\frac{l^2}{6h} + \frac{h}{2}\right)$.

where, l = Distance between any two Legs of the spherometer.

h = height of central screw above the plane of the circular section. This height is called sagita.

Diagram of spherometer :-

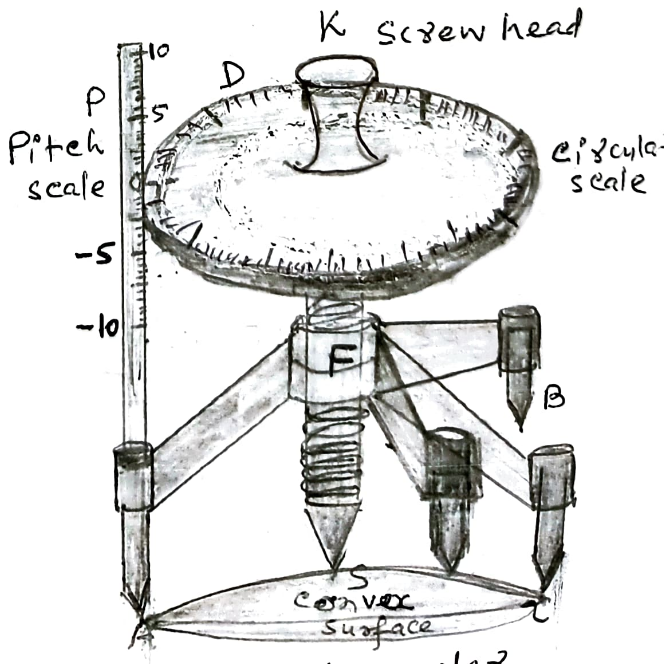


Fig: Spherometer

Procedure :- (i) The spherometer is made free from errors i.e it is ~~made~~ zero error.

(ii) Pitch and Least Count of the spherometer are determined.

(iii) The Central screw is raised sufficiently and it is placed on the Convex surface which is placed on a plane glass.

(iv) The central screw is turned gently downwards with the help of knob "K" till its tip just touches the spherical surface of convex mirror.

(v) The circular scale division is noted that coincides with vertical Linear scale.

(vi) The spherometer is removed from the convex mirror and it is placed on the plane glass plate. Now, the central screw is turned gently downwards so that its tip just touches the surface of plane glass plate.

(vii) While moving the central screw downwards, the circular division coinciding with the vertical Linear scale is noted.

(viii) Average distance between the three legs of the spherometer is noted i.e AB = BC = CA = Length is measured = h

(ix) All the above procedures and measurements are performed by three times and their average value is calculated.

Observation table for the radius of curvature by spherometer :-

Sr.No.	Convex mirror surface measurement			Plane glass surface measurement			Sagita
	Main Scale Reading (A_1)	Circular scale Reading	Total $H_1 = A_1 + B_1$	Main Scale Reading A_2	Circular Scale Reading $B_2 = n \times LC$	Total $H_2 = A_2 + B_2$	$h = H_2 - H_1$
1.	0.1cm	$B_1 = n \times LC$ $= 42 \times 0.001$ $= 0.042cm$	$= 0.1cm$ $+ 0.042cm$ $= 0.142cm$	0.1cm	$78 \times 0.001cm$ $= 0.078cm$	$= 0.1cm$ $+ 0.078cm$ $= 0.178cm$	$0.178cm$ $- 0.142cm$ $= 0.036cm$
2.	0.1cm	$36 \times 0.001cm$ $= 0.036cm$	$0.1cm$ $+ 0.036cm$ $= 0.136cm$	0.1cm	$83 \times 0.001cm$ $= 0.083cm$	$= 0.1cm$ $0.083cm$ $= 0.183cm$	$0.183cm$ $- 0.136cm$ $= 0.047cm$
3.	0.1cm	$33 \times 0.001cm$ $= 0.033cm$	$0.1cm$ $+ 0.033cm$ $= 0.133cm$	0.1cm	$87 \times 0.001cm$ $= 0.087cm$	$0.1cm$ $+ 0.087cm$ $= 0.187cm$	$0.187cm$ $- 0.133cm$ $= 0.054cm$

Sagita of Convex mirror, $h = \frac{h_1 + h_2 + h_3}{3}$

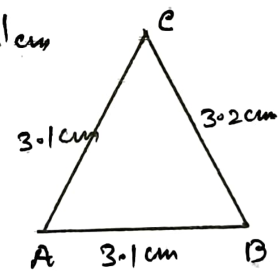
ie, $h = \frac{0.036cm + 0.047cm + 0.054cm}{3} = \frac{0.137cm}{3}$

ie, $h = 0.0456\ cm \Rightarrow h = 0.046cm$

Average distance of three Legs of the Spherometer :-

$l = \frac{AB + BC + CA}{3} = \frac{3.1 + 3.2 + 3.1}{3} cm$

$l = \frac{9.4}{3} cm = 3.1cm$



Calculation for radius of curvature of the Convex mirror,

$$R = \left[\frac{l^2}{6h} + \frac{h}{2}\right] = \left[\frac{(3.1)^2}{6 \times 0.046} + \frac{0.046}{2}\right] cm$$

$$= \left[\frac{9.61}{0.276} + \frac{0.046}{2}\right] cm = \left[\frac{9610}{276} + \frac{0.046}{2}\right] cm$$

$$= \left[34.82 + 0.023\right] = 34.843cm$$

Result :- Radius of curvature of the convex surface, $R = 34.843cm = 34.8cm$

observation table for the radius of curvature of Convex mirror (or, Convex Surface) by spherometer :-

S. No.	Measurement for Convex Surface			Measurement for Plane glass surface			Sagita
	Main Scale Reading A	Circular Scale Reading $B = n \times L.C.$	Total $H = (A+B)$	Main scale Reading A'	Circular scale Reading $B' = n \times LC$	Total $H' = (A' + B')$.	$h = H - H'$
1.	2 mm	65×0.01 mm $= 0.65$ mm	2.65 mm	0	5×0.01 $= 0.05$ mm	0.05 mm	$2.65 - 0.05$ $= 2.60$ mm
2.	2 mm	50×0.01 mm $= 0.50$ mm	2.50 mm	0	8×0.01 mm $= 0.08$ mm	0.08 mm	$2.50 - 0.08$ $= 2.42$ mm
3.	2 mm	70×0.01 mm $= 0.70$ mm	2.70 mm	0	12×0.01 mm $= 0.12$	0.12 mm	$2.70 - 0.12$ mm $= 2.58$ mm

Mean value of $h = \dfrac{(2.60 + 2.42 + 2.58)\,mm}{3} = \dfrac{7.60\,mm}{3} = 2.53\,mm$

i.e $h_{mean} = 2.53\,mm = \dfrac{2.53}{100}\,cm = 0.0253\,cm$

i.e Sagita of spherometer, $h = 0.0253\,cm$.

Calculation :- Radius of curvature, $R = \left(\dfrac{l^2}{6h} + \dfrac{h}{2}\right)$

Here measurements are, l = Distance between any two Legs of the spherometer.

i.e $l = 4.3\,cm$, $h = 2.53\,mm = 0.0253\,cm$

$R = \left(\dfrac{l^2}{6h} + \dfrac{h}{2}\right) \Rightarrow R = \left(\dfrac{(4.3)^2}{6 \times 0.0253} + \dfrac{0.0253}{2}\right)cm = \left(\dfrac{18.49}{1.51} + 0.1265\right)cm$

$R = 12.24\,cm + 0.13\,cm \Rightarrow R = 12.37\,cm$

Result :- Radius of curvature of the convex surface,

$= R = 12.37\,cm$

Experiment No (4)

Aim :- To determine the spring constant of a spring.

Apparatus required :- A spring, hanger, slotted weights, vertical scale, pointer, a scale, graph paper etc.

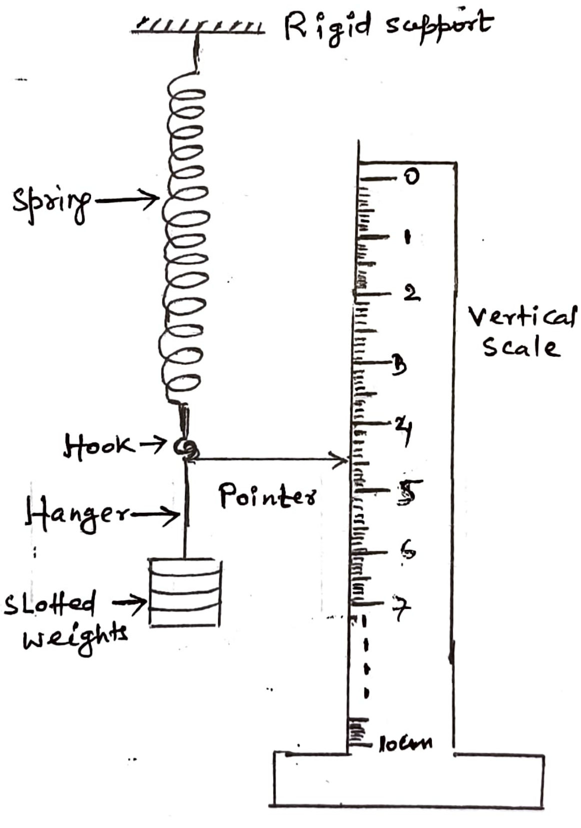
Theory :- When a Load force F is suspended from the free end of the spring hanging from a rigid support then Length of the spring increases by l

i.e, $F \propto l$ from Hook's Law.

or, $F = Kl$, where, K = force constant or, spring const.

or, $K = \frac{F}{l}$

Diagram :-



Procedure :- (1) A spring is suspended from a rigid support. A pointer and a hook are attached at its free end.
(2) An experimental set up is arranged as shown in the fig.

(3) A 20 gm slotted weight is put in the hanger.

(4) vertical wooden scale is set such that the tip of the pointer comes over the scale.

(5) position of the pointer is noted.

(6) Another 20 gm slotted weights are added to the hanger, upto five times and corresponding positions of the pointer are noted.

(7) Now, one slotted weight is removed and position of pointer is noted.

(8) Unloading process is repeated and corresponding positions of pointer are noted.

Observation Table(1):— Least count of vertical scale = 0.1 cm
slotted weight = 20g.

S. No	Applied force(F) or, Load on hanger (gwt.)	Position of Pointer: In case of Loading (x cm)	Position of Pointer: In case of unloading (y cm)	Position of Pointer: Average $= \frac{x+y}{2}$	Extension (l cm)	Spring Const $K = \frac{F}{l}$
1	0	0	0	0	0	Not applicable
2	20	0.6	0.6	$(0.6+0.6)/2 = 0.6$	0.6	$\frac{20}{0.6} = 33.33$
3	40	1.5	1.5	1.5	1.5	$\frac{40}{1.5} = 26.66$
4	60	2.5	2.5	2.5	2.5	$\frac{60}{2.5} = 24$
5	80	3.4	3.4	3.4	3.4	$\frac{80}{3.4} = 23.53$
6	100	4.4	4.4	4.4	4.4	$\frac{100}{4.4} = 22.73$

Average value of spring constant $K = (33.33 + 26.66 + 24 + 23.53 + 22.73)/5$

$$K = \frac{(130.25)}{5} = 26.05 \text{ Dyne/cm} \quad \text{Ans.}$$

Experiment No(5)

Name of the experiment or, Aim :- Determine the time period of oscillation of a given bar pendulum.

Apparatus Required :- A bar pendulum (or, metallic bar with holes) knife-edge support, stopwatch, meter scale, sprit Level, Graph paper etc.

Diagram :-

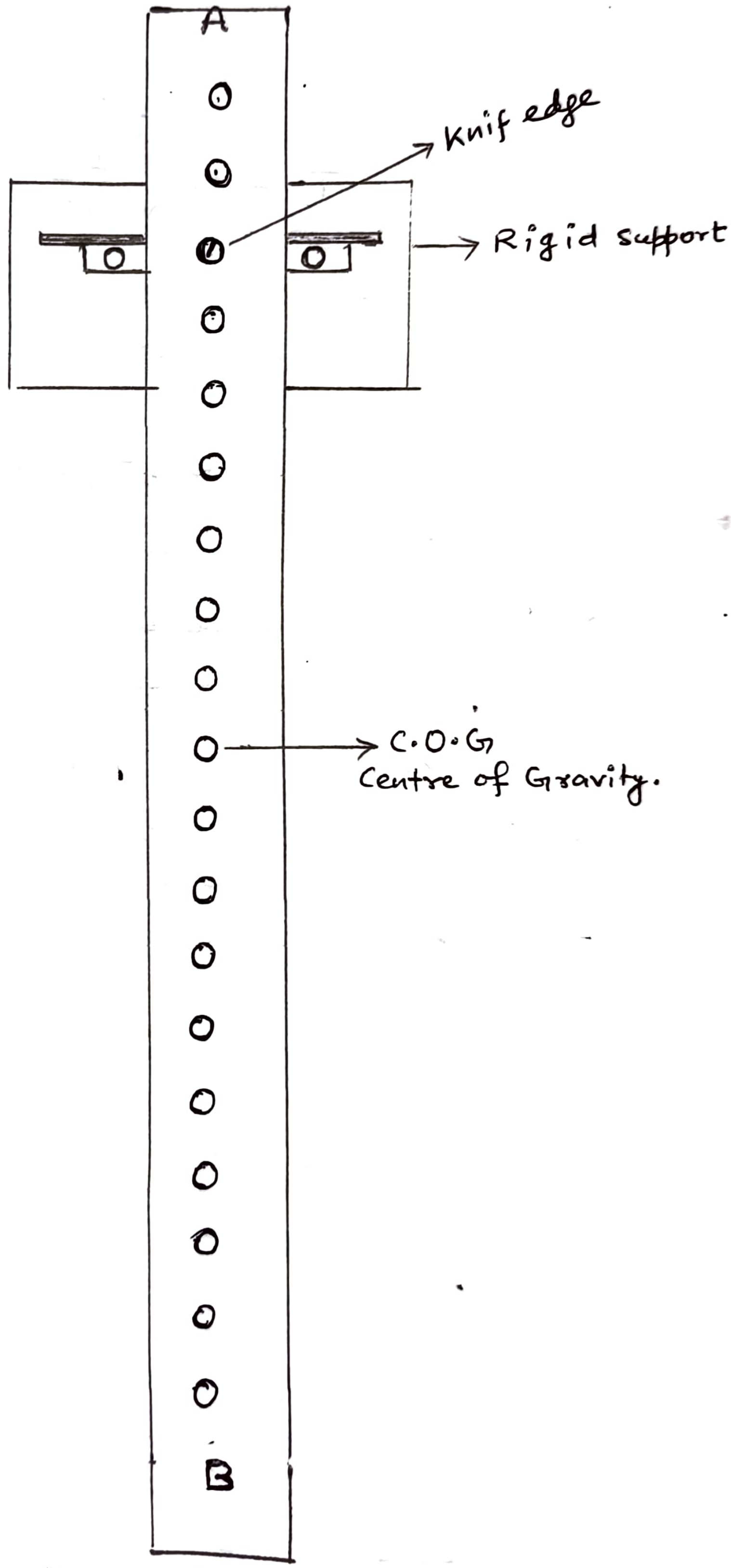


Fig: Bar pendulum suspended knif edge

Theory :- A bar pendulum is a rigid body of definite shape that can oscillate about a horizontal axis passing through it. When it is displaced from its mean position then it excutes angular simple harmonic motion.

The time period (T) of oscillation of a bar pendulum is given by

$$\boxed{T = 2\pi\sqrt{\frac{I}{mgh}}}$$

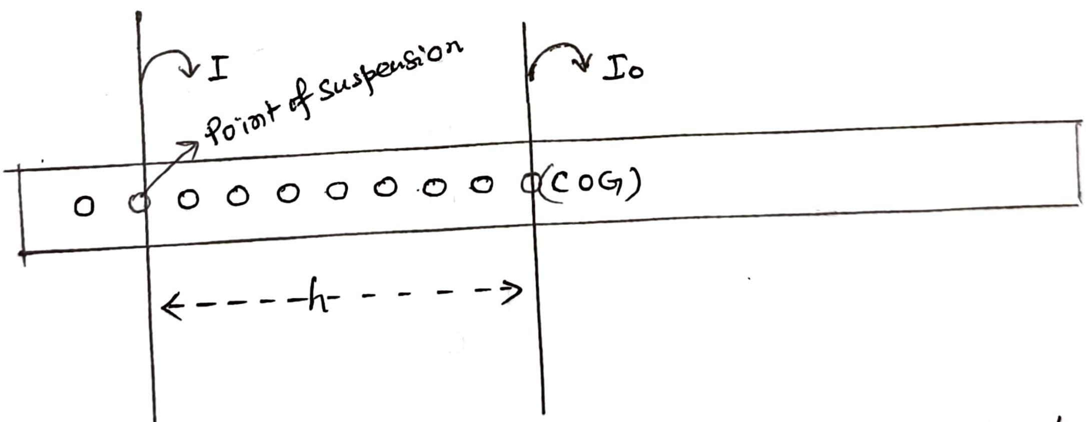
where, T = Time period of oscillation

I = Moment of Inertia of the bar pendulum about the axis of suspension.

m = Mass of the pendulum.

g = Acceleration due to gravity.

h = Distance between the point of suspension and the centre of gravity.



If moment of Inertia of the bar pendulum about an axis passing through its centre of gravity is "Io" then from parall axes theorem, $I = (I_o + mh^2)$

$$\therefore\ T = 2\pi\sqrt{\frac{(I_o + mh^2)}{mgh}}$$

But, for a bar pendulum of mass "m" and length "L"

$$I_o = \frac{1}{12} m L^2$$

$$\therefore T = 2\pi\sqrt{\frac{(I_0 + mh^2)}{mgh}} = 2\pi\sqrt{\frac{(\frac{mL^2}{12} + mh^2)}{mgh}}$$

$$\therefore \boxed{T = 2\pi\sqrt{\frac{(L^2 + 12h^2)}{12gh}}}$$

Procedure:– (i) The centre of gravity (COG) of the bar pendulum is determined by balancing it on the knife edge
(ii) The length of bar pendulum is measured from end to end.
(iii) The bar pendulum is suspended from one of the holes at a distance "h" from the centre of gravity.
(iv) The bar pendulum is displaced slightly (about 5°) and released to start oscillation.
(v) The time for 20 oscillation are measured and its time period is calculated.
(vi) The measurement for different suspension points are repeated on both of the C.G.
(vii) Observations are recorded in a tabular form

For the holes on side A:–

S.No.	Distance from CG = h(cm)	Time for 20 oscillations Trial 1 (sec)	Trial 2 (sec)	Trial 3 (sec)	Mean time (sec)	Time period T = t/20
1	h_1 = 45cm	31.78	31.35	31.66	31.59	1.579
2	h_2 = 40cm	31.10	30.86	30.63	30.86	1.543
3	h_3 = 35cm	30.62	30.45	30.38	30.48	1.524
4	h_4 = 30cm	30.15	30.33	30.34	30.27	1.513
5	h_5 = 25cm	30.42	30.62	30.24	30.42	1.521
6	h_6 = 20cm	31.72	31.40	31.34	31.48	1.574
7	h_7 = 15cm	33.28	33.44	33.53	33.41	1.670
8	h_8 = 10cm	38.48	38.89	38.36	38.57	1.928
9	h_9 = 05cm	50.87	51.19	51.88	51.31	2.565

For the holes on the side B

S.No	Distance from C.G (cm)	Time for 20 oscillations Trial 1 (sec)	Trial 2 (sec)	Trial 3 (sec)	Mean time in (sec)	Time period $t = T/20$
1	$h_1 =$ 45 cm	32.60	31.79	31.53	31.97	1.598
2	$h_2 =$ 40 cm	31.02	31.20	31.15	31.12	1.556
3	$h_3 =$ 35 cm	30.58	30.36	30.88	30.60	1.525
4	$h_4 =$ 30 cm	30.61	30.60	30.60	30.60	1.53
5	$h_5 =$ 25 cm	30.59	31.49	30.49	30.85	1.54
6	$h_6 =$ 20 cm	31.53	33.42	31.42	32.12	1.606
7	$h_7 =$ 15 cm	33.90	39.58	33.58	35.68	1.784
8	$h_8 =$ 10 cm	38.98	30.01	39.01	36.00	1.8
9	$h_9 =$ 05 cm	53.53	53.70	53.70	53.64	2.682

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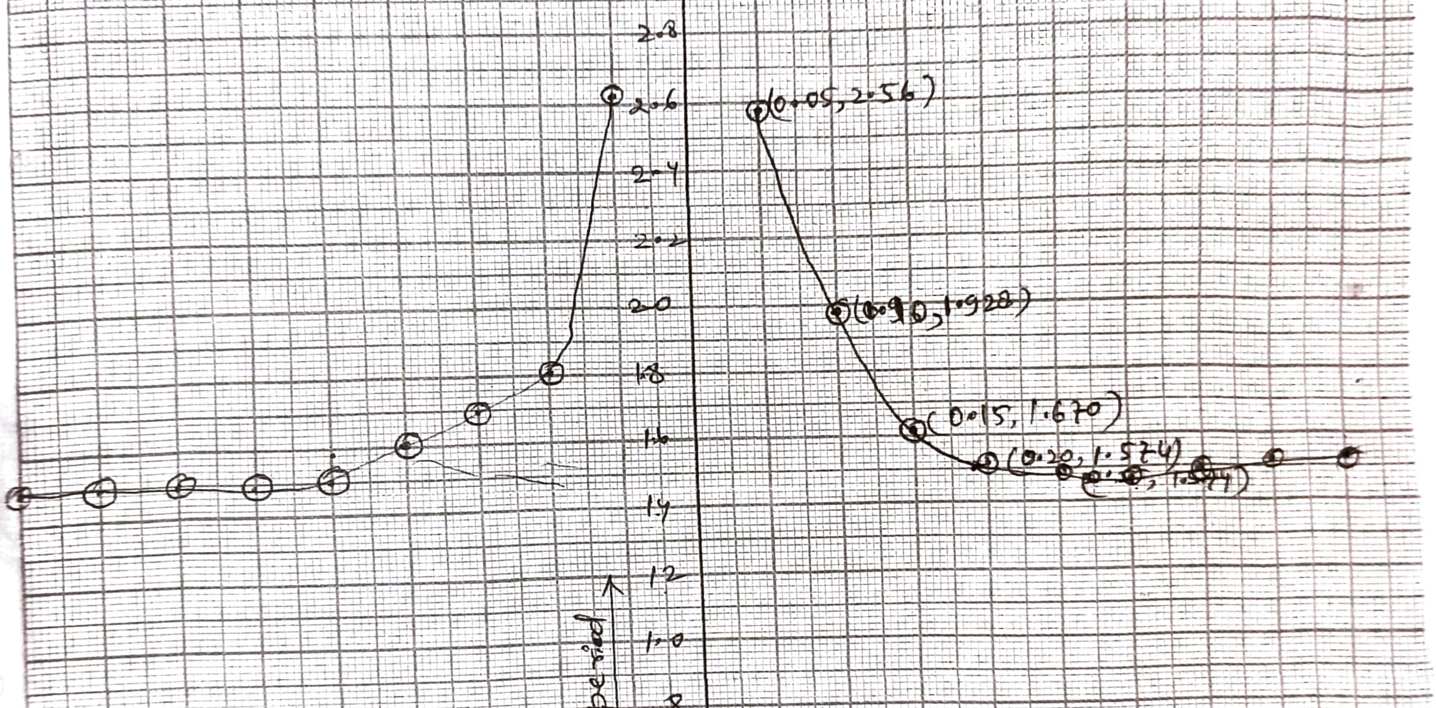


Experiment No (6)

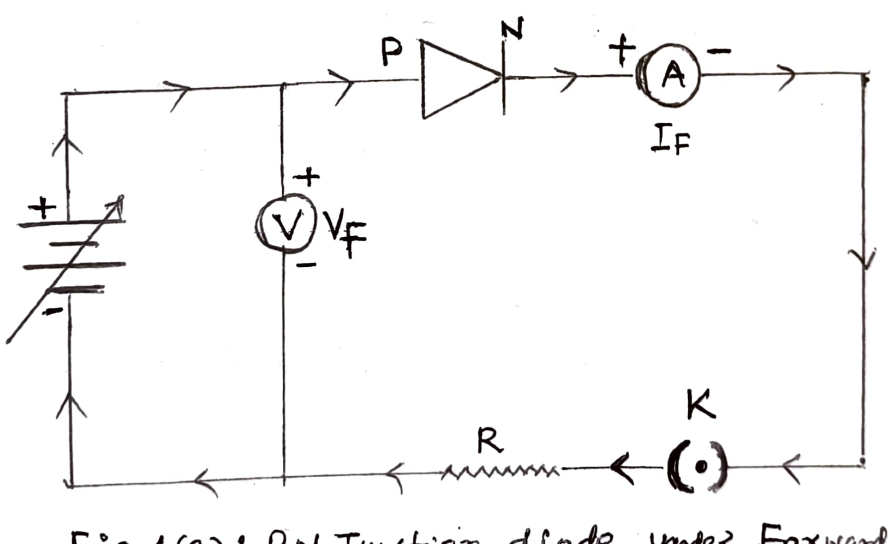
Name of the experiment:- To draw (or, determine) the V-I characteristics of a given PN Junction diode.

Required Materials:- A PN Junction diode set up which contains a battery (or, battery eliminator of 6 volt), a variable voltage power supply (0-12) volt, a millimeter (0 to 200 mA) voltmeter (0 to 30 volt), a micrometer (0 to 200 μA), Connecting wires, sand paper, a one-way key.

Theory:- In forward biased PN Junction diode, the current increases exponentially. On obtaining a knee voltage, even a tiny increases in voltage causes a massive increase in the current.

While in the reverse biased PN junction diode, initially a very small current flows. On obtaining breakdown voltage, even a slight increase in voltage causes a sharp increase in the current.

Circuit diagram of forward biased PN junction diode and reverse biased PN Junction diode:-



Fig, 1(a): PN Junction diode under Forward biasing.

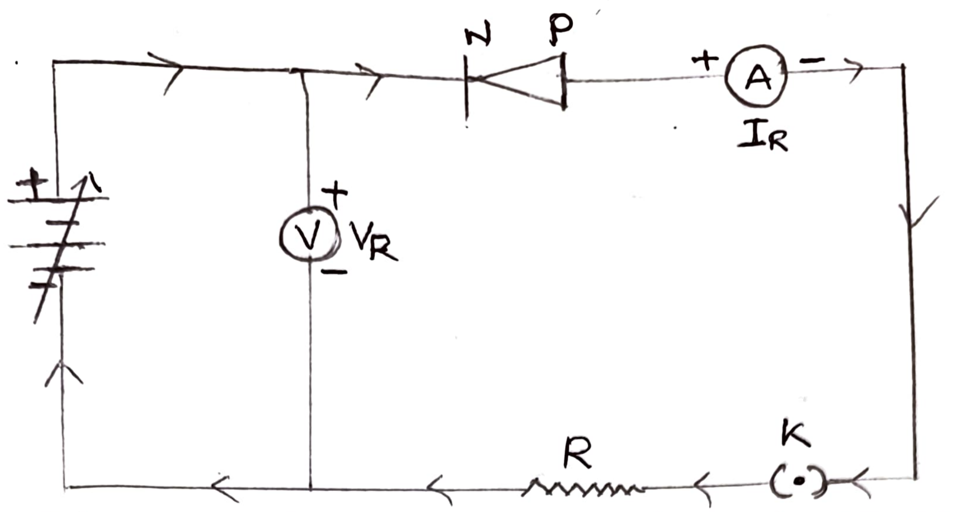


Fig 1(b): PN Junction diode under reverse biasing.

Procedure:- (i) Least Counts of : Voltmeter, Milliammeter and microammeter are noted.

(ii) The electric circuit is set up as shown in the fig- 1(a) and 1(b) ie in forwarding biased and reverse biased. And it should be noted that voltmeter is connected in parallel to the circuit.

(iii) The voltmeter is adjusted to zero volt and it is observed that the ammeter also shows zero Ampere.

(iv) The forward potential applied to the PN Junction diode is increased and their corresponding readings in the ammeter are noted about 10 times.

(V) The reverse potential applied to the PN Junction diode is increased and their corresponding readings in the ammeter are noted about 10 times.

(vi) A suitable scale is choosen and a graph is plotted taking applied potential along x-axis and current along y-axis.

For forwad bias characteristics

observation :- Least Count of voltmeter = $\frac{0.25}{10}$ V = 0.025 volt.

Least count of milliammeter = $\frac{2}{10}$ mA = 0.2 mA.

For reverse bias characteristic

Least count of voltmeter = $\frac{5}{10}$ = 0.5 Volt

observation Table :- Least count of micrometer = $\frac{20}{10}$ = 2 μA

	Forward Biasing		Reverse Biasing	
S.No.	Forward Applied voltage, VF (volt)	Forward Current, IF (milli Ampere)	Reverse Applied voltage, VR (volt)	Reverse Current, IF (Micro Ampere)
1	1 × 0.025 = 0.025	0	2 × 0.5 = 1.0	0 × 2 = 0
2	2 × 0.025 = 0.050	0	8 × 0.5 = 4.0	1 × 2 = 2
3	3 × 0.025 =	0	5 + 3 × 0.5 =	2 × 2 = 4
4	4 × 0.025 =	0	10 + 4 × 0.5 = 12	5 × 2 = 10
5	5 × 0.025 =	0	15 + 0 × 0.5 = 15	20 + 1 × 2 = 22
6	20 × 0.025 = 0.50	0	15 + 4 × 0.5 = 17.0	20 + 8 × 2 = 36
7	0.5 + 2 × 0.025 = 0.550	2 × 0.2 = 0.4	20 + 0 × 0.5 = 20	40 + 8 × 2 = 56
8	0.5 + 6 × 0.025 = 0.65	4 × 0.2 = 0.8	20 + 1 × 0.5 = 20.5	60 + 0 × 2 = 60
9	0.75 + 0.025 = 0.75	2 + 0 × 0.2 = 2	20 + 5 × 0.5 = 22.5	60 + 5 × 2 = 70
10	1 + 0 × 0.025 = 1	4 + 7 × 0.2 = 5.4	20 + 8 × 0.5 = 24	80 + 0 × 2 = 80
11	1 + 4 × 0.025 = 1.10	6 + 4 × 0.2 = 6.8	25 + 0 × 0.5 = 25	80 + 4 × 2 = 88
12	1.25 + 0 × 0.025 = 1.25	8 + 6 × 0.2 = 9.2	25 + 3 × 0.5 = 26.5	100 + 0 × 2 = 100

Experiment No - (7)

Aim :- Determine the capacitance of a given parallel plate capacitor.

Apparatus Required :- Two rectangular (or, square) conducting plates of Aluminium foil sheet (or, Copper), Digital multimeter (or, LCR meter), Dielectric materials (such as paper or, glass plastic), Vernier Callipers, Meter Scale, Screw guage, Connecting wires, DC Power Supply, Voltmeter, Switch etc.

Theory :- A parallel plate capacitor consists of two parallel conducting plates separated by air. Its capacitance, $C = \frac{\varepsilon_0 A}{d}$, where, A = Area of one of two equal plates, d = separation between the two plates, ε_0 = electric permittivity of air $= 8.85 \times 10^{-12}$ Farad/meter.

Circuit diagram :-

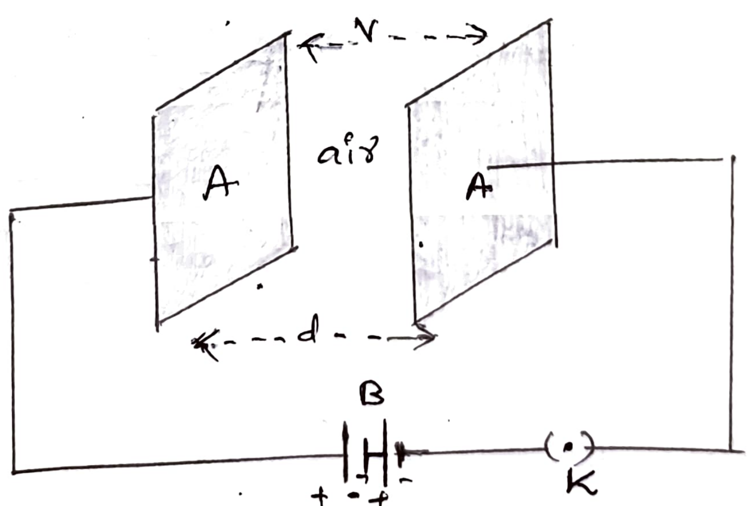


Fig: Parallel plate capacitor.

Procedure :- (i) Area of plate of the capacitor is calculated by measuring with help of a meter scale.

(ii) The separation between the two plates of the capacitor is measured with a vernier callipers

(iii) The circuit is connected as shown in the figure diagrams

(iv) Capacitance of the capacitor, $C = \frac{\epsilon_0 A}{d}$ is calculated putting the values of ϵ_0, A and d.

(v) The measurement is repeated for the different plate separations.

Observation Table :-

S. No.	Area of plate $A = L \times b$	Separation d (mm)	Capacitance, $C = \frac{\epsilon_0 A}{d}$
1	3 mm x 2 mm = 6 mm²	1 mm	$C = \frac{8.85\times10^{-12} \times 6\times10^{-6}}{1\times10^{-3}} F = 53.1\times10^{-15} F$
2	$3\times2 = 6mm^2 = 6\times10^{-6}m^2$	$1.5mm = 1.5\times10^{-3}m$	$C = \frac{8.85\times10^{-12}\times6\times10^{-6}}{1.5\times10^{-3}} F = 35.4\times10^{-15} F$
3	$6\times10^{-6} m^2$	$2\times10^{-3} m$	$C = \frac{8.85\times10^{-12}\times6\times10^{-6}}{2\times10^{-3}} F = 26.55\times10^{-15} F$
4	$6\times10^{-6} m^2$	$2.5\times10^{-3} m$	$C = \frac{8.85\times10^{-12}\times6\times10^{-6}}{2.5\times10^{-3}} F = 21.24\times10^{-15} F$
5.	$6\times10^{-6} m^2$	$3\times10^{-3} m$	$C = \frac{8.85\times10^{-12}\times6\times10^{-6}}{3\times10^{-3}} F = 17.7\times10^{-15} F$

Result :→ Capacitance ≥

$$C = \frac{53.1\times10^{-15} + 35.4\times10^{-15} + 26.55\times10^{-15} + 21.24\times10^{-15} + 17.7\times10^{-15}}{5}$$

$$= \frac{153.99\times10^{-15} F}{5} = 30.798\times10^{-15} F \simeq 30.8\times10^{-15} F$$

Photoelectric cell Experiment

Experiment No(8)

Aim :→ "Determine the inverse square Law relation the distance of photocell and and light source."

or,

verification of inverse square Law of intensity of light using a photocell.

Apparatus Required :– A photocell with mounting arrangement, a source of light with mounting arrangement, a galvanometer and an optical bench

Theory :– The intensity of light from a point source is inversely proportional to the square of the distance from the source.

i.e, intensity of light, $I \propto \frac{1}{d^2}$.

Since, photoelectric current(I_p) is directly proportional to the intensity of light(I).

i.e $I_p \propto I \Rightarrow I_p \propto \frac{1}{d^2}$ or, $I_p = K \times \frac{1}{d^2}$,

where, "K" is a const. $\therefore$ $\boxed{I_p \times d^2 = K = \text{Const.}}$

Experimental Setup :–

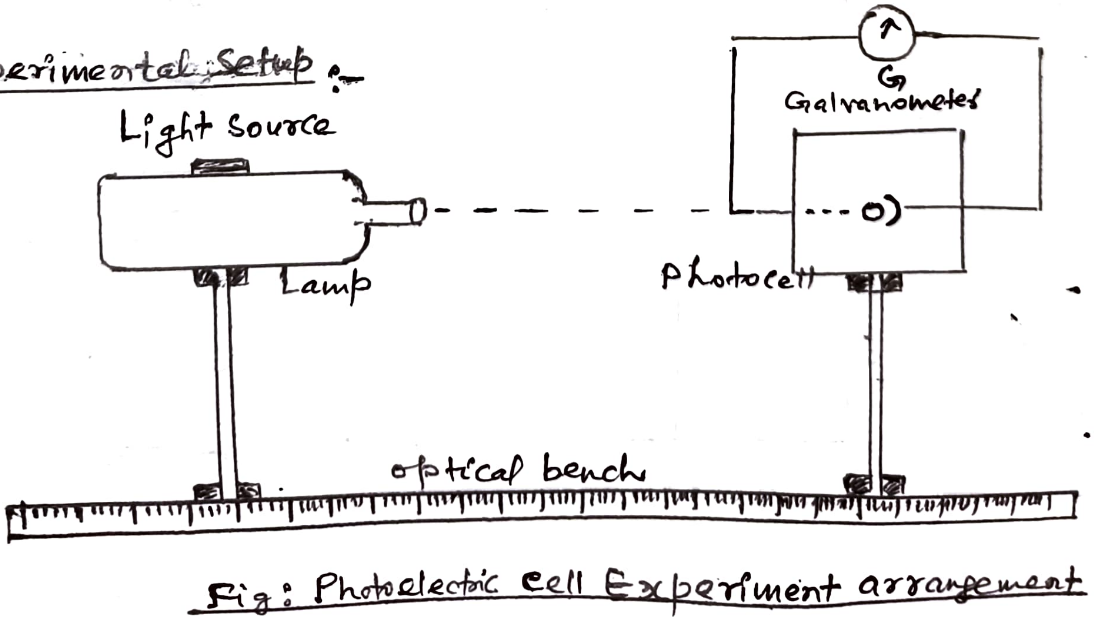


Fig: Photoelectric cell Experiment arrangement

Procedure :- (i) The Light source (Lamp), photoelectric cell and a galvanometer (or, micrometer) are arranged on an optical bench in a straight line.

(ii) The circuit is completed and the Lamp is switched on and the distance between source Lamp and Photoelectric cell "d" is measured.

(iii) For each distance "d", the photoelectric current "I_p" is noted from the micrometer.

(iv) This experiment is performed "5" to "10" times and related datas are recorded.

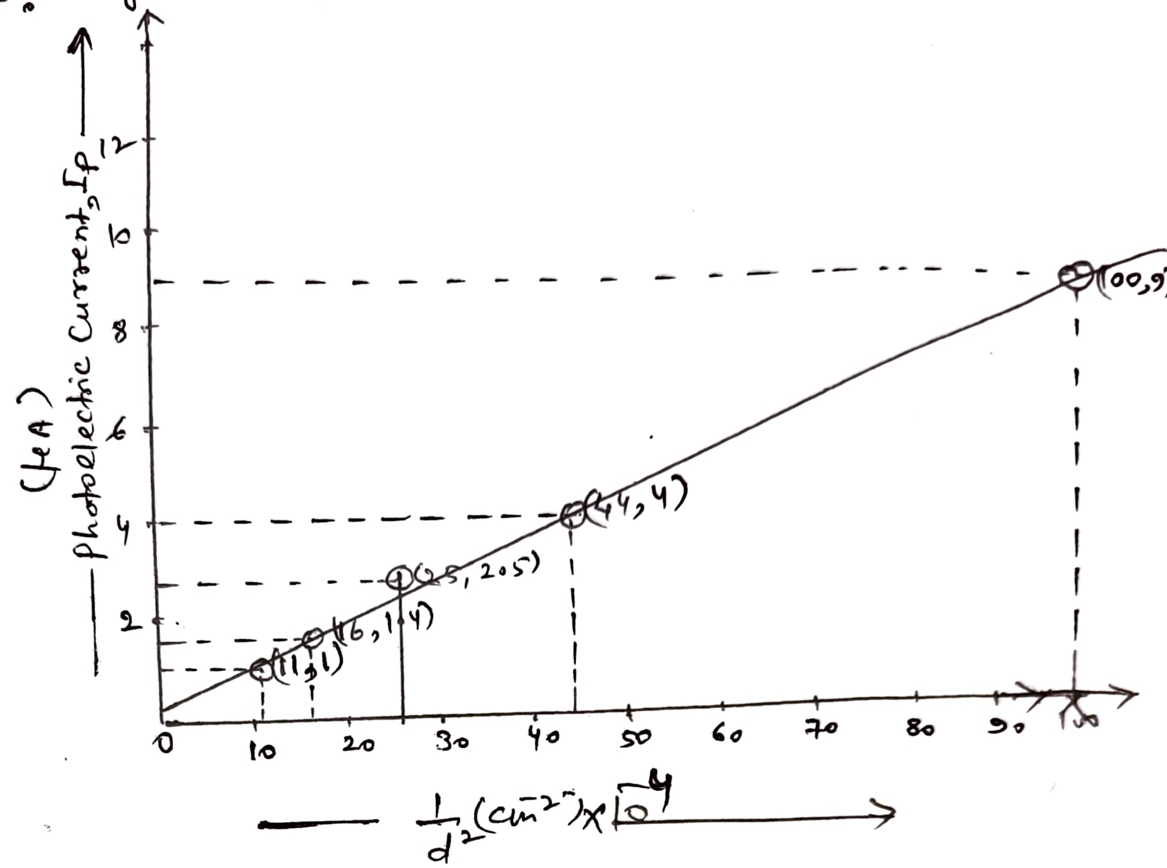
(v) The values of $\frac{1}{d^2}$ are calculated and "I_p" is plotted against $\frac{1}{d^2}$.

Observations Table :-

S.No	Distance "d" (cm)	Photoelectric Current I_P (μA)	$\frac{1}{d^2}$ (cm^{-2})	$I_p \times d^2$ (μA·cm^2)
1.	10	9.00	$\frac{1}{10^2}$ = 0.0100 = 100×10^{-3}	$9 \times (10)^2 = 900$
2.	15	4.00	$\frac{1}{15^2}$ = 0.0044 = 44×10^{-4}	$4 \times (15)^2 = 900$
3.	20	2.25	$\frac{1}{20^2}$ = 0.0025 = 25×10^{-4}	$2.25 \times (20)^2 = 900$
4.	25	1.44	$\frac{1}{25^2}$ = 0.0016 = 16×10^{-4}	$1.44 \times (25)^2 = 900$
5.	30	1.00	$\frac{1}{30^2}$ = 0.0011 = 11×10^{-4}	$1 \times (30)^2 = 900$

From the above calculation and observation it is clear $I_p \times d^2$ = const $\Rightarrow I_p \propto \frac{1}{d^2}$.

Graph :-



Result :- From the above graph, it is clear that,

$I_p \propto \frac{1}{d^2}$ i.e Photoelectric current Ip is inversely proportional to the square of the distance between the source of light and the photoelectric cell.

Hence, Inverse square Law is verified.

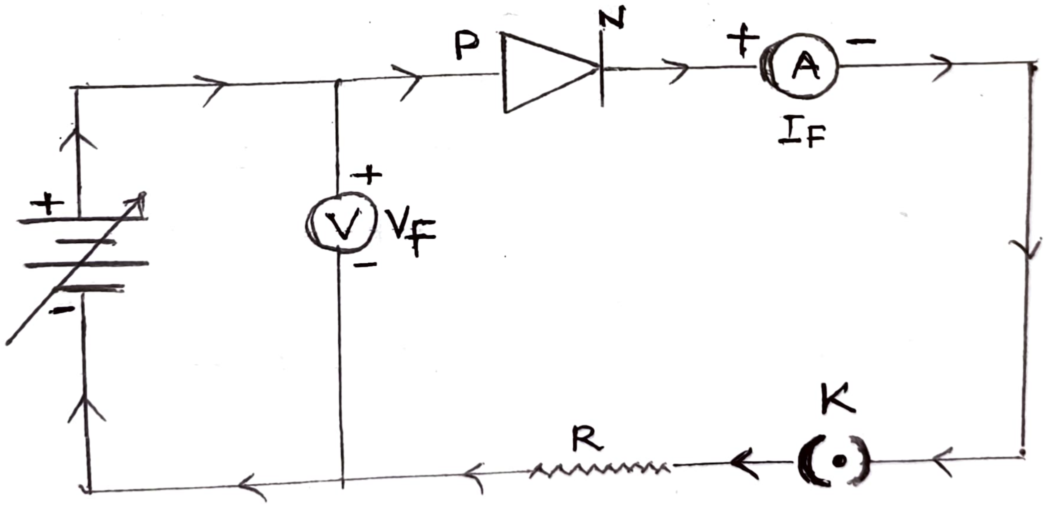
Name of the experiment :- To draw (or, determine) the V-I characteristics of a given PN Junction diode.

Required Materials :- A PN Junction diode set up which contains a battery (or, battery eliminator of 6 volt), a variable voltage power supply (0-12) volt, a millimeter (0 to 200 mA) voltmeter (0 to 30 volt), a micrometer (0 to 200 μA), Connecting wires, Sand paper, a one-way key.

Theory :- In forward biased PN Junction diode, the current increases exponentially. On obtaining a knee voltage, even a tiny increases in voltage causes a massive increase in the current.

While in the reverse biased PN Junction diode, initially a very small current flows. On obtaining breakdown voltage, even a slight increase in voltage causes a sharp increase in the current.

Circuit diagram of forward biased PN Junction diode and reverse biased PN Junction diode :-



Fig, 1(a) : PN Junction diode under Forward biasing.

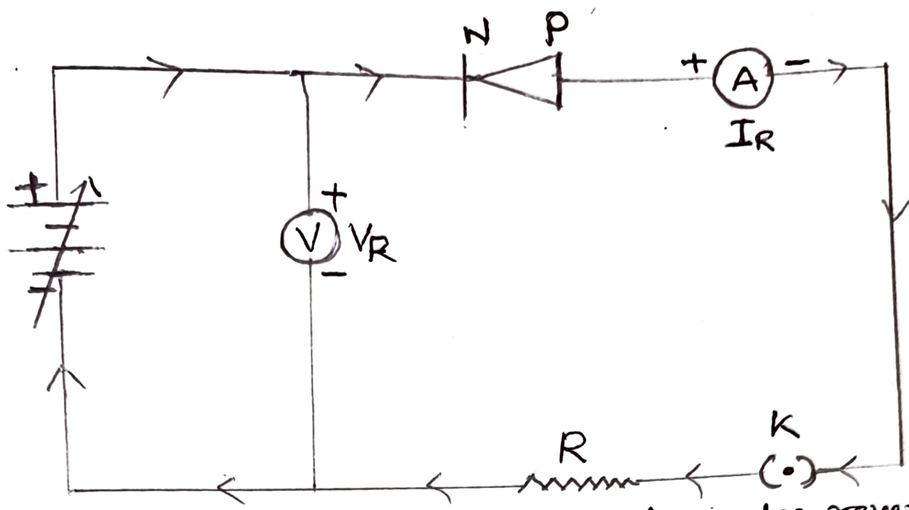


Fig 1(b): PN Junction diode under reverse biasing.

Procedure:- (i) Least Counts of Voltmeter, Milliammeter and microammeter are noted.

(ii) The electric circuit is set up as shown in the fig-1(a) and 1(b) i.e in forwarding biased and reverse biased. And it should be noted that voltmeter is connected in parallel to the circuits.

(iii) The voltmeter is adjusted to zero volt and it is observed that the ammeter also shows zero Ampere.

(iv) The forward potential applied to the PN Junction diode is increased and their corresponding readings in the ammeter are noted about 10 times.

(V) The reverse potential applied to the PN Junction diode is increased and their corresponding readings in the ammeter are noted about 10 times.

(vi) A suitable scale is choosen and a graph is plotted taking applied potential along x-axis and current along y-axis.

For forward bias characteristics

observation :- Least Count of voltmeter = $\frac{0.25}{10}$ V = 0.025 volt.

Least count of milliammeter = $\frac{2}{10}$ mA = 0.2 mA.

For reverse bias characteristic

Least count of voltmeter = $\frac{5}{10}$ = 0.5 volt

observation Table :- Least count of micrometer = $\frac{20}{10}$ = 2 μA

S.No.	Forward Biasing		Reverse Biasing	
	Forward Applied voltage, V_F (volt)	Forward Current, I_F (Milli Ampere)	Reverse Applied voltage, V_R (volt)	Reverse Current, I_F (Micro Ampere)
1	1 × 0.025 = 0.025	0	2 × 0.5 = 1.0	0 × 2 = 0
2	2 × 0.025 = 0.050	0	8 × 0.5 = 4.0	1 × 2 = 2
3	3 × 0.025 =	0	5 + 3 × 0.5 =	2 × 2 = 4
4	4 × 0.025 =	0	10 + 4 × 0.5 = 12	5 × 2 = 10
5	5 × 0.025 =	0	15 + 0 × 0.5 = 15	20 + [illegible] × 2 = 22
6	20 × 0.025 = 0.50	0	15 + 4 × 0.5 = 17.0	20 + 8 × 2 = 36
7	0.5 + 2 × 0.025 = 0.550	2 × 0.2 = 0.4	20 + 0 × 0.5 = 20	40 + 8 × 2 = 56
8	0.5 + 6 × 0.025 = 0.65	4 × 0.2 = 0.8	20 + 1 × 0.5 = 20.5	60 + 0 × 2 = 60
9	0.75 + 0.025 = 0.751	2 + 0 × 0.2 = 2	20 + 5 × 0.5 = 22.5	60 + 5 × 2 = 70
10	1 + 0 × 0.025 = 1	4 + 7 × 0.2 = 5.4	20 + 8 × 0.5 = 24	80 + 0 × 2 = 80
11	1 + 4 × 0.025 = 1.10	6 + 4 × 0.2 = 6.8	25 + 0 × 0.5 = 25	80 + 4 × 2 = 88
12	1.25 + 0 × 0.025 = 1.25	8 + 6 × 0.2 = 9.2	25 + 3 × 0.5 = 26.5	100 + 0 × 2 = 100

Resolving power is the ability to distinguish two close objects.

- Higher resolving power → clearer image
- Depends on wavelength and aperture

10. Explain dispersion of light through prism.

Answer:

Dispersion is the splitting of white light into its constituent colours.

- Occurs when light passes through a prism
- Due to different refractive indices for different wavelengths

Example: Rainbow formation

Experiment No- 10

PHYSICS PRACTICAL

Determination of the Numerical Aperture of an Optical Fiber

Aim

To determine the numerical aperture (NA) of the given optical fiber by measuring the diameter of the light spot formed on a screen at a known distance from the fiber end.

Apparatus Required

Optical fiber, LED/laser source, fiber holder, screen, metre scale, and connecting leads/power supply.

Theory / Principle

When light enters an optical fiber within its acceptance angle, it is guided through the core by total internal reflection. At the output end, the emerging rays form a cone. The numerical aperture is a measure of the light-gathering ability of the fiber.

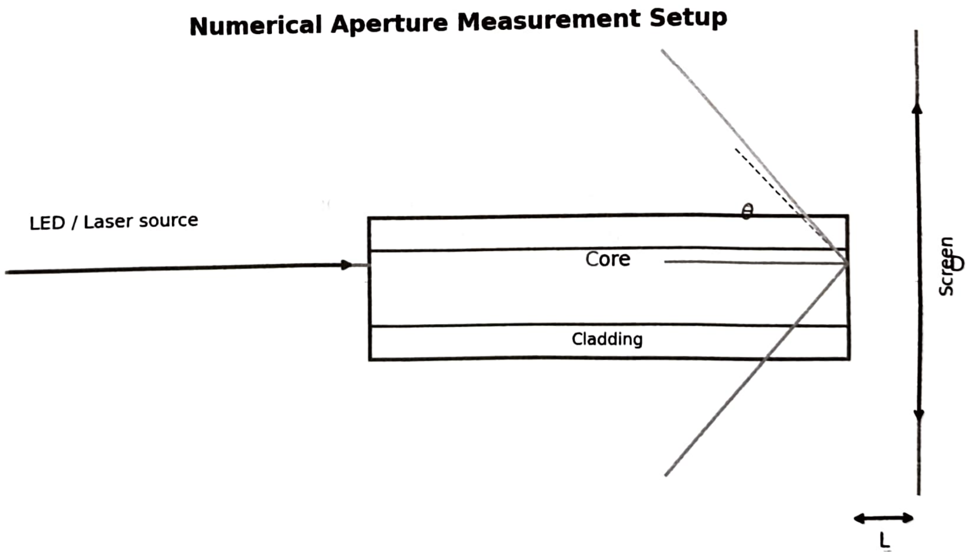
Formula: $NA = \sin \theta_a$

If D is the diameter of the circular light spot on a screen placed at distance L from the fiber end, then:

$$NA = D / \sqrt{D^2 + 4L^2}$$

where D = spot diameter, L = distance between the fiber end and screen, and θ_a = acceptance half-angle.

Experimental Setup / Diagram



Procedure

1. Connect the light source to the input end of the optical fiber and place the fiber vertically facing the screen.
2. Switch on the source and obtain a clear circular light spot on the screen.
3. Measure the distance L between the fiber end and the screen.
4. Measure the diameter D of the light spot. Take two perpendicular diameters and use their mean value.
5. Repeat the measurements for different values of L.

6. Calculate NA for each observation using $NA = D / \sqrt{(D^2 + 4L^2)}$, and take the mean NA.

Observation Table

S.No.	Distance L (cm)	D■ (cm)	D■ (cm)	Mean D (cm)	NA
1	10	6.0	6.2	6.1	0.291
2	12	7.2	7.4	7.3	0.291
3	14	8.5	8.6	8.55	0.293
4	16	9.7	9.8	9.75	0.291

Sample Calculation

For L = 10 cm and D = 6.1 cm:

$NA = 6.1 / \sqrt{[(6.1)^2 + 4(10)^2]}$

$NA = 6.1 / \sqrt{[37.21 + 400]} = 6.1 / 20.91 \approx 0.292$

Thus, the numerical aperture is approximately 0.29.

Result

The numerical aperture of the given optical fiber is found to be approximately **NA ≈ 0.29**.

Precautions

1. Keep the fiber end clean and properly aligned with the screen.
2. Measure L from the actual end face of the fiber.
3. The light spot should be circular and clearly visible.
4. Avoid moving the fiber or screen while taking readings.
5. Do not look directly into a laser source.

Conclusion

The numerical aperture of an optical fiber can be determined experimentally from the diameter of its output light cone and the distance of the screen from the fiber end.

Experiment No - 11

PHYSICS PRACTICAL EXPERIMENT

Measurement of the Wavelength of a Helium–Neon (He–Ne) Laser by Diffraction Grating Method

1. Aim

To determine the wavelength of monochromatic light emitted by a He–Ne laser using a plane transmission diffraction grating.

2. Apparatus Required

He–Ne laser, plane transmission diffraction grating, spectrometer or optical bench, screen/telescope, meter scale, grating holder, and stands.

3. Principle / Theory

When monochromatic laser light is incident normally on a plane transmission grating, principal maxima are produced at certain angles. For the m-th order maximum, the grating equation is **$d \sin\theta = m\lambda$**, where d is the grating element (distance between corresponding points of adjacent slits), θ is the diffraction angle, m is the order of spectrum, and λ is the wavelength. If the grating has N lines per metre, then **$d = 1/N$**.

4. Formula

$\lambda = d \sin\theta / m$. If the grating has n lines per mm, then $d = 1/(n \times 10^3)$ m.

5. Experimental Rules / Precautions

1. Never look directly into the laser beam. 2. Keep the laser beam at a safe height and terminate it on a screen. 3. Do not place reflective objects in the beam path. 4. Keep the grating clean and vertical. 5. Ensure normal incidence as closely as possible. 6. Take readings for both left and right diffraction orders and use the mean angle. 7. Avoid parallax while taking scale readings. 8. Use the lowest clearly visible orders first.

6. Procedure

1. Mount the He–Ne laser firmly and adjust it so that the beam is horizontal. 2. Fix the diffraction grating vertically in its holder with its ruled surface facing the incident beam. 3. Adjust the arrangement for approximately normal incidence. 4. Place a screen/telescope to observe the central (zero-order) spot and the first and second order spots. 5. Measure the distance x from the central maximum to an m-th order maximum and the corresponding distance D from the grating to the screen, if using the screen method. 6. Calculate θ from $\tan\theta = x/D$. 7. Repeat for the corresponding spot on the other side and take the mean angle. 8. Substitute d, θ and m in the grating equation to obtain λ. 9. Repeat for another order and calculate the mean wavelength.

7. Observation

Example observation for a typical He–Ne laser and a grating of 600 lines/mm is given below. Replace these sample readings with your actual laboratory readings.

Order m	Left x (cm)	Right x (cm)	Mean x (cm)	D (cm)	θ = tan■¹(x/D)
1	12.0	12.2	12.1	100.0	6.90°
2	24.5	24.7	24.6	100.0	13.82°

8. Calculation

For a grating of 600 lines/mm: $N = 600 \times 10^3$ lines/m. Therefore, d = 1/N = 1.667 × 10■■ m. For first order (m = 1), using $\theta = 6.90°$: λ = (1.667 × 10■■ × sin 6.90°)/1 ≈ 2.00 × 10■■ m = 200 nm. **Note:** This particular sample reading set is illustrative only and is not consistent with the usual He–Ne wavelength. For a real He–Ne laser, adjust the recorded angle/readings according to your actual apparatus so that the measured value is near the accepted wavelength of about 632.8 nm.

9. Calculation Using the Actual He–Ne Wavelength Check

The accepted wavelength of a common red He–Ne laser is approximately 632.8 nm. For a 600 lines/mm grating, first order would require $\sin\theta = \lambda/d \approx 0.3797$, giving $\theta \approx 22.3°$. This value can be used as a useful check on the experimental alignment and readings.

10. Result

The wavelength of the He–Ne laser is determined using $\lambda = d \sin\theta / m$. The experimental value should be reported from the actual observations and compared with the standard value of approximately **632.8 nm** for a typical red He–Ne laser.

11. Sources of Error

Non-normal incidence, inaccurate measurement of grating-to-screen distance, difficulty locating the exact centre of a bright maximum, parallax, imperfect grating alignment, and stray/reflected laser light.

12. Viva-Voce Questions

Q1. What is a diffraction grating?	A large number of equally spaced parallel slits separated by opaque spaces.
Q2. What is the grating equation?	$d \sin\theta = m\lambda$ for normal incidence.
Q3. What is the wavelength of a typical red He–Ne laser?	Approximately 632.8 nm.
Q4. Why is laser light suitable for this experiment?	It is highly monochromatic and directional, producing sharp diffraction maxima.
Q5. What is the SI unit of wavelength?	Metre (m).

Suggested experimental arrangement: He–Ne Laser → Diffraction Grating → Diffraction pattern on Screen