PERIYAR INSTITUTE OF DISTANCE EDUCATION (PRIDE)

PERIYAR UNIVERSITY

SALEM - 636 011.

B.Sc. CHEMISTRY

FIRST YEAR

PRACTICAL – I : PHYSICS ALLIED - I

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B.Sc. CHEMISTRY

FIRST YEAR

PRACTICAL – I : PHYSICS ALLIED – I

BLOCK 1

PART I	**Mechanics and Properties of matter**
PART II	**Heat**
PART III	**Sound**
PART IV	**Optics**
PART V	**Electricity and Magnetism**
PART VI	**Electronics**

ALLIED PHYSICS PRACTICALS

1. Young’s modulus – non uniform bending – scale and telescope method
2. Young’s modulus – uniform bending – scale and telescope method
3. Torsion pendulum – rigidity modulus of material of a wire
4. Surface tension and interfacial surface tension method of drops
5. Coefficient of thermal conductivity of a bad conductor – Lee’s disc method
6. Sonometer –frequency of AC
7. Newton’s rings – Radius of curvature of a lens
8. Potentiometer – Ammeter calibration
9. Field along the axis of a coil – determination of B_H
10. Voltage regulator – Zener diode
11. OR, AND, NOT gates using ICs
12. NAND / NOR as universal building blocks

BLOCK PLAN (CONTENT)

PART I Mechanics and Properties of matter

1. Young’s modulus – non uniform bending – scale and telescope method
2. Young’s modulus – uniform bending – scale and telescope method
3. Torsion pendulum – rigidity modulus of material of a wire
4. Surface tension and interfacial surface tension method of drops

PART II Heat

5. Coefficient of thermal conductivity of a bad conductor – Lee’s disc method

PART III Sound

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BLOCK INTRODUCTION

This book has been written for keeping in mind to suit the needs of Under-graduate students of PRIDE. It is hoped that the book would serve as a good guide and help students to perform the experiments with better understanding. The book has 12 experiments covering the topics on Mechanics, Properties of matter, Heat, Optics, Magnetism, Electricity and Electronics.

The book is written in a simple and lucid style. Each experiment contains essential theory, detailed procedure, systematic data tables has been given for the successful performance of the experiment. Some objective questions are provided at the end of each experiment. Data of Physical constants and symbols for electronic devices have been given at the end of the book.

Suggestions for further improvement of the book and enlarging its utility will be gratefully acknowledged.

EXPERIMENT - 1

YOUNG'S MODULUS – NON UNIFORM BENDING – SCALE AND TELESCOPE METHOD (SINGLE OPTIC LEVER)

Aim:

To determine Young's modulus of elasticity of the material of the beam, subjecting it to non-uniform bending using Scale and Telescope method.

Apparatus:

Rectangular bar, knife edges, optic lever, scale and telescope etc.

Procedure

The depression at the mid point of a beam subjected to non-uniform bending can be measured accurately using single optic lever with scale and telescope arrangement. The given beam is placed symmetrically on knife edges. The front leg of single optic lever is resting on the mid point C of the beam (Fig. 1). The other two hind legs are resting on a suitable support kept at same level behind the beam. As shown in Fig. 1, the scale and telescope are kept at a distance of about one meter in front of optic lever. The weight hanger H with a dead weight W is suspended at the mid point C of the bar.

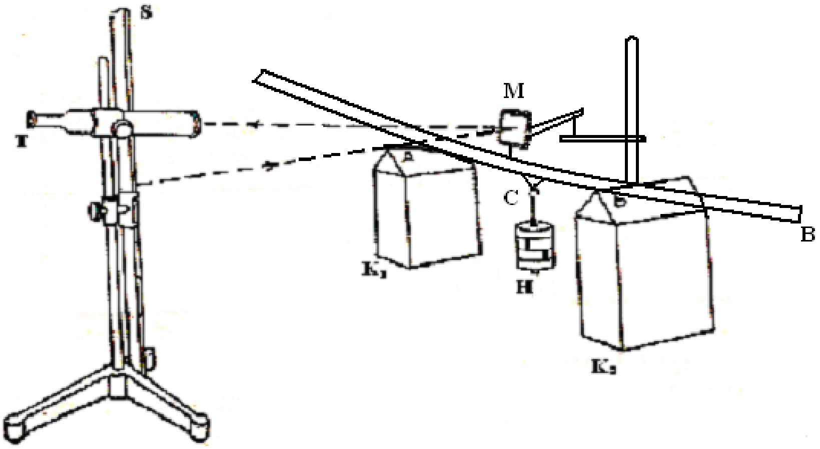


Fig. 1.

The telescope is properly focused to see the image of the vertical scale reading formed by the plane mirror of the optic lever. The telescope is adjusted to make the horizontal cross wire of the eye piece to coincide with certain scale reading (preferably with the middle zero of the scale). This is the first reading with the initial dead weight W. Then weights are added to hanger in steps of m, say, 50g. Each time, the scale reading viewed through telescope is taken. For convenience, including the reading for the dead weight W, eight or ten (even number of) readings can be taken while loading.

The procedure is repeated by unloading the weights in steps of m. The readings are tabulated as in Table 1.

Table 1.

Load (Kg)	Telescope Reading		Mean cm	Shift for 4 kg cm
	Loading cm	Unloading cm		
W			x_0	
W + m			x_1	
W + 2m			x_2	
W + 3m			x_3	
W + 4m			x_4	$x_4 - x_0$
W + 5m			x_5	$x_5 - x_1$
W + 6m			x_6	$x_6 - x_2$
W + 7m			x_7	$x_7 - x_3$

Mean shift for 4 cm = cm

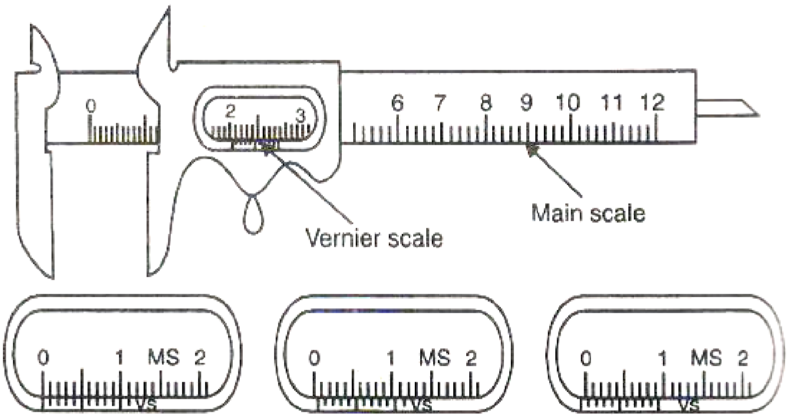
Shift for m= x = cm

The distance D of the scale from the mirror and the length *l* of the beam between the knife edges are measured accurately.

The breadth b and thickness d of the beam are measured as in the previous case.

Experiment is repeated for different length of the beam between the knife edges.

Breadth b – Using Vernier Calipers



Least count

The number of divisions in one cm of main scale (M) and total number of divisions in vernier scale (V) are noted. The zero of vernier scale is made to coincide with any division of main scale. The number of main sale divisions covered by vernier scale is found out. Fot a typical Vernier calipers used in the laboratory,

10 vernier scale divisions (v.s.d) = 9 main scale divisions (m.s.d.)

Number of main scale divisions in one cm = 10

Value of one m.s.d.= (1/10) cm

Value of one v.s.d. = (9/10) m.s.d.

The least count is defined as:

Least count = 1 main scale division – 1 Vernier scale division

i.e., L.C. = 1 m.s.d. – 1 v.s.d.

= 1 m.s.d. – (9/10) m.s.d.

= (1/10) m.s.d.

= (1/10) X (1/10) cm

= 0.01 cm.

Table 2.

S. No.	MSR cm	Coinciding V.S.D.	Observed Reading = MSR + VSD. (L.C) cm	Correct Reading = O.R. + Z.C. cm
1. 2. 3.				

Mean = cm

Table 3. **Thickness d – Using screw gauge**

***(iii)* To find the thickness (*d*) of the beam using screw gauge**

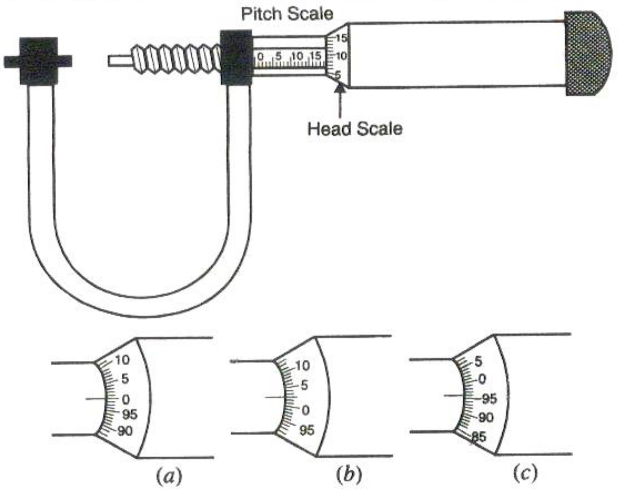


Fig. 1(*i*).3

Zero error : Nil
Zero correction : Nil

Zero error = +ve
(3 div. below)
Zero correction = – 3 × L.C.

Zero error = –ve
(4 div. above)
Zero correction = +4 × L.C.

Least count

$$\text{Pitch} = \frac{\text{Distance mover on main scale}}{\text{Number of rotations}}$$

$$= \frac{5\text{mm}}{5} = 1 \text{ mm.}$$

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$$

$$= \frac{1}{100} mm$$

= 0.01 mm

= 0.001 cm

S. No.	PSR mm	H.S.D.	Observed Reading = PSR + HSD. (L.C)	Correct Reading = O.R. + Z.C. mm
1.				
2.				
3.				

Mean = mm

Formula:

The depression s of the midpoint of the beam under non-uniform bending due to a load m, is given by

$$E = \frac{gl^3}{4bd^3}\left(\frac{m}{s}\right).$$

Let p be the perpendicular distance from the front leg to the line joining the hind legs of the optic lever as shown in fig. 2. It can be shown that the depression s in the beam for a load m and the shift x in the scale reading are related by the expression:

$$\frac{s}{p} = \frac{x}{2D}$$

Substituting the value of s in terms of x, p and D,

$$\text{Young's modulus } E = \frac{gl^3 D}{2bd^3 p}\left(\frac{m}{x}\right).$$

To find the perpendicular distance p, the three legs of optic lever are pressed gently on a plane paper and the impressions of the tips of three legs from vertices of a triangle. The perpendicular distance from the tip of front leg is measured. (Refer fig. 2)

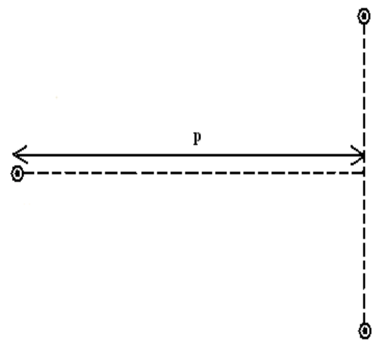


Fig. 2.

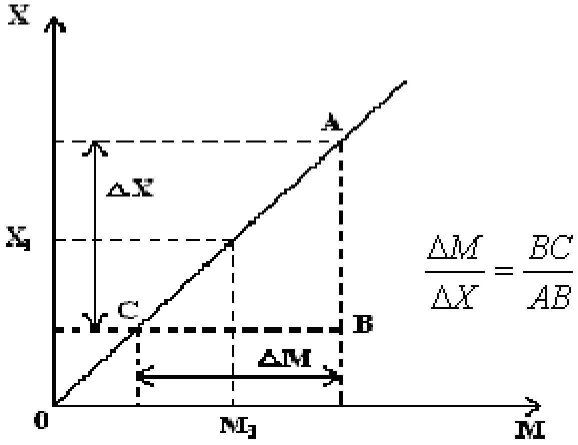


Fig. 3.

A graph is drawn (Refer fig. 3) between the mass M = m, 2m, …etc. and scale reading X – the mean reading after subtracting dead weight reading. The reciprocal of the slope of straight line graph gives ΔM/ΔX = m/x.

Observations:

Distance between the knife edges l = m

Breadth of beam b = m

Thickness of beam d = m

Acceleration due to gravity g = 9.81 ms^{-2}

Distance between the mirror and scale D = m

Perpendicular distance between

front leg and line joining hind legs p = m

Mean m/x = kg m^{-1}

By graph, m/x = ΔM/ΔX = kg m^{-1}

Young's Modulus $E = \frac{gl^3D}{2bd^3p}\left(\frac{m}{x}\right)$. = Nm^{-2}

Result: (i) Young's Modulus by calculation = Nm^{-2}

(ii) Young's Modulus by graph = Nm^{-2}

EXPERIMENT - 2

YOUNG'S MODULUS – UNIFORM BENDING – SCALE AND TELESCOPE METHOD (SINGLE OPTIC LEVER)

Aim:

To determine Young's modulus of elasticity of the material of the beam, subjecting it to uniform bending using Scale and Telescope method

Apparatus:

Uniform rectangular bar, two knife edges, two weight hangers with slotted weights, optic lever, scale and telescope etc.

Procedure:

The rectangular bar is placed symmetrically on two knife edges K_1 and K_2. The front leg of single optic lever is resting on the mid-point O of the beam [Fig.1]. The other two hind legs are resting on a suitable support kept at same level behind the beam. The weight hangers H_1 and H_2 with dead weight W, as in previous case, are suspended from the points C and D of the beam as shown in fig. 1.

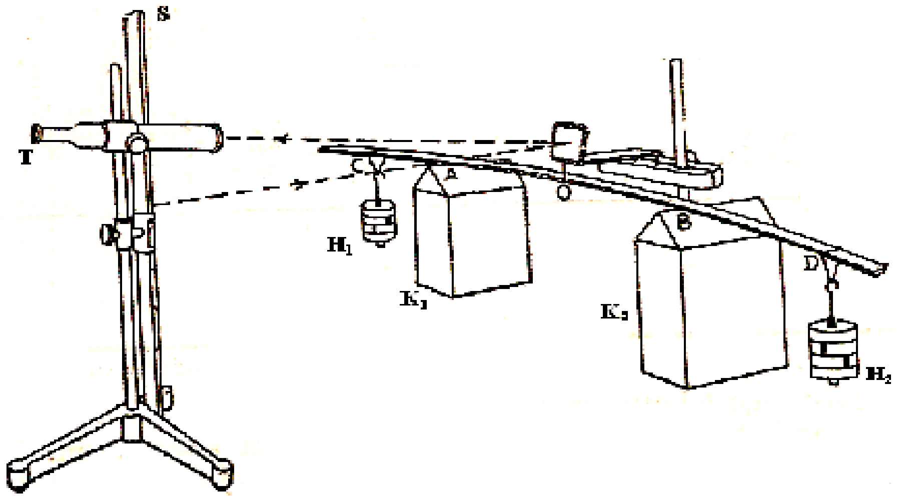


Fig. 1.

The scale with telescope is held vertically in front of the plane mirror of optic lever. The telescope is focused to see the image of scale divisions reflected by the mirror of the optic lever. The horizontal cross wire of the telescope is adjusted to coincide with a definite division on the scale and the reading is noted. Weights are added equally to both the hangers in steps of m, say 50g and corresponding scale readings are noted. Similarly, by removing equal weights from the hangers in step of m, the scale readings are taken and tabulated as in Table.1.

Table 1.

Load (Kg)	Telescope Reading		Mean cm	Shift for 4m cm
	Loading cm	Unloading cm		
W W + m W + 2m W + 3m			x_0 x_1 x_2 x_3	
W + 4m W + 5m W + 6m W + 7m			x_4 x_5 x_6 x_7	$x_4 - x_0$ $x_5 - x_1$ $x_6 - x_2$ $x_7 - x_3$

Mean shift for 4 cm = cm

Shift for m = x = cm

The length l of the beam between two knife edges, the distance a of the hanger from nearest knife edge, the distance D between the scale and mirror of optic lever are measured.

The perpendicular distance p of front leg from the line joining hind legs in noted.

Using Vernier calipers and screw gauge, the breadth b and thickness d of the beam are respectively found out [Table 2 and Table 3].

Table 2. Breadth b – Using Vernier Calipers

S. No.	MSR cm	Coinciding V.S.D.	Observed Reading = MSR + VSD. (L.C) cm	Correct Reading = O.R. + Z.C. cm
1. 2. 3.				

Mean = cm

Table3. Thickness d – Using screw gauge

S. No.	PSR mm	H.S.D.	Observed Reading = PSR + HSD. (L.C)	Correct Reading = O.R. + Z.C. mm
1. 2. 3.				

Mean = mm

Experiment is repeated by either changing the length l or the distance a of the hanger from adjacent knife edge.

Formula:

The elevation s produced at the midpoint of the beam subjected to uniform bending in terms of shift x in scale reading is given by $\frac{s}{p} = \frac{x}{2D}$.

Young's modulus $E = \frac{3}{2}\frac{gal^2}{bd^3}\left(\frac{m}{s}\right)$

$$E = \frac{3gal^2 D}{bd^3 p}\left(\frac{m}{x}\right)$$

A graph is drawn, as in previous cases, with load M = m, 2m, … etc. along x – axis and the mean scale reading X (after subtracting dead weight reading) along y – axis, [see Fig. 2]. From the straight line graph, mean (m/x) = $\frac{\Delta M}{\Delta X}$ is calculated.

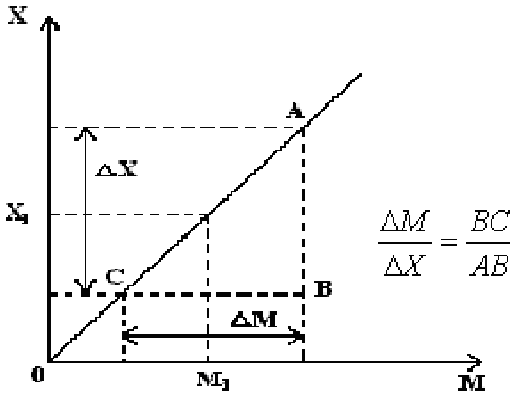


Fig. 2

Observations:

Length of the beam between knife edges 1 = m

Distance between weight hanger

and nearest knife edge a = m

Distance between the scale and mirror of optic lever D = m

Perpendicular distance of front leg from

line joining hind legs of the lever p = m

Acceleration due to gravity g = 9.8 ms^{-2}

Breadth of the beam b = m

Thickness of the beam d = m

Mean (m/x) = kgm^{-1}

By graph, ΔM / ΔX = kgm^{-1}

Young's modulus $E = \frac{3gal^2D}{bd^3p}\left(\frac{m}{x}\right)$ = Nm^{-2}

Result:

(i) Young modulus, by calculation = Nm^{-2}

(ii) Young's modulus, by graph = Nm^{-2}

EXPERIMENT - 3

TORSINAL PENDULUM: RIGIDITY MODULUS OF MATERIAL OF A WIRE

Aim:

To determine rigidity modulus N of the material of wire, by the method of torsional oscillations

(a) TORSIONAL PENDULUM – Without symmetrical masses

Apparatus:

Torsional pendulum – circular disc with suspension wire of uniform cross section, screw chuck, long knitting needle, stop clock etc.

Description:

As shown in the diagram (fig. 1) a torsional pendulum is a circular metal disc, fixed to a suspension wire at the center. The other end of the wire is firmly fixed to a vertical screw chuck, rigidly clamped to a support. By adjusting the screw, the length of suspension wire is changed accordingly.

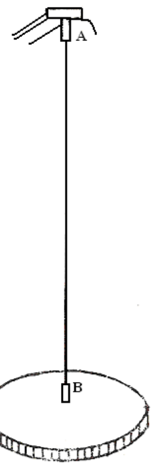


Fig. 1.

Procedure:

To start with, the length of the pendulum is adjusted to a suitable length, say, 50 cm. A mark is made on the rim of the disc and a knitting needle is placed in front of its when the disc is at rest. This refers the equilibrium position of the pendulum. A small twist is given to the disc so as to set up torsional oscillations. After two or three oscillations, just when the mark passes the needle, a stop clock is started. The time taken to complete twenty oscillations is found with two trails. From the mean of two observations, the period of oscillation T is determined. The experiment is repeated by increasing the length in the step of 10 cm and observations are tabulated as in Table .1.

Using screw gauge, the diameter of the wire and hence its radius a is found out at five or six different positions and mean radius is determined very accurately. The radius R of the disc (by measuring its circumference $2\pi R$) and mass M of the disc are found out.

A graph is drawn, as shown schematically in fig. 2, by taking L along x-axis and T^2 along y-axis. By calculation and by graph, the mean value of l/T^2 is determined and hence the rigidity modulus is calculated.

Table 1 : Period of oscillations of Torsional pendulum

Length l Cm	Time for 20 oscillations		Mean s	Period T s	l/T^2 cm s^{-2}
	I s	II s			
40 50 60					

Mean (l/T^2) = cm s^{-2}

$l \times 10^{-2} m$	T^2 s^2
40 50 60 - - -	

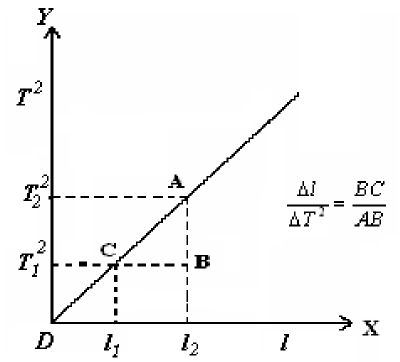


Fig. 2

Formula:

Consider a circular disc of radius R an d mass M, suspended by uniform wire of radius a and length l. Let the disc be given a small twist so as to execute torsional oscillations. The time period T of oscillation is given by

$$T = 2\pi\sqrt{\frac{I}{C}}.$$

where I is the moment of inertia of the disc about an axis passing through the center, at right angles to the plane of the disc. C is the coupler per unit twist, given in terms of rigidity modulus N of the material of the wire, by

$$C = \frac{\pi N a^4}{2l}$$

Therefore,

$$N = \frac{8\pi l}{a^4}\left(\frac{l}{T^2}\right)$$

Now the moment of inertia I, for the circular disc about its axis of suspension is

$$I = MR^2/2.$$

[For rectangular disc of length L and breadth B, the moment of inertia:

$$I = M(L^2 + B^2)/12.$$

For a cylinder of radius R and length L, the moment of inertia:

$$I = M(L^2/12 + R^2/4)$$

We note that, for a given wire of radius of cross section a; the graph of length l versus T^2 is a straight line of constant slope. Therefore experimentally, by finding the period of oscillation T for various length l, one can determine the rigidity modulus of the material of the wire.

Observations:

Radius of the wire a = m

Radius of the disc R = m

Mass of the disc M = kg

Mean (l/T^2) = ms^{-2}

By graph, $\Delta l / \Delta T^2 = l/T^2$ = ms^{-2}

Result:

(i) Rigidity Modulus by calculation = Nm^{-2}

(ii) Rigidity modulus by graph = Nm^{-2}

EXPERIMENT - 4

SURFACE TENSION

DROP WEIGHT METHOD

Aim

To determine the surface tension of (i) water (ii) liquid (kerosene oil) and interfacial surface tension between liquid and water.

Apparatus

A glass funnel with vertical stand, a short glass tube of suitable diameter, rubber tubing, beaker, pinch clip, Hare's apparatus, etc.

Description

As shown in Fig. 1, a short glass tube is connected to the lower end of funnel through a rubber tube. The funnel is held vertical with a rigid support. The flow of liquid through the glass tube can be adjusted by means of pinch clip, provided with the rubber tubing.

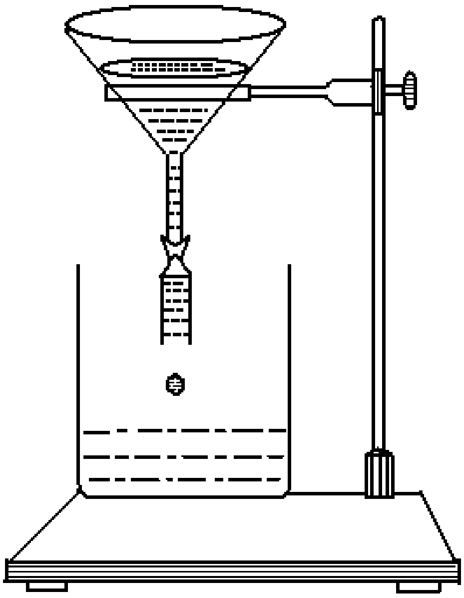


Fig. 1

Procedure

To start the experiment, pure clean water is poured into the funnel. The pinch clip is adjusted so that drops are formed slowly and steadily at the open end of the glass tube. A dry, clean weighed beaker [weighing is done by electronic balance] is taken and, say fifty drops of water are collected. The mass of beaker with 50 drops is measured. The experiment is repeated by collecting drops in steps of 50 and in each case, after deducting the mass of empty beaker, one can determine the mass of single drop. Hence mean mass of single drop of water is calculated. The readings are recorded as in Table 1.

Formula

For Rayleigh Formula, the surface tension of water is given by

$$T = \frac{mg}{3.8r}$$

where, m is the mass of one drop of water, r is the radius of glass tube and g is the acceleration due to gravity.

Note:

The dropping end of the glass tube should be flat. The glass tube should be kept vertical. The pinch cock is adjusted so that the liquid drops are formed slowly, say at the rate of about eight drops per minute. In the case of a liquid which wets glass (like water), the value of r used is the external radius of the tube. For waxed tubes, the value of r is the internal radius has to be found out by measuring the internal diameter of the tube using a vernier microscope.

Table 1. Drop weight – water : m_1

Object	Mass g	Mass of 50 drops g	Mass of single drop m_1 g
Empty Beaker	w_1		
Beaker + 50 drops	w_2	$(w_2 - w_1)$	
Beaker + 100 drops	w_3	$(w_3 - w_2)$	

Mean mass of one drop m_1 = g.

Surface Tension of liquid (Kerosene):

To find the surface tension of the liquid (kerosene), the funnel and glass tube are dried thoroughly and in filled with the kerosene oil. A dried and weighed beaker is taken to collect liquid drops in steps of fifty and after each collection, the mass of beaker with liquid drops is noted. The mean mass of single liquid drop m_2 is calculated. Use the same table as Table 1

Interfacial Surface Tension

To find interfacial surface tension of water in a lighter liquid (kerosene oil), sufficient quantity of kerosene is taken in the beaker. Mass of beaker with liquid is noted. By dropping the end of the glass tube in the liquid, water drops are formed within the liquid. The water drops are formed slowly within the liquid, say about six drops per minute. As in previous case, mass of water drops in steps of fifty is noted. From these readings the mean mass of single water drop in kerosene m_3 is calculated [Table. 2].

Table 2: Interfacial Drop weight: m_3

Object	Mass g	Mass of 50 drops g	Mass of single drop m_3 g
Beaker + Liquid	w_1	________	________
Beaker + Liquid + 50 drops of water	w_2	$(w_2 - w_1)$	________
Beaker + Liquid + 100 drops of water	w_3	$(w_3 – w_2)$	________

Mean mass of one drop m_3 = g.

The interfacial surface tension of water of density ρ_1 in a liquid of density ρ_2 is given by

$$T_{WL} = \frac{m_3 g}{3.8r}\left[1 - \frac{\rho_2}{\rho_1}\right]$$

m_3 being the mass of a drop of water in liquid.

The density of the liquid is determined using Hare’s apparatus. It is an inverted U-tube of uniform area of cross section, with the bent part connected to a rubber tube, as shown in Fig.2. Both the limbs of U-tube are dipped in water and liquid respectively. By means of rubber tube, water and liquid raise in respective limbs.

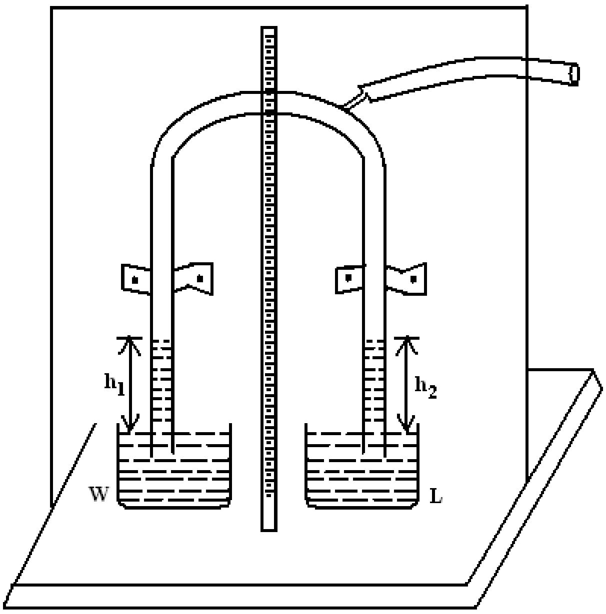


Fig. 2

The readings corresponding to beaker level and limb level both for water and liquid are noted on a metre scale provided with the apparatus. The heights of water (h_1) and liquid (h_2) columns are calculated and hence the density of liquid [Table 3] is determined.

Table 3 – Hare's Apparatus : ρ_2/ρ_1

S.No	Water Readings cm		Height of water column $h_1$cm	Liquid Readings cm		Height of liquid column h_2 cm	$\rho_2/\rho_1 = h_1/h_2$
	Beaker level	Limb level		Beaker level	Limb level		

Mean $\rho_2/\rho_1 = h_1/h_2 =$

As the water and kerosene wet the glass, the outer radius (r) of the glass tube must be used. It is measured by using screw gauge at different diametrically opposite points.

Observations:

Mass of one drop of water	m_1 =	kg
Mass of one drop of liquid	m_2 =	kg
Mass of one drop of water in liquid	m_3 =	kg
Acceleration due to gravity	g =	9.8 ms^{-2}
Ratio of density of liquid	ρ_2	
to that of water ρ_1	$(\rho_2/\rho_1) = h_1/h_2$	
Mean radius of glass tube	r =	m
Surface tension of water	T_W =	Nm^{-1}
Surface tension of liquid(kerosene)	T_L =	Nm^{-1}
Interfacial surface tension of water	T_{WL} =	Nm^{-1}

Result

Surface tension of water	=	Nm^{-1}
Surface tension of liquid	=	Nm^{-1}
Interfacial surface tension	=	Nm^{-1}

EXPERIMENT - 5
COEFFICIENT OF THERMAL CONDUCTIVITY OF A BAD CONDUCTOR – LEE'S DISC METHOD

Aim

To determine thermal conductivity of a bad conductor using Lee's disc.

Apparatus

Lee's Disc with steam chamber, a thin card board disc, two 100°C thermometers, a rigid support, stop clock, etc.

Description:

Lee's apparatus consists of a brightly polished circular brass disc D, about 5cm in radius and 1 cm in thickness. It is suspended horizontally by three strings from a suitable rigid stand, as shown in Fig. 1a.

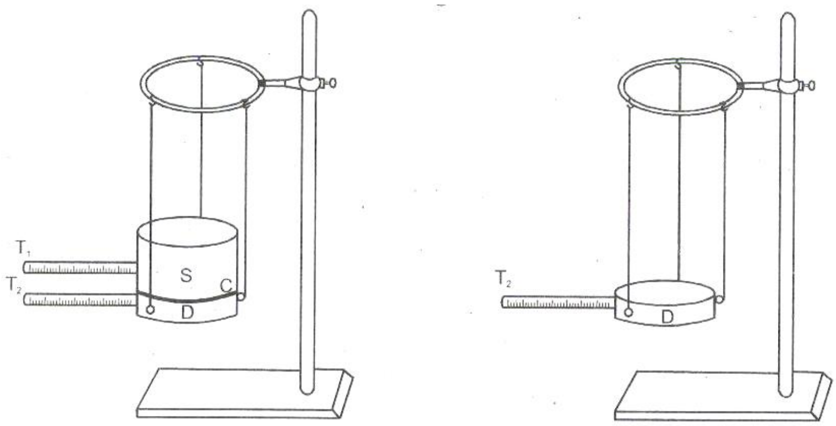


Fig. 1a **Fig. 1b**

A cylindrical steam chamber S of same cross-sectional size as that of Lee's Disc is placed over the disc. The given bad conductor, say, a card board is cut into a thin circular disc C of same diameter as that of Lee's Disc. It can be placed between the disc and the chamber. Two thermometers T_1 and T_2 can be inserted into the holes drilled in the disc and the chamber respectively.

Procedure:

Before beginning the experiment, the thickness h of Lee's Disc and d of the cardboard are determined using screw gauge. The radius r of the disc, which is also of cardboard, is found by measuring its circumference, $2\pi r$.

The cardboard is kept between Lee's disc and steam chamber (Fig. 1a) The steam from a boiler is passed through the chamber, the temperatures as shown by the thermometers T_1 and T_2 start raising. After an hour or so of passing the steam, the thermometers show steady readings. Let the steady temperatures of the steam and the disc be θ_1°C and θ_2 °C respectively.

Now the cardboard is carefully removed and the steam chamber S is placed directly on the Lee's Disc D (Fig. 1b). Steam is passed till the temperature of the disc rises 10°C above θ_2 °C. Then the chamber is removed and the disc is allowed to cool down freely. Stop clock is started and the decreasing temperature of the disc is noted for every 30 seconds, till the temperature comes 5 °C below θ_2 °C. The readings are tabulated as given in Table 1. A graph of time t along x-axis and temperature θ along y-axis is drawn, as shown in Fig. 2. From the graph, the time Δt required to cool down the disc from (θ_2 + 1) °C to (θ_2 - 1) °C is noted. Using the formula, the thermal conductivity of the bad conductor (cardboard) is calculated.

Formula:

In steady state, heat conducted per second through a cardboard of thermal conductivity K from steam chamber (θ_1 °C) to the Lee's Disc (θ_2 °C) is given by

$$Q = \frac{KA(\theta_1 - \theta_2)}{d}$$

where $A = \pi r^2$ is the area and d is the thickness of the cardboard.

The heat conducted thus in steady state is radiated to the surroundings by the exposed surface of the disc D, that is, from its bottom surface and curved surface. Let R be the rate of cooling of exposed surfaces. Now if dθ/dt is the rate of cooling of whole surface of the disc of radius r and thickness h, then

$$R = \frac{(r+2h)}{2(r+h)}\left(\frac{d\theta}{dt}\right)$$

From the graph (Fig. 2), dθ/dt = (2/Δt) °C/s

Hence, $$R = \frac{2}{\Delta t}\frac{(r+2h)}{2(r+h)}$$

If M is the mass and s is the specific heat capacity of the Lee's Disc, then heat radiated per second by the exposed surface is given by

H = MsR

$$= \frac{Ms}{2}\frac{(r+2h)}{(r+h)}\left(\frac{d\theta}{dt}\right)$$

In steady state, Q = H,

Substituting,

Thermal conductivity $$K = \frac{Msd(r+2h)}{2\pi r^2(\theta_1 - \theta_2)(r+h)}\left(\frac{d\theta}{dt}\right)$$

Table 1: Time – Temperature readings

Time t s	Temperature θ °C
0	$\theta_2 + 10$
.	.
.	.
.	θ_2
.	.
.	.
.	θ_2-5

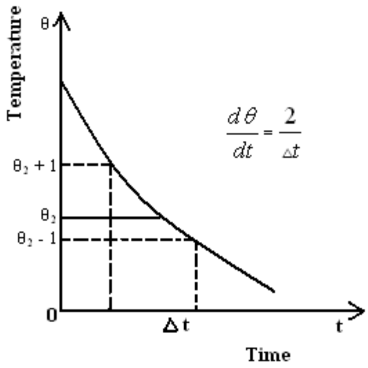


Fig. 2

Observations:

Mass of Lee's Disc M = kg

Thickness of the Disc h = m

Radius of the Disc r = m

Thickness of cardboard d = m

Specific heat capacity of Disc s = Jkg^{-1}/ °C

Steady temperature of stream θ_1= °C

Steady temperature of Disc θ_2= °C

Time required to cool the Disc from (θ_2 + 1) °C to (θ_2 - 1) °C = /Δt = s

Rate of cooling $\left(\frac{d\theta}{dt}\right) = \frac{2}{\Delta t} =$ $^{o}Cs^{-1}$

Coefficient of Thermal conductivity $K = \frac{Msd(r+2h)}{2\pi r^2(\theta_1 - \theta_2)(r+h)}\left(\frac{d\theta}{dt}\right)$

= Wm^{-1}/°C.

Note

The emissivity of the Lee's Disc can be calculated from the above observations as follows:

The emissivity E at steady temperature θ_2 is the heat radiated per second per unit area of the surface per °C difference in temperature with the surrounding, is given by $E = \frac{Ms}{2\pi r(r+h)(\theta_2 - \theta)}\left(\frac{d\theta}{dt}\right)$.

where θ is the temperature of surrounding.

Result

The coefficient of thermal conductivity of bad conductor (cardboard) is found to be = Wm^{-1}/°C.

EXPERIMENT - 6

SONOMETER – Frequency of AC

(a) A.C. Frequency – Steel Wire

Aim

To find a.c. frequency using sonometer with uniform steel wire.

Apparatus

Sonometer, steel wire, electromagnet, weight hanger with slotted weights, etc.

Procedure

A uniform steel wire is kept stretched on sonometer with two movable bridges. A load of, say, 2.5 kg or 3 kg is applied through weight hanger. Electromagnet is fixed just above the sonometer wire between two movable bridges. A paper rider is placed on the vibrating segment. By passing alternate current of frequency, f in hertz through electromagnet, the wire is excited to transverse vibrations, as shown in fig. 1.

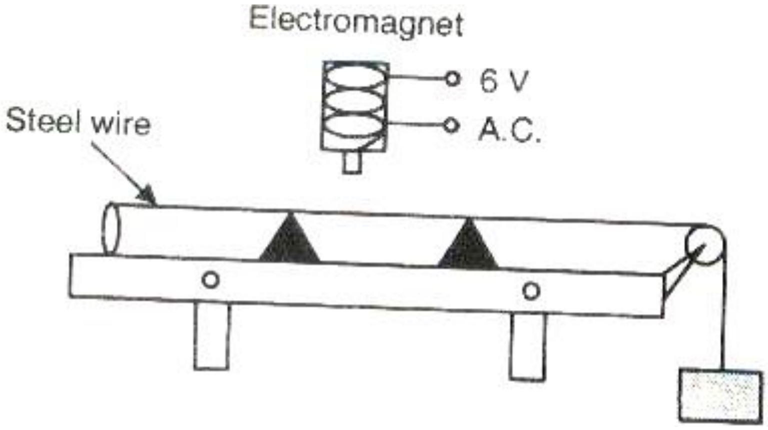


Fig. 1

The movable bridges are adjusted will the paper rider flutters violently and falls away from the wire. The vibrating length *l* is measured. Experiment is repeated for various loads and readings are tabulated as in Table 1. The radius of the wire is measured using screw gauge. Using the formula, at resonance,

$$n = \frac{1}{2}\sqrt{\frac{g}{m}}\left(\frac{M}{l^2}\right)^{1/2},$$

Now during one cycle of a.c., the wire is pulled twice, during positive and negative peak value.

Therefore a.c. frequency f = n/2.

Table 1. Determination of M / l^2

Load suspended including hanger : M kg	Vibrating length l m	l^2 m^2	M / l^2 kg m^{-2}

Mean M / l^2 = kg m^{-2}

Observations:

Density of steel wire ρ = kg m^{-3}

Radius of steel wire r = m

Linear density $m = \pi r^2 \rho$ = kg m^{-1}

Acceleration due to gravity g = 9.8 ms^{-2}

$$Mean\sqrt{\frac{M}{l}} = \qquad kg^{1/2}\, m^{-1}.$$

The a.c. frequency $f = \frac{n}{2} = \frac{1}{2}\left(\frac{1}{2}\sqrt{\frac{g}{m}}\left(\frac{M}{l^2}\right)^{1/2}\right)$

= Hz

Result

The a.c. frequency f = Hz

(b) A.C. Frequency – Brass Wire

Aim

To determine a.c. frequency, using sonometer with brass wire.

Apparatus

Step down transformer, horse shoe magnet, sonometer, brass wire, weight hanger with slotted weights, etc.

Procedure

As in previous case, a brass wire is kept stretched by suitable load in weight hanger. A horse shoe magnet is placed so that the wire passes between north pole and south pole of the magnet. Further, the magnetic field is in horizontal plane, at right angels to the length of sonometer wire. A.C. main is connected to the primary of transformer, the secondary of which are connected to the ends of the sonometer wire. Refer fig. 2.

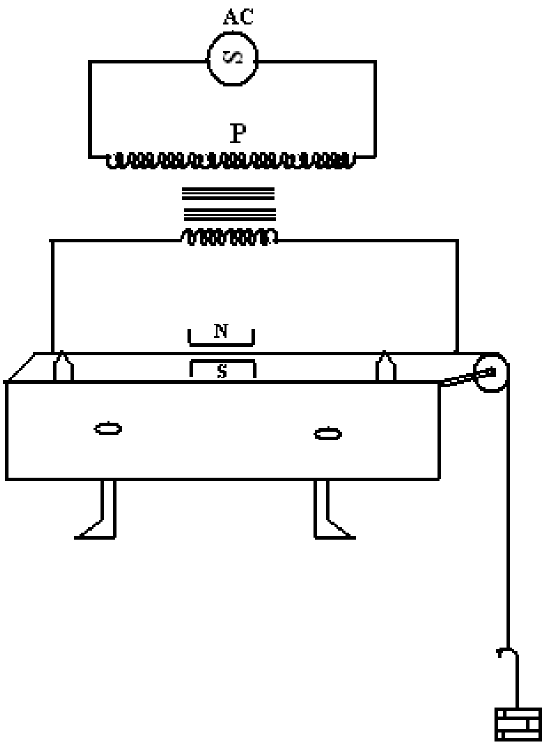


Fig. 2

With the help of paper rider, the movable bridges are adjusted so that vibrating segment is at resonance with the A.C. main. The experiment is repeated for various loads and readings are tabulated as in Table 2.

The radius r of the brass wire is measured accurately by using screw gauge. The linear density $m = \pi r^2 \rho$, ρ being the density of brass, is calculated.

At resonance, the natural frequency of vibrating segment is equal to frequency f of A.C. mains,

$$f = \frac{1}{2}\sqrt{\frac{g}{m}}\left(\frac{M}{l^2}\right)^{1/2}$$

where linear density $m = \pi r^2 \rho$

Table 2. Determination of M / l^2

Load suspended including hanger : M kg	Vibrating length l m	l^2 m^2	M / l^2 kg m^{-2}

Mean M / l^2 = kg m^{-2}

Observations:

Density of brass ρ = kg m^{-3}

Radius of the wire r = m

Linear density $m = \pi r^2 \rho$ = kg m^{-1}

Acceleration due to gravity g = 9.81 ms^{-2}

A.C. frequency $$f = \frac{1}{2}\sqrt{\frac{g}{m}}\left(\frac{M}{l^2}\right)^{1/2}$$

= Hz

Result

A.C. frequency using brass wire = Hz

EXPERIMENT - 7

NEWTON'S RINGS

RADIUS OF CURVATURE OF A LENS

Aim

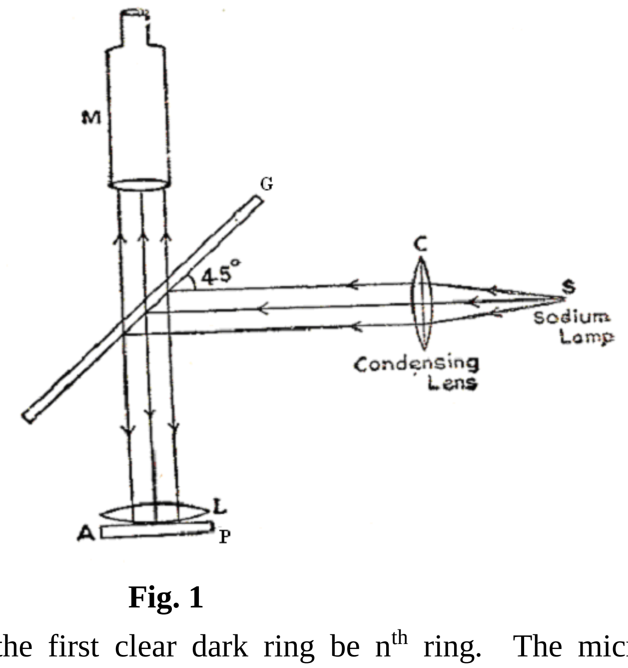
To determine radii of curvature of a double convex lens by forming Newton's rings and to calculate Refractive index of the material of the lens.

Apparatus

Convex lens, glass plates, sodium vapour lamp, 45^o slot, Vernier microscope, etc..

Procedure

A large focal length (1 metre or more) convex lens L is placed on a glass plate P, kept on the bed plate of microscope, as shown in fig. 1. Rays of light from sodium vapour lamp S, incident horizontally on a glass plate G inclined at 45^o are reflected vertically downward and are incident normally on the air film enclosed between the lens and glass plate. Due to interference between the light reflected from top and bottom surface of air film, the alternate dark and bright concentric rings can be observed through the microscope. At the point of contact of lens with the plate, the thickness of air film is zero. Therefore, the center of concentric rings appears dark. As one moves away from the point of contact, the thickness of air film increases symmetrically and hence, alternate bright and dark rings are obtained. These rings are called Newton's rings, [Fig. 2]



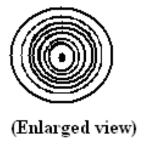


Fig. 1 **Fig. 2**

Let the first clear dark ring be n^{th} ring. The microscope is moved slowly to the left side by working its screw to cover, say, twenty seven dark rings. The rings are counted as n, n + 3, n + 6 etc upto n + 26. The vertical cross wire is made tangent to $(n + 27)^{th}$ dark ring and the reading in horizontal scale is noted. By working on horizontal screw of the vernier, the vertical cross wire is made tangent to (n + 24)th , (n + 21)th , … nth ring on the left side and respective readings on the scale are noted. Now moving the microscope in same direction, [i.e., moving to the right of the centre to avoid error due to back-lash], the cross wire is made tangential to nth (n + 3)rd , (n + 6)th , …(n + 27)th dark ring on other side (right side) of the center. The corresponding readings are taken and are tabulated as in Table 1. The difference in readings between two sides of a particular ring gives the diameter of that ring. For example d_n is the diameter of nth Newton's dark ring.

Table.1 L.C. = 0.001 cm

Order of ring	Microscope Readings		$d_n \times 10^{-2}$ m	$d_n^2 \times 10^{-4}$ m^{-2}	$(d^2_{n+m} - d_n^2)$ (m = 15)
	Left: cm	Right : cm			
n				x_1	
n+3	↑	↓		x_2	
n+6				x_3	
n+9				x_4	
n+12				x_5	
- - - - - - - -	- - - -↑- - - -	- - - -↓- - - -	- - - - - - - - -	- - - - - - - - - - -	- - - - - - - - -
n+15				x_6	$x_6 - x_1$
n+18				x_7	$x_7 - x_2$
n+21				x_8	$x_8 - x_4$
n+24				x_9	$x_9 - x_4$
n+27				x_{10}	$x_{10} - x_5$
	↑	↓			

For R_1 Mean $(d^2_{n+m} - d^2_n)$ = × 10^{-4} m^2

As shown in Table 1 ten sets of readings are taken and d_n and d_n^2 are calculated. Dividing the table in the middle $(d^2_{n+m} - d_n^2)$ is obtained in the last column keeping m =15.

Let us take the mean value of the last column as C_A.

That is $C_A = d^2_{n+m} - d^2_n$

The convex lens is reversed and the experiment is repeated and the radius of curvature, R_2 of the second face is determined.

Formula

Let d_n and d_{n+m} be the diameter of n^th and $(n+m)^{th}$ dark Newton's rings respectively. If λ is the wavelength of monochromatic light and R is the radius of curvature of the lens, then,

$$d^2{}_n = 4Rn\lambda$$

$$d^2{}_{n+m} = 4R(n+m)\lambda$$

Therefore $R = \frac{\left(d^2{}_{n+m} - d^2{}_n\right)}{4m\lambda} = \frac{C_A}{4m\lambda}$

By taking $\lambda = 589.3 \times 10^{-9} m$, radii of curvature R_1 and R_2 can be determined. The focal length of the convex lens (focal length more than 100 cm) is determined using telescope method.

The refractive index μ of the lens of focal length f is given by

$$\mu = 1 + \frac{R_1 R_2}{f(R_1 + R_2)}$$

Observations:

Wavelength of sodium light λ = $589.3 \times 10^{-9} m$

Radius of curvature R_1 = m

Radius of curvature R_2 = m

Focal length of lens f = m

Refractive index $\mu = 1 + \frac{R_1 R_2}{f(R_1 + R_2)}$ =

Result

Refractive index of material of double convex lens =

EXPERIMENT - 8

POTENTIOMETER – CALIBRATION OF AMMETER

Aim:

To calibrate a given ammeter using potentiometer.

Apparatus required:

Potentiometer, rheostats, accumulators, Daniell cell, standard 1 ohm resistance, plug keys, sensitive galvanometer, etc.

Procedure:

Part I. The potentiometer wire is first calibrated, using a Daniell cell as standard. (The e.m.f of a freshly prepared Daniell cell remains steady at 1.08 volts.)

Connections are made as shown in the diagram (Fig.1). The rheostat is adjusted so that the e.m.f of the Daniell cell is balanced by almost the entire length of the potentiometer wire. The length (L cm.) balancing the e.m.f. 1.08 volts of the Daniell cell is accurately determined. Then the p.d. per cm. Length of the wire is (1.08/L) volt. (The rheostat should not be disturbed hereafter.)

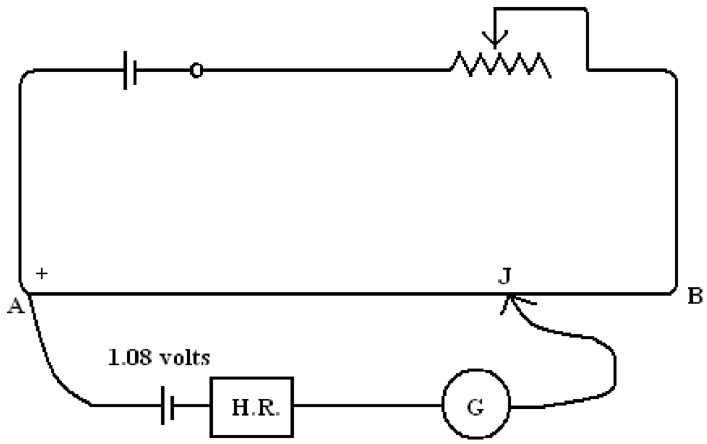


Fig. 1.

Part II. The Daniell cell is then replaced by the standard resistance of 1 ohm included in a second circuit, having the ammeter in series with it, (Fig. 2).

The plug key K_2 of the second circuit is closed and the rheostat in that circuit is adjusted so that the reading of the ammeter is 0.1 ampere. The length (l cm) of the potentiometer wire that balances the p.d. across the standard 1 ohm coil is determined. The experiment is repeated by adjusting the rheostat, so that the ammeter readings are successively 0.2, 0.3, ……., 1 ampere. The current flowing through the circuit is calculated in each case and the corrections to the readings of the ammeter determined.

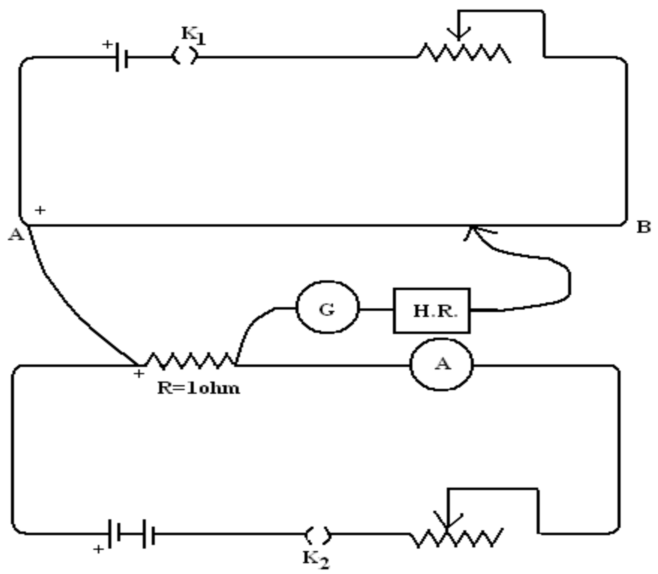


Fig. 2.

Theory:

If a current of I amp. flows through the standard resistance R,

the p.d. across R = IR …….(by Ohm's Law).

Since a length l cm. of the potentiometer balances this p.d.,

the p.d. across R is also = $\frac{1.08}{L} Xl.$

$\therefore \quad IR = \frac{1.08}{L} Xl.$

Since, in this case. R = 1 ohm,

$$I = \frac{1.08}{L} Xl \text{ amperes.}$$

Readings are tabulated as follows:-

Length of wire balancing the e.m.f. of the Daniel cell $\Big\} = L$ cm.

The p.d. per length of wire = $\frac{1.08}{L}$. Volt.

Ammeter reading	Length balancing the p.d. across the 1 ohm coil (*l* cm)	Calculated current $I = \frac{1.08}{L} Xl$ amperes.	Correction * (amp.)
0.1 amp. 0.2 " 0.3 " …… …… 0.9 " 1.0 "		0.09 amp.	- 0.01 amp.

- If the calculated value is less than the ammeter reading, the correction is negative; if greater than the ammeter reading, the correction is positive

Result:

The given ammeter is calibrated and the calibration graph is drawn.

Note:

For high range ammeter (0-5A), 2ohm rheostat and fractional resistance box R are connected in secondary circuit.

EXPERIMENT - 9

FIELD ALONG THE AXIS OF A CIRCULAR COIL

DETERMINATION OF B_H

Aim

To determine the horizontal component of earth's magnetic field, using current carrying circular coil and deflection magnetometer.

Apparatus

Circular coil apparatus, compass box, 6V power supply, ammeter, rheostat, commutator, plug key etc.

Description

A circular coil of adjustable turns N = 5, 10, 15 etc., is mounted vertically on a rigid horizontal base, resting on three leveling screws. The plane of the coil can be rotated about a vertical axis passing through the center. A wooden bench with scales on both sides of the coil is fixed at same horizontal level as that of the center of circular coil. The scales are graduated in centimeters such that zeros of both the scales coincide with the center of the coil. A deflection magnetometer with a pivoted magnetic needle and perpendicular aluminium pointer can be placed at any point along the length of the scale on either side of the circular coil. Refer fig. 1.

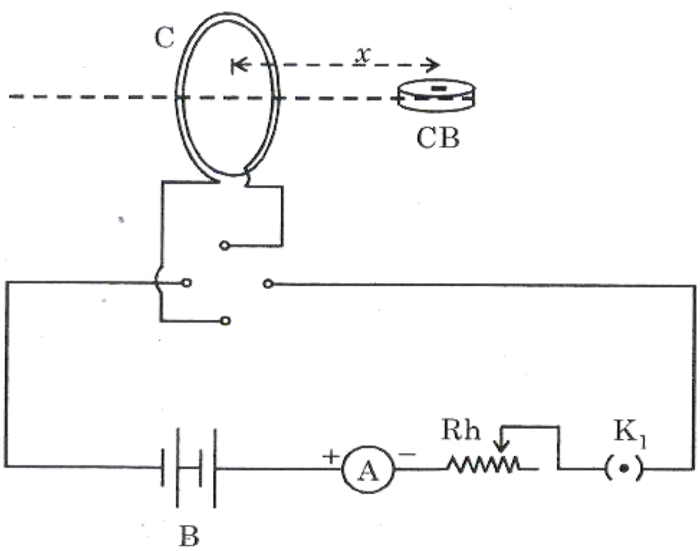


Fig. 1

Initial adjustments

(i) The base of circular coil is leveled horizontally using leveling screws. The plane of the coil should be vertical.

(ii) The plane of the coil is adjusted to be in the magnetic meridian. That is, the plane of the coil is parallel to the magnetic needle or the wooden bench with the scale is parallel to the aluminium pointer of the compass box.

(iii) The compass box along is rotated so that the aluminium pointer reads $0 – 0^o$.

Procedure

After the initial adjustments, the circular coil C of suitable turns (N=5 or 10) is connected to a 6V d.c. supply B through a commutator in series with an ammeter A and a rheostat (Rh) as shown in fig. 1. With commutator, the direction of current in the coil can be reversed.

The compass box, CB is moved from the center of the coil to a point at a distance x on one side of the coil. By adjusting rheostat, a suitable current (1A) is passed so that the deflection is in the range of 30^o to 60^o. The reading I of the ammeter is noted. The readings corresponding to the ends of the pointer are taken. By reversing the current using commutator, two more readings of the pointer are noted. Now the compass box is placed on other side of the coil at the same distance x. Four more readings of the aluminium pointer are taken as done on the other side of the coil. The experiment is repeated for different distances x, keeping the current same. Thus, for each position x, there are eight readings and the average deflection θ of the pointer is calculated. The whole experiment is repeated for another current I = 1.5 A. The readings are tabulated as given in Table 1. The radius a of the coil is found by measuring the inner and outer diameter of the coil and taking mean of them which is equal to 2a. The number of turns N of the coil is noted. Now using the formula, the horizontal component of Earth's magnetic field B_H can be determined.

Formula

The magnetic field F at a distance x from the centre of circular coil of radius a with number of turns N carrying a current I is given by

$$F = \frac{\mu_o N I a^2}{2(a^2 + x^2)^{3/2}}$$

If θ is the deflection in magnetometer, then from Tangent law,

$$F = B_H \tan\theta$$

Therefore, horizontal component of earth's magnetic field

$$B_H = \frac{\mu_o N I a^2}{2(a^2 + x^2)^{3/2}} \; \frac{1}{\tan\theta}$$

The unit is tesla, T

Table 1

Current I A	Distance x m	Deflection θ								Mean θ	Tan θ	B_H T
		Right				Left						
		1	2	3	4	5	6	7	8			

Mean B_H = T

Observations

Number of turns of the coil N =

Inner diameter of the coil d_1 = m

Outer diameter of the coil d_2 = m

Mean diameter d = $\frac{(d_1 + d_2)}{2}$ = m

Mean radius a = d/2 = m

Absolute permeability of vacuum $\mu_o = 4\pi \times 10^{-7} Hm^{-1}$

Horizontal component of earth's field B_H = T

Result

The horizontal component of earth's magnetic field B_H = T

EXPERIMENT - 10

VOLTAGE REGULATOR – ZENER DIODE

Aim

To draw the characteristics curves of zener diode.

Apparatus

A zener diode (BZ 148), d.c. supply unit (or a 12V battery), d.c. voltmeter (0-10V), milliammeter, rheostat, connecting wires, etc.

Circuit diagram

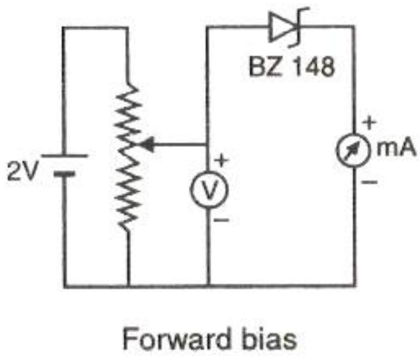


Fig. 1

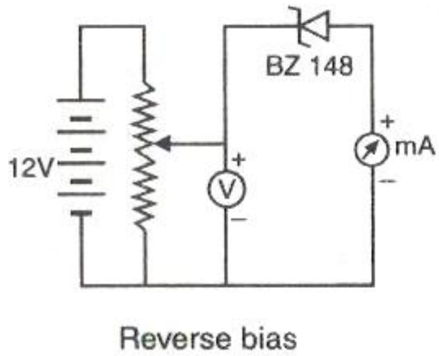


Fig. 2

Procedure

(i) Forward bias

The connections are made as shown in Fig. 1

Here the zener diode, with its anode connected to the positive of the battery, is said to be forward biased. The forward bias voltage is increased from 0V to 1V in steps of 0.1V. In each case, the milliammeter reading is noted. The readings are tabulated.

(ii) Reverse bias

The connections are made as shown in Fig. 2.

Here the zener diode, with its cathode connected to the positive of the battery, is said to be reverse biased. The reverse bias voltage is increased from 0V to 6V in steps of 0.4V. In each case, the milliammeter reading is noted. The readings are tabulated.

Graphs

A graph is drawn taking the voltage (V) along X-axis and the current (I) along the Y-axis. The graph is as shown in Fig. 3. Here V_Z represents the zener voltage (or) Breakdown voltage of the zener diode.

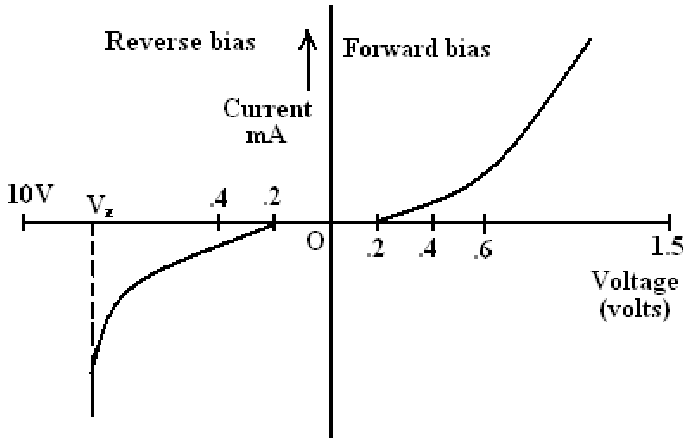


Fig. 15.3

Observations

Forward bias

Trial no.	Voltage V (volts)	Current I (mA)
1.	0	
2.	0.1	
3.	0.2	
-	-	
-	-	
-	-	
-	-	
-	1.0	

Reverse bias

Trial no.	Voltage V (volts)	Current I (mA)
1.	0	
2.	0.2	
3.	0.4	
4.	-	
5.	-	
-	-	
-	-	
-	6.0	

Result

The forward and reverse bias characteristics of a zener diode are drawn.

EXPERIMENT - 11

OR, AND, NOT GATES USING ICs

Aim

To verify the truth tables of logic gates such as AND, OR, NOT, NAND, NOR and EX-OR using ICs.

Apparatus

IC 7408, IC 7432, IC 7404, IC 7400, IC 7402 and IC 7486, 5V power supply digital trainer kit, etc.

Procedure

The pin configurations of all the ICs are given below. For all the ICs, 5 Volts must be given through the pin number 14 and pin number 7 must be connected to ground.

a) AND gate

IC 7408 consists of four 2-input AND gates. If the inputs are given to the pins 2 and 2, then the output of the AND gate is verified at pin 3. The symbol and the truth of AND gate is shown in Fig. 1.

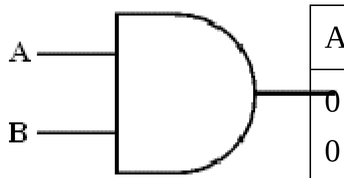
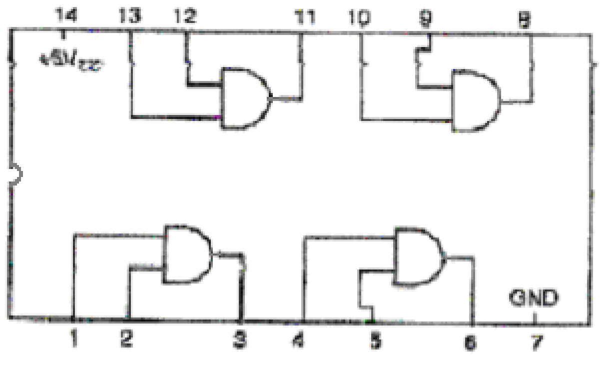


Fig. 1

A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1

Truth table of AND gate



7408 – 2 INPUT AND

b) OR gate

IC 7432 has four 2-input OR gates. The output of the OR gate is verified at pin 3 if the inputs are given to the pins 1 and 2. The symbol and the truth table of OR gate is given in Fig. 2.

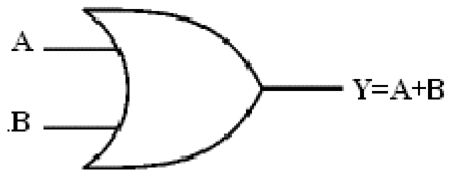
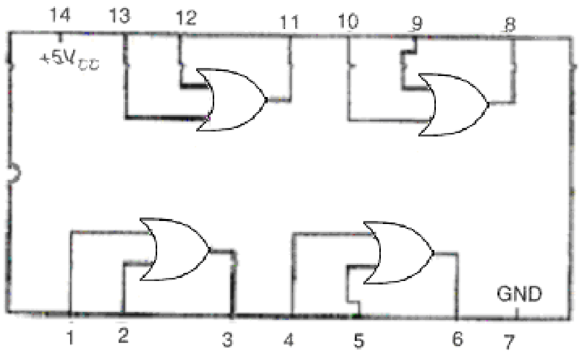


Fig. 2

A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

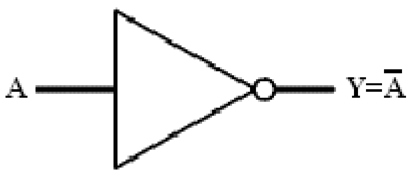
Truth table of OR gate



7432 – 2 Input OR

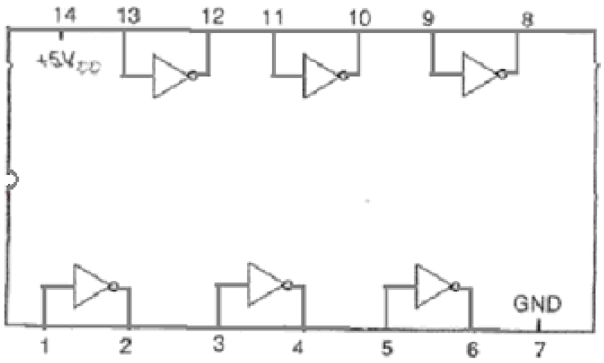
c) NOT gate

IC 7404 consists of six NOT gates. If the input is given at pin 1, then the output of the NOT gate is verified at pin 2. The symbol and the truth table of NOT gate is given in Fig. 3.



A	Y=$\bar{A}$
0	1
1	0

Fig. 3. **Truth table of NOT gate**



7404 – NOT gate

d) NAND gate

IC 7400 has four 2-input NAND gates. The input may be given to the pins 1 and 2. The output is taken from the pin 3. The symbol and the truth table of NAND gate is given in Fig. 4.

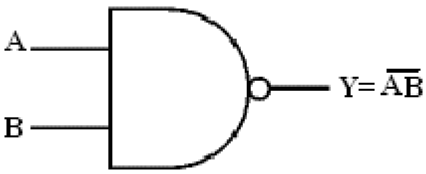
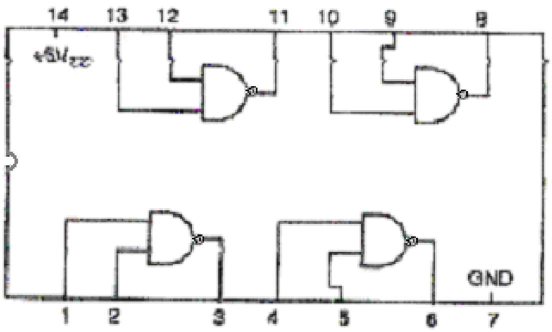


Fig. 4.

Truth table of NAND gate

A	B	$Y=\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0



7400- 2 Input NAND gate

e) NOR gate

IC 7402 consists of four 2-input NOR gates. The inputs may be given to the pins 2 and 3 and the output is taken from the pin 1. The symbol and the truth table of NOR gate is given in Fig. 5.

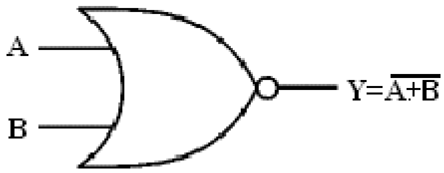
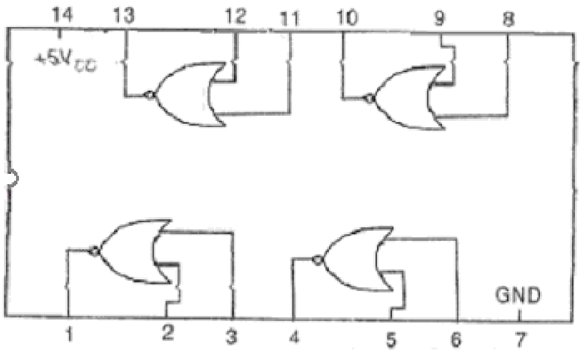


Fig. 5.

A	B	Y=$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

Truth table of NOR gate



7402- 2 Input NOR gate

f) Ex-OR gate

IC 7486 has four 2-input Ex-OR gates. The inputs are given to the pins 1 and 2 and the output is taken from the pin 3. The symbol and the truth table of Ex-OR gate is shown in Fig. 6.

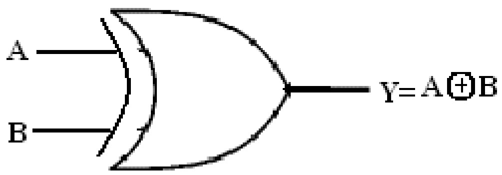
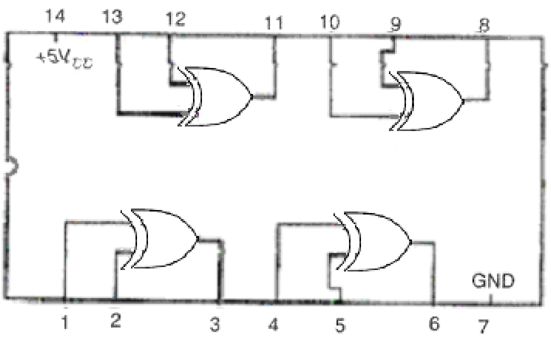


Fig. 6.

A	B	Y=A⊕B
0	0	0
0	1	1
1	0	1
1	1	0

Truth table of Ex-OR gate



7486 – 2 input EX-OR

Note

Each IC has four gates (except 7400 – NOT which has 6 gates) and any can be used for checking the truth table. Also, the pin configuration for NOR gate is different from other gates.

Result

The truth tables of AND, OR, NOT, NAND, NOR and Ex-OR gates are verified using ICs.

EXPERIMENT - 12

NAND / NOR AS UNIVERSAL BUILDING BLOCKS

Aim

To prove that NAND gate is a universal gate.

Apparatus

IC 7400 chip, bread board, 5 V supply, voltmeter etc.

Procedure

A NAND gate is known as a universal gate because it can be used to realize all the basic logic functions of an OR gate, AND gate and NOT gate.

The IC 7400 has four 2-input NAND gates in it.

The IC 7400 chip has a 14 pin configuration.

The pin configuration of IC 7400 is given below:

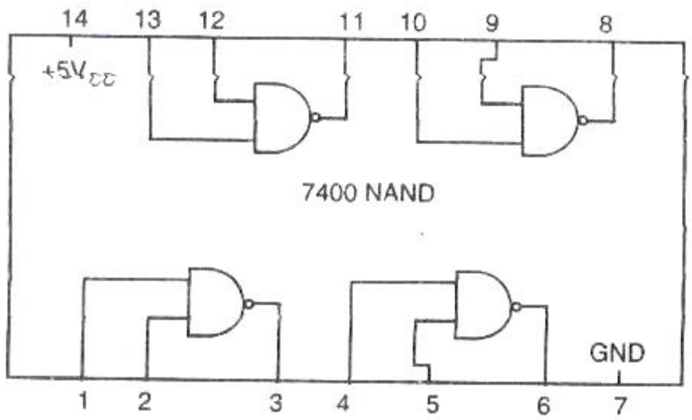


Fig. 1

The IC 7400 is fixed to the bread board.

The IC chip IC 7400 should be energized by connecting the 5V supply to terminals 7 and 14. Connect the circuit as per the circuit diagram.

Switch on the input according to the truth table condition. 0 refers to 0 volt; 1 refers to +5 volt.

Verify the output and compare it with the Truth result.

(i) NOT gate:

Using a NAND gate with input terminals 1 and 2 and output terminal 3, connections are made. Terminals 1 and 2 are shorted and used as a single input terminal. The output is measured at 3.

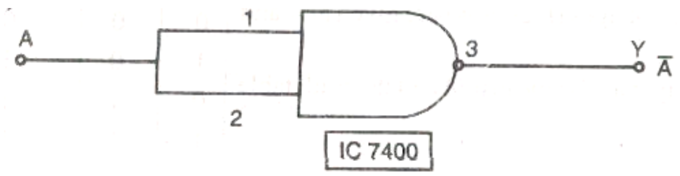


Fig. 2.

When A is high, Y is low.

When A is low, Y is high.

Truth table

Input A	Output Y
1 0	0 1

(ii) AND gate:

Two NAND gates in the IC 7400 chip are connected as shown. Applying proper voltages at 1 and 2, output is measured at 6. The truth-table of the AND gate is verified.

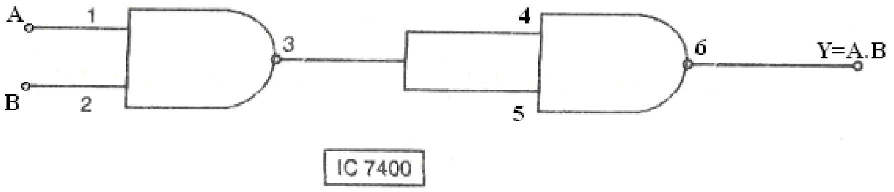


Fig. 3

Truth table

A	B	Y = A+B
0	0	0 (low level)
1	0	0 (low level)
0	1	0 (low level)
1	1	1(high level)

(iii) OR gate:

Three of the NAND gates in IC 7400 chip are connected as shown.

The numbers in the Fig. 4 represent the terminals of the chip to be used. After energizing the chip, proper voltages (high/low) are given at A and B.

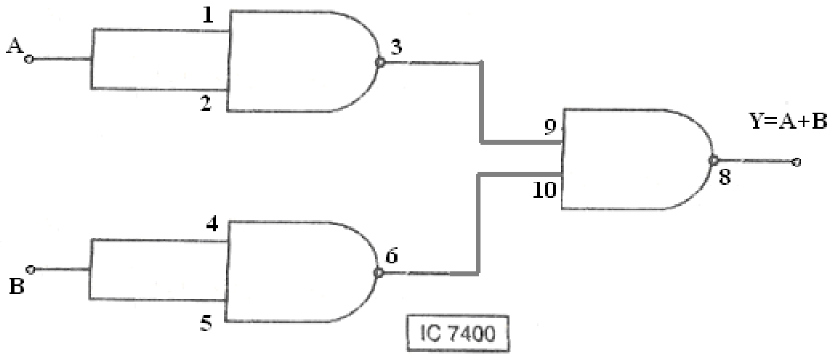


Fig. 4

The output at Y is measured and the truth table is verified.

Truth table

A	B	Y = A+B
0	0	0
1	0	1
0	1	1
1	1	1

Result

By realising the logic functions AND, OR and NOT, it is proved that NAND gate is a universal gate.

Questions

1. Measure the central depression produced in the given bar for various loads using scale and telescope. Draw the load-depression graph. From the graph determine the Young's modulus of the material of the bar. Take readings for two different lengths between the knife edges.
2. Using optic lever measure the elevation at the centre of a bar subjected to uniform bending. Draw the load-elevation graph and hence determine the Young's modulus of the material of the bar. Take readings for two different lengths between the knife edges.
3. Determine the rigidity modulus of the wire and the M.I. of the disc by torsional oscillations method.
4. Determine the frequency of AC mains using Sonometer.

5. Determine the horizontal component of earth’s magnetic field using current carrying circular coil and deflection magnetometer.
6. Calibrate the given ammeter using potentiometer. Draw the calibration graph.
7. Use the optic lever to measure the elevation at the centre of the given bar subjected to uniform bending. Verify the relation between the load and the central elevation. Draw the load elevation graph and use it to determine the Young’s modulus of the material of the bar. Take readings for the two different lengths between the knife-edges.
8. With a torsion pendulum find the relation between l and T^2 for each of the two wires of the same material but of different radii. Compare their radii.
9. With a torsion pendulum find the relation between l and T^2 for each of two wires of the same radii but different materials. Compare their rigidity modulii.
10. Prove that NAND gate is a universal gate.
11. Prove that NOR gate is a universal gate.
12. Verify the truth tables of logic gates such as AND, OR, NOT, NAND, NOR and EX-OR using ICs.
13. Draw the characteristics curves of zener diode.
14. Determine radii of curvature of a double convex lens by forming Newton’s rings and to calculate Refractive index of the material of the lens.
15. Determine thermal conductivity of a bad conductor using Lee’s disc.

APPENDIX – A

DATA OF PHYSICAL CONSTANTS

1) Density of solids **(Kgm^{-3})**

Aluminium – 2700	Glass (crown) – 2600
Brass - 8600	Glass (Flint) - 4000
Copper - 8930	Steel - 7800

2) Density of liquids **(Kgm^{-3})**

Castor oil - 970	Kerosene - 800
Coconut oil – 910	Mercury - 13596
Glycerine - 1260	Water - 1000

3) Elastic constants

a) Young's modulus (X 10^{10} Nm^{-2})

Aluminium – 6.9 – 7.2	Glass – 6.0
Brass - 9.8	Steel – 20.0
Copper - 11.7	Wood - 0.8-1.9

b) Rigidity modulus (X 10^{10} Nm^{-2})

Aluminium – 2.5	Glass – 2.6
Brass - 3.45	Iron (cast) – 10 - 13
Copper - 4.0	Steel - 7.6

c) Poisson's ratio

Aluminium – 0.34	Glass – 0.15
Brass - 0.35	Iron (cast) – 0.28
Copper - 0.3	Steel - 0.28

4) Surface tension (at room temperature 30^{o}C) (Nm^{-1})

Substance	**Surface tension Nm^{-1}**	**Angle of contact with glass**
Kerosene	0.030	-
Mercury	0.470	137^o – 20^o
Soap solution	0.02 – 0.04	-
Water	0.072	8^o – 9^o

5) **Coefficient of viscosity (at 30°C) ($Ns\ m^{-2}$)**

Castor oil	- 0.986	Kerosene	- 0.002
Coconut oil	- 0.0154	Mercury	- 0.0015
Glycerine	- 0.3094	Water	- 0.0008

6) **Velocity of sound (at 0°C) (ms^{-1})**

Air – 331.3 Brass – 3500 Copper – 3800

7) **Specific heat capacity ($JKg^{-1}\ K^{-1}$)**

Aluminium	– 913	Coconut oil	- 2000
Copper	- 385	Kerosene	- 2100
Glass	- 670	Water	- 418

8) **Latent heat capacity (JKg^{-1})**

Latent heat of fusion of ice – 33 X 10^4

Latent heat of vaporization of steam – 226 X 10^4

9) **Thermal conductivity ($Wm^{-1}K^{-1}$)**

Aluminium	– 201	Brass	- 110
Copper	- 385	Card board	- 0.04
Glass	- 1.00	Rubber	- 0.15

10) **Wavelengths:**

a) **Mercury spectrum - nm – (10^{-9}m)**

Violet I	- 404.4	Green	- 546.1
Violet II	- 407.8	Yellow I	- 576.9
Blue	- 435.8	Yellow II	- 579.1
Blue Green	- 491.6	Red	- 623.4

b) **Sodium yellow light – nm – (10^{-9}m)**

D_1 Line	- 589.0	D_2 Line	- 589.6

c) **Hydrogen Spectrum – nm - (10^{-9}m)**

H_α (Red)	- 656.27	H_γ (Blue)	- 435.8
H_β (Blue Green)	– 486.13	H_δ (Violet)	- 410.17

11) **Refractive Index:**

Crown glass	- 1.5	Water	- 1.333
Flint glass	- 1.56	Glycerine	- 1.473

12) **Specific resistance - $\mu\Omega m$ (10^{-6} μm)**

Aluminium	- 0.0265	Constantan	- 0.4900
Brass	- 0.0680	Manganin	- 0.4400
Copper	- 0.0170	Steel	- 0.15

13) **Temperature coefficient of resistance - (per degree Celsius)**

Aluminium	- 0.0043	Copper	- 0.0039
Brass	- 0.001 – 0.002	Steel	- 0.0050

14) **Fundamental constants**

Speed of light in vacuum	c-2.998 $\times 10^{8}$ ms^{-1}
Absolute permeability of vacuum	μ_o - 4π $\times 10^{-7}$ Hm^{-1}
Absolute permittivity of vacuum	ε_o - 8.854 $\times 10^{12}$ Fm^{-1}
Planck's constant	h – 6.626 $\times 10^{-34}$ Js
Stefan's constant	σ - 5.6697 $\times 10^{-8}$ Wm^{-2} K^{-4}
Electron charge	e – 1.602 $\times 10^{-19}$ C
Electron mass (rest)	m_e – 9.109 $\times 10^{-31}$ Kg
Sun – Earth distance (Astronomical unit)	D_{SE} – 1.496 $\times 10^{11}$ m
Radius of the sun -	R_s – 6.96 $\times 10^{8}$ m

Some Useful Data

$\sqrt{2}$ = 1.414

$\sqrt{3}$ = 1.732

e = 2.71828

π radians = 180^o

π^2 = 9.86960

1 sec = 1/86,400 of mean solar day

1 inch = 2.54 cm

1 micron (μ) = 10^{-6} m

1 Angstron (Å) = 10^{-10} m

1 cc = 0.999972 ml

1 Joule = 10^{7} ergs

1 Joule/second = 1 watt

1 H.P. = 746 watts

1 Newton = 10^{5} dyne

1 Bar = 10^6 dynes/sq.cm

1 atm = 1.01325 Bar

Length of second's pendulum = g/π^2 = 99.357 cm

1 eV = 1.60 X 10^{-19} J

$$\frac{1}{4\pi\varepsilon_0} = 8.988 X 10^9 Nm^2C^{-2}$$

$$\frac{\mu_0}{4\pi} = 10^{-7} Wb/A-m$$

1 Tesla = 10^4 Guass

$\log_e N = 2.303 \ X \log_{10} N$

Fundamental Physical constants

Acceleration due to gravity	g = 9.807 m/s^2
Avagadro's number	N = 6.023 × 10^{23} molecules/mole
Boltzmann's constant	k = R/N = 1.38 × 10^{-23} J/K
Electric permittivity of free space	ε_0 = 8.854 × 10^{-12} C^2 N^{-1} m^{-2}
Electron charge	e = 1.602 × 10^{-19} C
Electron charge mass ratio	e/m =1.759 × 10^{11} C/kg
Faraday's constant	F = Ne = 9.648 × 10^4 C/mole
Gravitational constant	G = 6.672 × 10^{-11} N.m^2/kg^2
Magnetic permeability	μ_0 = 4π × 10^{-7} Wb/A.m.
Mechanical equivalent of heat	J = 4.1852 J/Cal
Planck's constant	h = 6.622 × 10^{-34} J.s
Rest mass of electron	m_e = 9.11 × 10^{-31} kg
Rest mass of neutron	m_n = 1.675 × 10^{-27} kg
Rest mass of proton	m_p = 1.673 × 10^{-27} kg
Rydberg constant	R_α = 10,973,731 m^{-1}
Solar constant	S = 1370 W/m^2

Stefan's constant	$\sigma = 5.67 \times 10^{-8}$ Wm^{-2} K^{-4}
Universal gas constant	R = 8.31 J/mole/K
Velocity of light in vacuum	$c = 2.998 \times 10^{8}$ m/s $\approx 3 \times 10^{8}$ m/s
Volume of one mole of ideal gas at NTP	$V = 22.414 \times 10^{-3}$ m^3/mole
Wien's constant	b = 0.002898 m.K

Relation between Practical Units and Electromagnetic Units (e.m.u.)

Electrical Quantity	Unit	Number of c.g.s.e.m.u. in one practical unit
Charge	Coulomb	10^{-1}
Current	Ampere	10^{-1}
Pot. Difference	Volt	10^{8}
Resistance	Ohm	10^{9}
Inductance	Henry	10^{9}
Capacitance	Farad	10^{-9}

Colour coding in carbon resistors

Colour	Numerical meaning 1st and 2nd figures	Multiplying factor	Percent tolerance
Black	0	1 or 10^{o}	
Brown	1	10^{1}	
Red	2	10^{2}	
Orange	3	10^{3}	
Yellow	4	10^{4}	
Green	5	10^{5}	
Blue	6	10^{6}	
Violet	7	10^{7}	

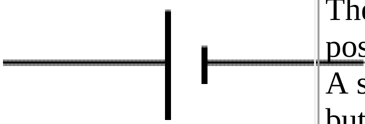
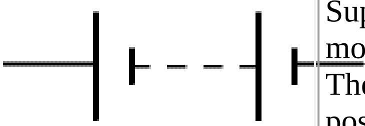
Gray	8	10^8	
White	9	10^9	
Gold	-	0.1 or 10^{-1}	
Silver	-	0.01 or 10^{-2}	
No colour	-	-	
			±5%
			±10%
			±20%

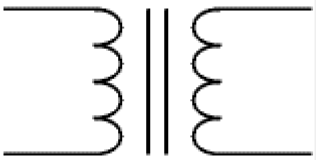
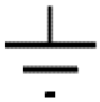
To remember the value of carbon resistors through colour code, the following sentence is found to be of great help.

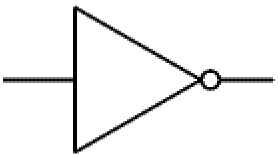
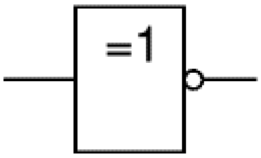
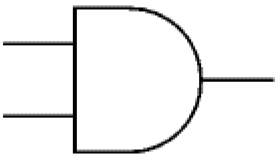
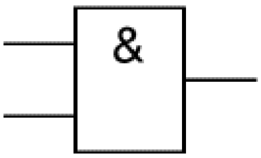
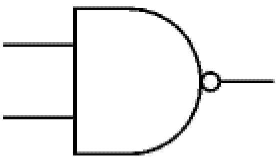
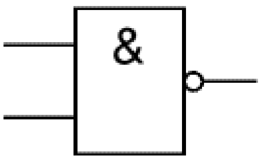
BB ROY Great Britain Very Good Wife

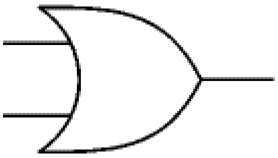
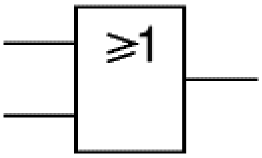
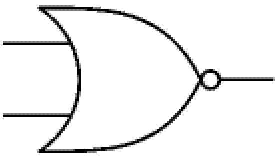
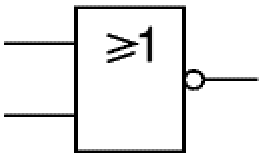
Example:

In a resistor if the first strip is yellow, second strip is red, third is orange and fourth is gold, then the value of the resistance is 42 X 10^3 Ω ±5%.

Power Supplies		
Component	**Circuit Symbol**	**Function of Component**
Cell		Supplies electrical energy. The larger terminal (on the left) is positive (+). A single cell is often called a battery, but strictly a battery is two or more cells joined together.
Battery		Supplies electrical energy. A battery is more than one cell. The larger terminal (on the left) is positive (+).
DC supply		Supplies electrical energy. DC = Direct Current, always flowing in one direction.
AC supply		Supplies electrical energy. AC = Alternating Current, continually

		changing direction.
Transformer		Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field in the core. There is no electrical connection between the coils.
Earth (Ground)		A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.

Traditional Symbol	**IEC Symbol**	**Function of Gate**
		A NOT gate can only have one input. The 'o' on the output means 'not'. The output of a NOT gate is the inverse (opposite) of its input, so the output is true when the input is false. A NOT gate is also called an inverter.
		An AND gate can have two or more inputs. The output of an AND gate is true when all its inputs are true.
		A NAND gate can have two or more inputs. The 'o' on the output means 'not' showing that it is a Not AND gate. The output of a NAND gate is true unless all its inputs are true.

		An OR gate can have two or more inputs. The output of an OR gate is true when at least one of its inputs is true.
		A NOR gate can have two or more inputs. The 'o' on the output means 'not' showing that it is a Not OR gate. The output of a NOR gate is true when none of its inputs are true.

Books for study and reference

1. Practical physics Ouseph Ranga Rajan
2. Practical physics Sultan Chand & Sons
3. Practical physics and Electronics C.C. Ouseph U.J. Rao V. Vijayendran