PG & RESEARCH DEPARTMENT OF PHYSICS

SEETHALAKSHMI RAMASWAMI COLLEGE (Autonomous)
(Affiliated to Bharathidasan University)
Accredited with "A" Grade by NAAC
TIRUCHIRAPPALLI – 620 002

CERTIFIED BONAFIDE RECORD OF

Name ___________________________________

Class ___________________________________

Register Number ______________________________

Staff Incharge

Submitted for the B. Sc degree Practical Examination of SEETHALAKSHMI RAMASWAMI COLLEGE (Autonomous), Tiruchirappalli – 620 002 on ____________.

EXAMINER

CONTENTS

1. YOUNG'S MODULUS – NON-UNIFORM BENDING

Aim:

To determine the Young's modulus of the material of a uniform bar of non-uniform bending.

Apparatus required:

A long rectangular bar, two knife-edge supports, pin & microscope, weight hanger and slotted weights.

Formula:

Young's modulus $\mathbf{E} = \frac{Mgl^3}{4bd^3 s} \quad N/m^2$

Where

S - mean depression for M (kg)

g - acceleration due to gravity (m/s)

l - length of the bar between the knife-edges (m)

b - mean breadth of the bar (m)

d - mean thickness of the bar (m)

Description:

The given rectangular bar is supported symmetrically on the two knife-edges in the same horizontal level. A weight hanger is suspended from a point on the bar midway between the knife-edges. A pin is fixed vertically at the mid point of the bar by means of some wax. A Vernier microscope, placed in front of the pin, is adjusted such that the tip of the pin coincides with the horizontal cross-wire.

Procedure:

The weight of the hanger is taken as the dead load 'w'. The experimental bar is brought to elastic mode by loading and unloading it a number of times with slotted weights. With the dead load 'w' suspended from the mid-point, the microscope is adjusted such that the horizontal cross-wire coincides with the image of the tip of the pin. Now the reading of the vertical scale is taken. The experiment is repeated by adding weights in steps of say 0.05 kg up to 0.40 kg.

Every time the microscope is adjusted and the vertical scale reading are taken. Then the load is decreased, in the same steps and the readings are taken. From the readings, the mean depression of the mid-point for a give load can be found. The length of the bar between the knife-edges is measured as ‘L’ metre. The bar is removed and its mean breadth ‘b’ is determined with a Vernier calipers and its mean thickness ‘d’ with a screw gauge.

To determine the thickness of the bar using Screw gauge (d):

LC = 0.01 mm **Z. E =** **Z.C =**

S. No	P.S.R mm	H.S.C. div	O. R= (P. S. R+ {H.S.C× LC}) mm	C.R = (O. R+Z. C) mm
1.				
2.				
3.				
4.				
5.				
			Average	

To determine the breadth of the bar using Vernier caliper (b):

L.C = 0 .01 cm **Z.E = Nil**

S. No	M.S.R cm	V.S.C. div	O. R= (M. S. R+ V.S.C× LC) cm	C.R = O.R cm
1.				
2.				
3.				
4.				
5.				
			Average	

To measure the depression of the bar (S):

Least Count = 0.001 cm

Load in gm	Microscope Reading in cm						Mean cm	Depression for M Kg in cm
	Loading			Unloading				
	MSR cm	VSC div	CR = (MSR +VSC X LC) cm	MSR cm	VSC div	CR = (MSR +VSC X LC) cm		
W								
W+50								
W+100								
W+150								
W+200								
W+250								
W+300								
W+350								
W+400								

Mean(S)=

Observations:

Mean depression for M kgs	S	=	m
Mean breadth of the bar	b	=	m
Mean thickness of the bar	d	=	m
Length of the bar between the knife-edges	**L**	=	m

Calculation:

Young's modulus $\mathbf{E} = \frac{\mathbf{MgL^3}}{\mathbf{4bd^3s}} \quad \mathbf{N/m^2}$

Result:

Young’s modulus of the material of the given bar E = N/m^2

2. RIGIDITY MODULUS OF A WIRE-TORSION PENDULUM

Aim:

To determine the rigidity modulus of a thin wire by the method of torsional oscillations.

Apparatus required:

Torsion pendulum, a pointer, a stop-clock, a screw gauge etc.

Formula:

The rigidity modulus of a thin wire $\eta = \frac{8 \Pi I L}{T^2 a^4}$ N/m²

$$I = \frac{MR^2}{2} \quad Kg\,m^2$$

Where

I - moment of inertia of the disc (Kg m^2)
M - mass of the disc (Kg)
R - radius of the disc (m)
L - length of the wire between the center of the disc and tied end (m)
T - time period of oscillations (sec)
a - radius of the wire (m)

Description:

The torsion pendulum consists of a circular disc symmetrically suspended by a long wire (whose rigidity modulus is required), from a rigid support.

Procedure:

The disc is turned slightly about the axis of the wire and released so that the system executes torsional oscillations about a vertical axis. The pointer is suitably arranged and the time for 10 oscillations is found. Hence the period T is calculated. The experiment is repeated for four or five different lengths of the wire and the corresponding periods of oscillations are noted. The radius of the wire is accurately found at various points along its length.

To calculate L / T^2:

S.No	Length of the wire 'L' (m)	Time taken for 10 oscillations (s)			Period T (S)	L / T^2 m/s^2
		Trial I (S)	Trial II (S)	Mean (S)		
1.						
2.						
3.						
4.						
5.						

Average =

To determine the thickness of the wire using Screw gauge (d):
LC = 0.01 mm Z. E = Z.C =

S. No	P.S.R mm	H.S.C. div	O. R= (P. S. R+ {H.S.C× LC}) mm	C.R = (O. R±Z. C) mm
1.				
2.				
3.				
4.				
5.				
			Average 'd'	

Radius of the wire (a) = Average d/2 =

Observations:

Circumference $2\pi R$ = cm

Radius of the disc 'R' = m.
Mass of the disc 'M' = Kg.
Thickness of the wire 'd' = m
Radius of the wire 'a' = m
Mean L/T^2 = m/sec^2

Calculation:

The rigidity modulus of a thin wire $\eta = \frac{8\Pi I L}{T^2 a^4}$; $I = \frac{MR^2}{2}$

Result:

Rigidity modulus of the material of the given wire = $\qquad$ N/m^2

3. RIGIDITY MODULUS – STATIC TORSION

Aim:

To determine the rigidity modulus of the material of the given cylindrical rod.

Apparatus required:

Searle's static torsion apparatus, weight hanger, slotted weights, mirror, scale and telescope.

Formula:

Rigidity modulus of the material of the given rod

$$G = \frac{4MgLRD}{\pi r^4 S} \quad N/m^2$$

Where

S - mean depression for M kg (m)

g - acceleration due to gravity (m/sec)

R - radius of the disc (m)

r - radius of the rod (m)

L - length of the bar between the knife-edges (m)

D - distance of the mirror from the scale (m)

Description:

The cylindrical rod is rigidly clamped at one end and attached to the center of a wheel at the other end. There is groove running along the edge of the wheel. A tape passing over the groove of the wheel has one end attached to the rim and it carries a weight hanger. A strip of plane mirror is fixed, almost vertically on the rod away from the fixed end and nearer to the wheel. A scale and telescope is arranged in front of the mirror at a distance of 1 metre. The telescope is focused at the reflected image of the scale into the plane mirror.

Procedure:

The weight hanger of weight W kg (dead load) is attached to the free end of the tape. The rod is put in the elastic mood by loading and unloading a number of times in the clock-wise as well as anti clockwise directions. After this, with the weight hanger alone suspended from the free end of the tape, the reading of the scale division coinciding with the horizontal cross-wire is noted. Suitable weights m, 2m, 3m, 4m, 7m may be added to and then removed from the weight hanger, each time taking the reading through the telescope. The experiment is done for clockwise and anti-clockwise twisting of the rod. The readings are tabulated and the mean shift in the telescope reading due to the addition of load M (=2m) on the weight hanger is determined.

To measure the depression S (m):

Load in gms.	Telescope reading in cm.						$\frac{(A \sim B)}{2}$ cm	Change in Reading for M gm (s) cm
	Clockwise			Anticlockwise				
	Loading	Unloading	Mean A	Loading	Unloading	Mean B		
W								
W+50								
W+100								
W+150								
W+200								
W+250								
W+300								
W+350								
W+400								

Average(S) = m

To determine the radius of the rod using Screw gauge (d):

LC = 0.01 mm **Z. E =** **Z.C =**

S. No	P.S.R mm	H.S.C. div	O. R= (P. S. R+ {H.S.C× LC}) mm	C.R = (O. R±Z. C) mm
1.				
2.				
3.				
4.				
5.				
			Average 'd'	

Radius of the rod ' r'= **d/2=**

Observations:

Length of the rod from the fixed end to the mirror L = m.

Mean radius of the rod r = m.

Circumference of the wheel $2\pi R$ = m.

Radius of the wheel R = m

Distance of the mirror from the scale D = m.

Mean shift S = m

Calculation:

Rigidity modulus of the material of the given rod

$$G = \frac{4MgRLD}{\pi r^4 s} \ N/m^2$$

Result:

The rigidity modulus of the material of the given rod = N/m^2

4. JUNCTION DIODE - CHARACTERISTICS

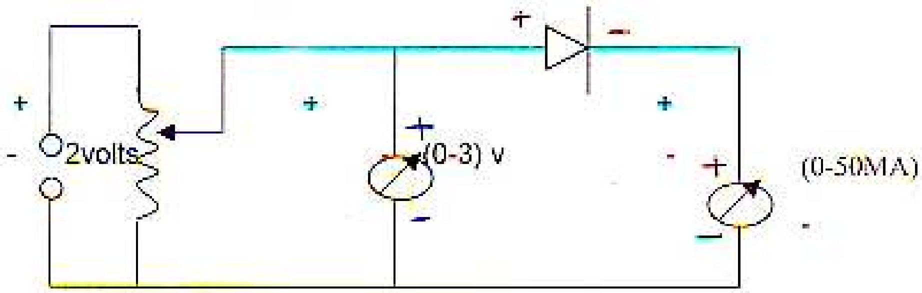
Aim:

To study the variation of current through a junction diode with applied voltage when it is (a) forward biased (b) reverse biased.

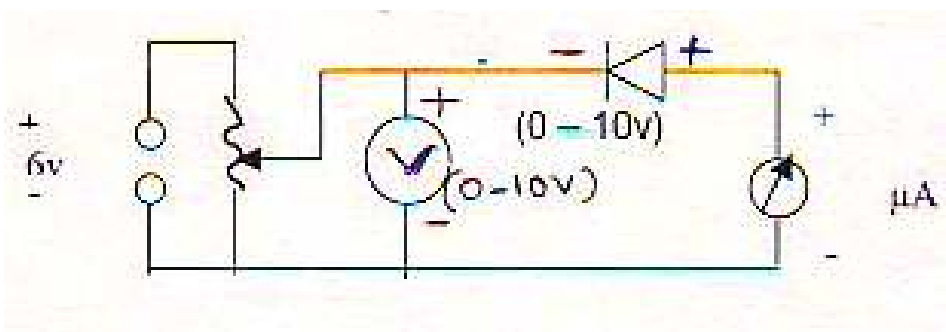
Equipments & Components required:

A Junction diode like OA79 (or) BY126, 10 volts D.C. power supply (or) 6V Battery, Voltmeter, Milliammeter, Micro ammeter, Commutator, Rheostat, Plug key etc.

Forward Bias:



Reverse Bias:



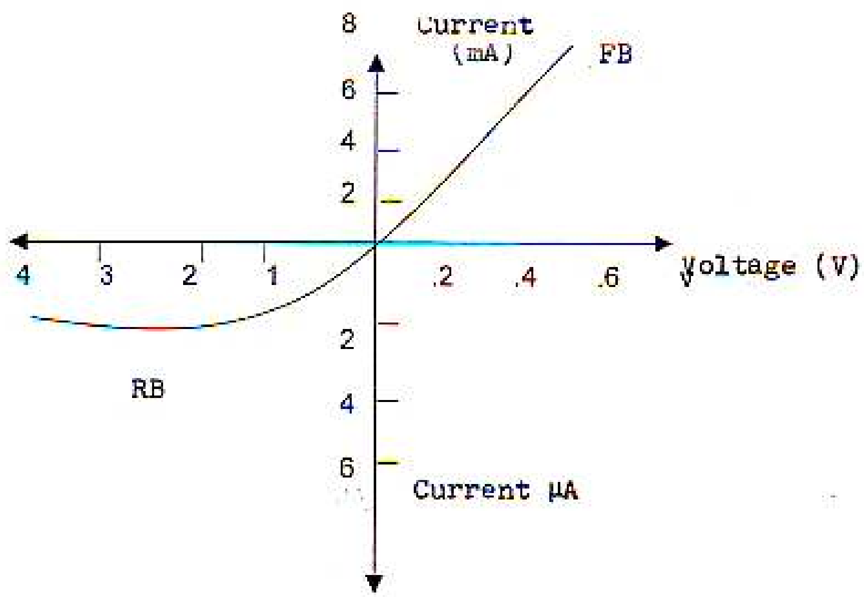
Procedure:

The connections are made as per the circuit for the forward bias mode. The current through the diode is shown by the millimeter. The applied input voltage is set to 1 V. The rheostat is adjusted such that voltmeter reads 0.1V. The millimeter reading is noted. The applied voltage is increased in the steps of 0.1 V and in each case millimeter reading is noted.

For the reverse bias the connections are made as shown in the figure. The input voltage is set to 6 V. The rheostat is adjusted for 1V, 2V, 3V….. and in each case micro ammeter reading is noted.

A graph is drawn with voltmeter reading X-axis and milli ammeter reading in positive side and micro ammeter reading in negative side of X-axis. This gives the characteristic curve of the diode.

Model graph:



Observations:

Forward Bias

Voltage applied (Volt)	Current through Diode (mA)
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	

Reverse Bias

Voltage applied (Volt)	Current through Diode (μA)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Result:

When the diode is forward biased the current through it increases by large amount as applied voltage is increased. When it is reverse biased the Current attains a saturation value quickly. Thus, the characteristics of junction diode is studied and its curve is drawn.

5. ZENER DIODE - CHARACTERISTICS

Aim:

To study the variation of current through a zener diode with applied voltage when it is (i) forward biased (ii) reverse biased.

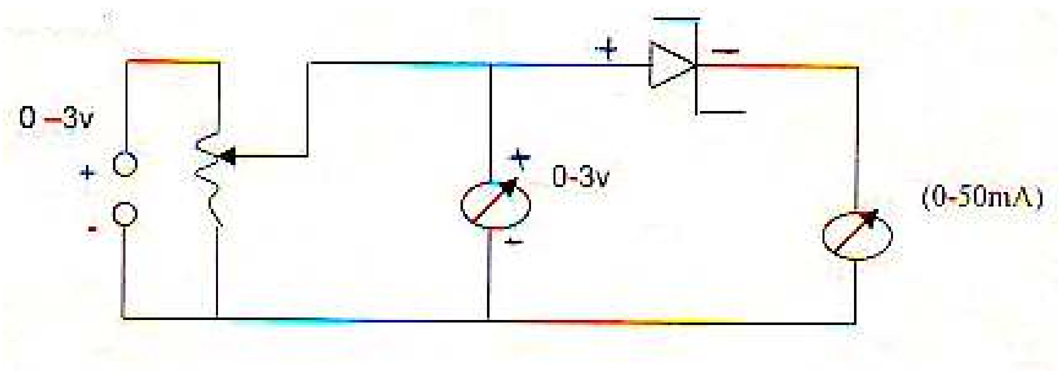
Equipments & Components required:

A zener diode (FZ 9.1 (or) RZ 6.1 or BZ 148) transistor power pack, rheostat, milliammeter, microammeter, DC Voltmeters, etc.

Procedure:

i) Forward Bias:

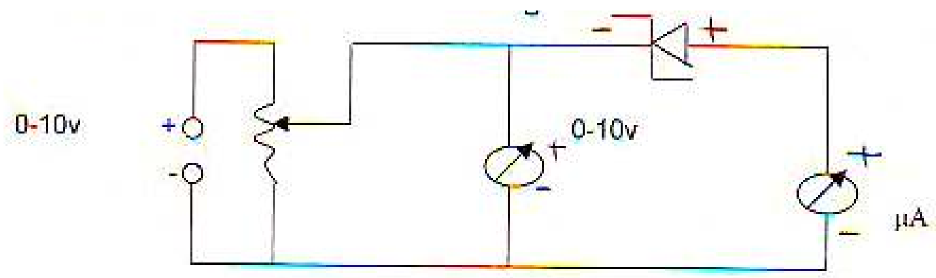
The zener diode is connected with a milliammeter and potential divider arrangement such that it is in forward bias as shown in figure. The power supply is switched on and the input voltage is set to 1 V. The rheostat is adjusted so that the voltmeter reads 0.1 volts. The milliammeter reading is noted. The applied voltage is increased in steps of 0.1 volt and milliammeter reading is noted every time.



ii) Reverse Bias

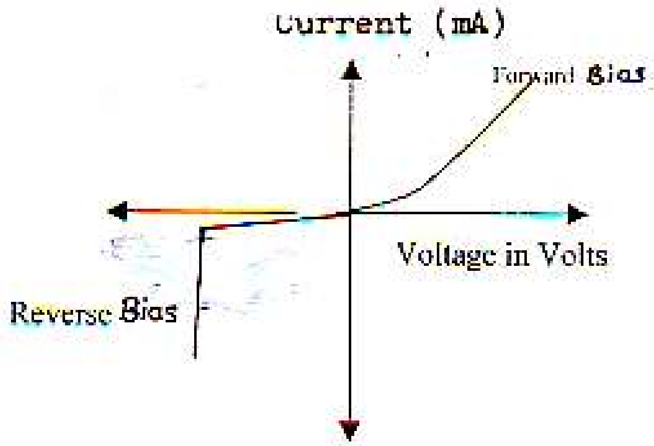
The terminal connections of the zener diode are interchanged. The milliammeter is replaced by a microammeter. Now, the zener diode is in reverse bias condition. The input voltage is set to 9 V. The rheostat is adjusted such that the voltmeter reads 1 volt. The microammeter reading is noted. The applied voltage is increased in the steps of 1 volt and every time the microammeter is noted.

It is seen that in reverse bias conditions the current through the zener diode increase steadily with the applied voltage up to a particular voltage and beyond that the current suddenly increases at a constant voltage.



A graph is drawn taking voltage in X –axis and current in Y – axis (mA in +Y & µA in –Y). The curves will be as in figure.(2) This is called the characteristic curve of zener diode.

Model Graph:



Observations:

Forward Bias

Voltage applied (Volt)	Current through Diode(mA)
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	

Reverse Bias

Voltage applied (Volt)	Current through Diode (μA)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Result:

1. The characteristic curves for the given Zener diode are drawn.
2. Break down voltage for the given Zener =   V

6. BASIC LOGIC GATES

Aim:

To study the function of logic gates AND, OR, NOT, NAND and NOR using IC chips (7408, 7432, 7404, 7400 and 7402 respectively) and verify their truth tables.

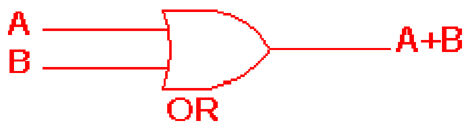
Components Required:

IC 7432,7408,7404,7400,7402 chips, power supply, voltmeter.

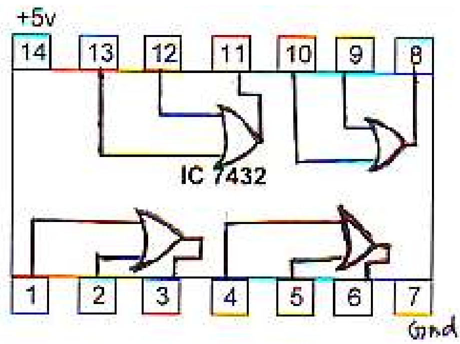
Procedure:

OR GATE:

Logic Symbol:



Pin Diagram:



Truth Table

A	B	Output Y
0	0	0
0	1	1
1	0	1
1	1	1

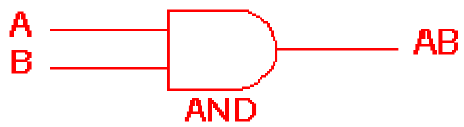
Actual Voltage

A(v)	B(v)	Output Y(v)

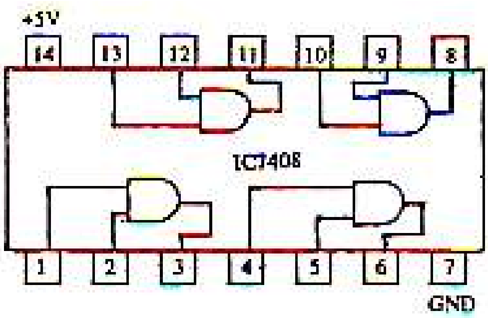
The IC chip 7432 is fixed on the bread board. The negative of the power supply is connected to pin'7' and the positive is connected to pin 14 and is kept at 5 volts. We can construct 4 OR gates with one IC chip. For the first OR gate 1,2 are inputs and 3 will be the output. The input levels are kept at (0,0) (0,1) (1,0) and (1,1) levels and the corresponding output voltage is measured and the truth table is verified. The output is (A+B) OR function. We can verify the output voltage with other OR gates also.

AND GATE:

Logic Symbol:



Pin diagram:



The IC chip 7408 is fixed on the bread board. The pin 7 connected to –ve and the 14 is connected to +ve of the powers supply which is kept at 5v. Here also we can construct 4 AND gate 4s with the same IC. The input levels are kept at (0,0) (0,1) (1,0) and (1,1). The corresponding outputs are measured and they are found to be A.B and the truth tables are verified.

Truth Table

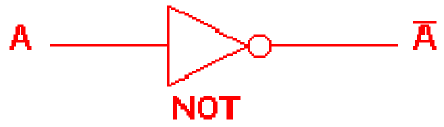
A	B	Output Y
0	0	0
0	1	0
1	0	0
1	1	1

Actual Voltage

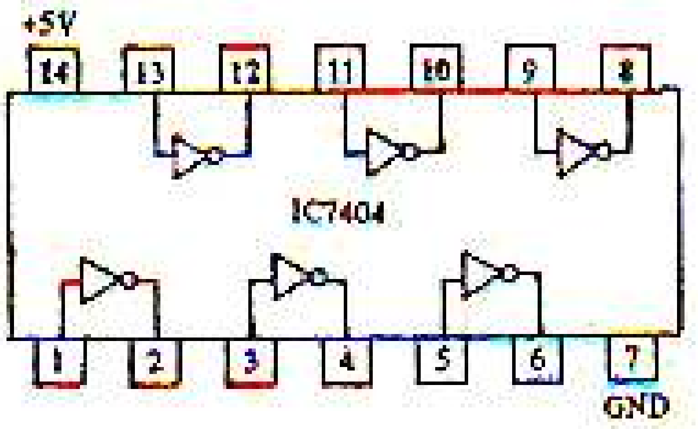
A(v)	B(v)	Output Y(v)

NOT GATE:

Logic Symbol:



Pin Diagram:



The IC chip 7404 is fixed on the bread board. The pin 7 is connected to –ve and the 14 is connected to +ve of the power supply which is kept at 5v. Here we can construct 6 NOT gates. When the input is 'o' we get 1 output and vice versa ie. The output is found to be A.

Truth Table

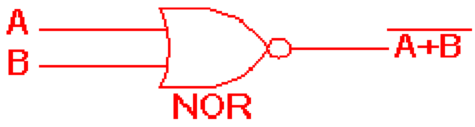
A	Output Y
0	1
1	0

Actual Voltage

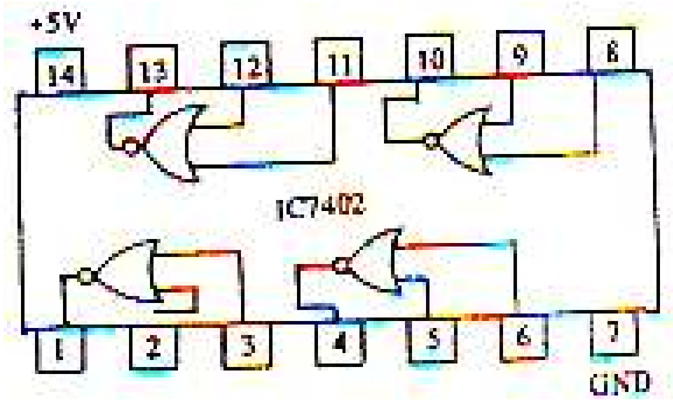
A(v)	Output Y(v)

NOR GATE:

Logic Symbol:



Pin Diagram:



The IC chip 7402 is fixed on the bread board. The pin 7 in connected to negative and 14 to the +ve of the power supply which is kept at 5 volts Here we get 4 NOR gates. The input is kept at (0,0) (0,1) (1,0) and is measured and it is found to follow the relation A+B =A. B. The truth table is also verified (ie) output is 1 when both the inputs are at '0' level.

Truth Table

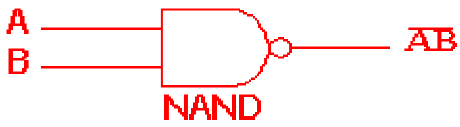
A	B	Output Y
0	0	1
0	1	0
1	0	0
1	1	0

Actual Voltage

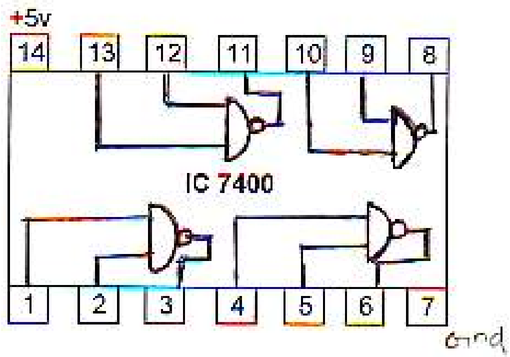
A(v)	B(v)	Output Y(v)

NAND GATE:

Logic Symbol:



Pin Diagram:



The IC chip 7400 is fixed on the bread board. The pin 7 is connected to negative and 14 to the positive of the power supply which is kept at 5 volts. We can get 4 NAND gates. The input is kept at (0,0) (0,1) (1,0) and (1,1) levels. The output is measured and it is found to follow the relation $\overline{A.\,B} = \overline{A} + \overline{B}$. The truth table is also verified. i.e. the output is found to be 1 if any of the inputs is at '0' level.

Truth Table

A	**B**	**Output Y**
0	0	1
0	1	1
1	0	1
1	1	0

Actual Voltage

A(v)	**B(v)**	**Output Y(v)**

Result:

The truth tables for various gates AND, OR, NOT, NAND and NOR are verified using respective integrated circuit chips.

7. NAND – UNIVERSAL GATE

Aim:

To show that NAND gate functions as a universal gate.

Apparatus Required:

Two input NAND chip (SN 7400), 5V power supply, voltmeter.

Procedure:

NAND gate can be used to implement all the fundamental gates namely NOT, AND, OR gates. Logic pin out for a NAND gate is shown in Fig. The output will be high when any one or both of the inputs are low. When both the inputs are high then the outputs are low. NAND chip SN7400 - consists of four NAND gates

NAND as AND gate:

The AND gate can be derived from NAND gate when the output of the first NAND gate is inverted using another NAND gate. The AND truth table is verified.

NAND as OR gate:

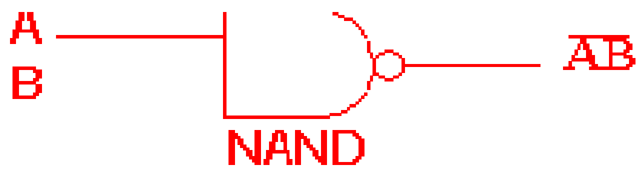
This gate is derived from NAND gate as follows. At First both the inputs A and B are inverted using two different NAND gates. The output will be A and B. these two are connected by the third gate where the output will be $Y=\overline{A.B}=\overline{A}+\overline{B}$ which is OR function. Thus, the truth table of OR gate is verified using NAND gates.

NAND as NOT gate:

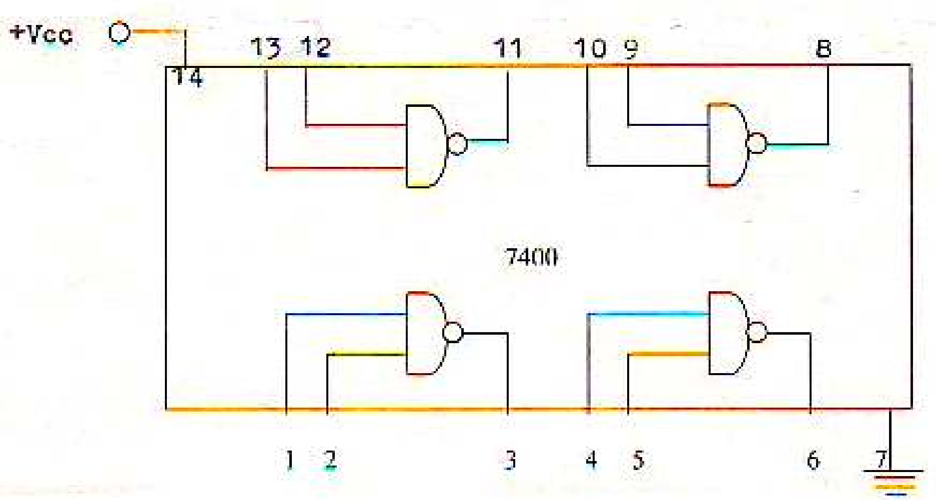
Here two input leads one and two are connected and is used as a single lead. Output is measured in terminal three and the NOT truth table is verified.

NAND GATE:

Logic Symbol:



Pin Diagram:



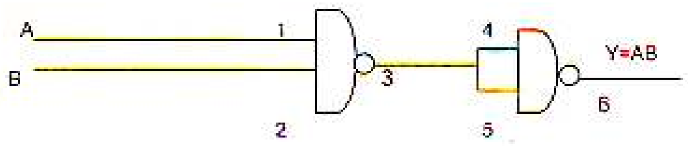
TRUTH TABLE :

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

VOLTAGE LEVEL

A(v)	B(v)	$Y=\overline{A.B}_{(v)}$

NAND as AND gate:



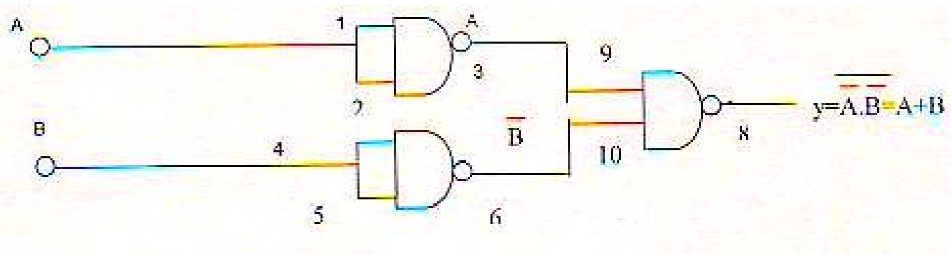
TRUTH TABLE :

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

VOLTAGE LEVEL

A(v)	B(v)	Output Y=A.B(v)

NAND as OR gate:



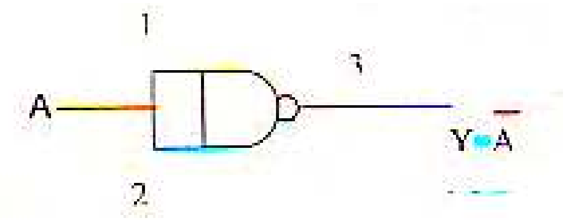
TRUTH TABLE :

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

VOLTAGE LEVEL

A(v)	B(v)	Output Y=A+B(v)

NAND as NOT gate :



TRUTH TABLE :

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

VOLTAGE LEVEL:

A(v)	$Y=\overline{A}(v)$

Result :

The logic gates AND, OR, NOT is constructed using NAND gates and their truth tables are verified. Thus, NAND gate functions as a universal gate.

8. NOR – UNIVERSAL GATE

Aim:

To show that NOR gate functions as a Universal gate.

Apparatus Required:

Two NOR chip (SN 7402), 5V power supply, and volt – meter.

Procedure:

NOR gate can be used to implement all the fundamental gates namely NOT, AND, OR gates. The Logic pin out for a NOR gate is shown in Fig. The output will be low when any one or both of the inputs are high. When both the inputs are low then the outputs are high. NOR chip SN 7402 - consists of four NOR gates.

NOR as AND gate:

The perform AND operation, both the inputs A and B are inverted using two different NOR gates. The output will be A and B. These two are connected by the third gate where the output will be $Y = \overline{A + B} = \overline{A.B}$ which is AND function. Thus, the truth table of AND gate is verified using NOR gates.

NAND as OR gate:

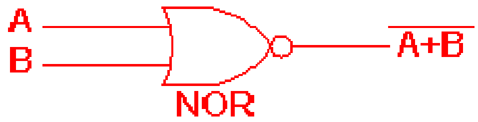
The OR gate can be derived from NOR gate, when the output of the first NOR gate is inverted using another NOR gate. The OR truth table is verified.

NOR as NOT gate

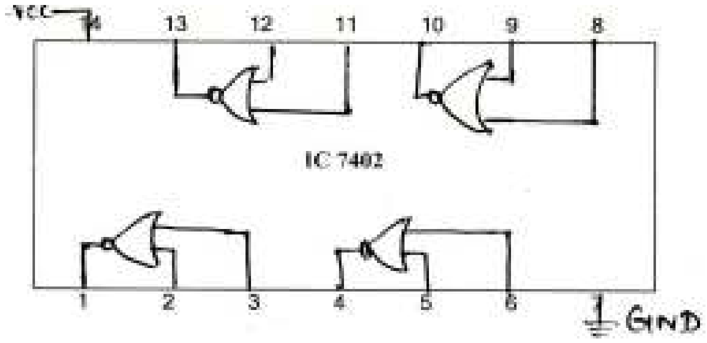
Here the two input leads one and two are connected and is used as a single lead. Output is measured in terminal three and the NOT truth table is verified.

NOR GATE:

Logic Symbol:



Pin Diagram:



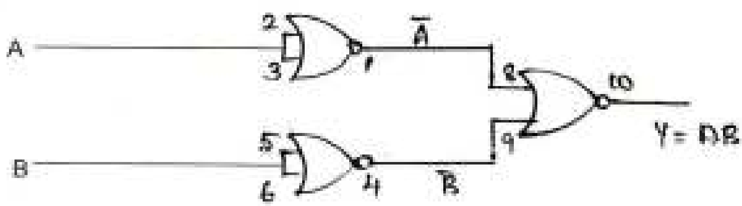
TRUTH TABLE:

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

VOLTAGE LEVEL

A(v)	B(v)	$Y=\overline{A+B}_{(v)}$

NOR as AND gate:



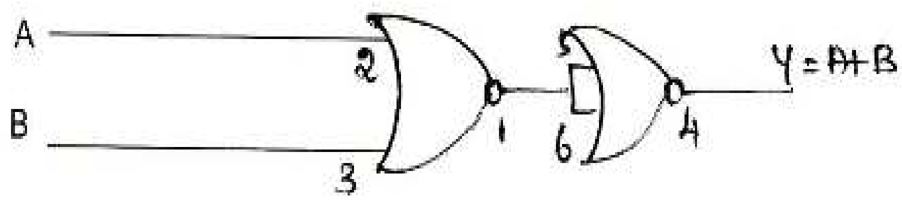
TRUTH TABLE :

A	B	Y=AB
0	0	0
0	1	0
1	0	0
1	1	1

VOLTAGE LEVEL

A(v)	B(v)	$Y=AB_{(v)}$

NOR as OR gate



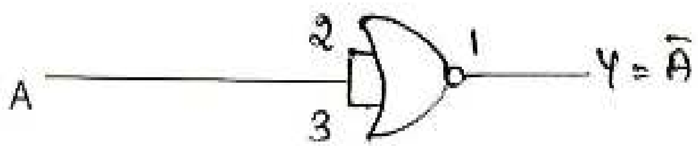
TRUTH TABLE :

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

VOLTAGE LEVEL

A(v)	B(v)	Y=A+B(v)

NOR as NOT gate



TRUTH TABLE :

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

VOLTAGE LEVEL

A(v)	Y=$\overline{A}_{(v)}$

Result:

Thus, the logic gates AND, OR, NOT are constructed using NOR gates and their truth tables are verified. Thus, NOR gate functions as an universal gate.

9. POTENTIOMETER – AMMETER CALIBRATION

Aim:

To Calibrate the given ammeter using a potentiometer.

Apparatus required:

Potentiometer, accumulator, Daniel cell, high resistance, galvanometer, Battery, rheostat, Standard resistance, an ammeter, Double pole Double Throw (DPDT) switch.

Circuit Diagram:

Formula:

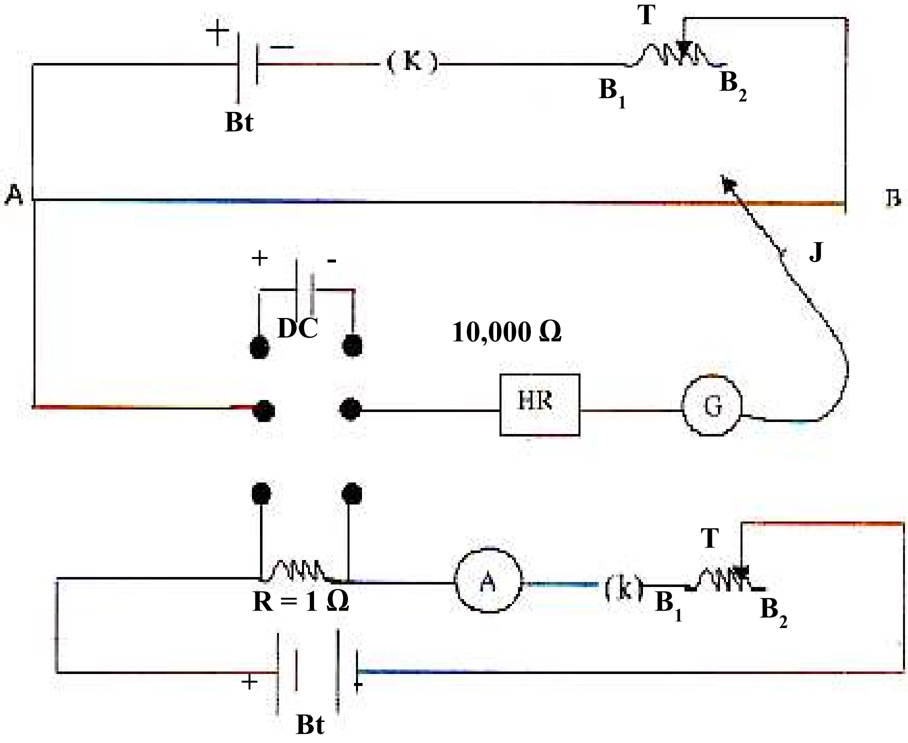
Calculated current $i_0 = \frac{E}{R} \times \frac{L}{L_0}$ **amperes**

Where

L_0 - Balancing length for the Daniel cell (m)

E - E.m.f of Daniel cell in volts

R - resistance (Ω)



Description:

The potentiometer consists of a uniform wire AB,10 metre long stretched intent parallel rows in a wooden board. The ends A and B are provided with binding screws. A jockey sides over the wire to make contact at any point on the wire.

Procedure:

Part – I

Daniel cell included with DPDT switch. To standardize the potentiometer the positive terminal is connected to B through a plug key. The position terminal of Daniel cell of emf E is connected to A and its negative is connected to the jockey through a high resistance and a galvanometer. The circuit is closed and with the high resistance the jockey is pressed near A and then near B. If the deflections are in opposite directions the connections are correct. Then by trial the balancing point is found for the cell. For maximum accuracy the high resistance is cut off and the balancing length l_o is measured. By the principle of potentiometer. $E \alpha l_o$.

Part – II

Ammeter & accessories included using DPDT switch. In secondary circuit Battery, Standard resistance (usually 1 ohm or 2 ohms) rheostat, plug key and an ammeter are connected in series with the positive end of R connected to the end A of the potentiometer & the other end to the jockey through high resistance & galvanometer. The plug keys are closed and the rheostat is adjusted for a current of 0.1 amp in the ammeter. The balancing length L is measured. If i_o is the current in the ammeter circuit the potential difference across R is i_o R.

$$i_o R \quad \alpha \quad l$$

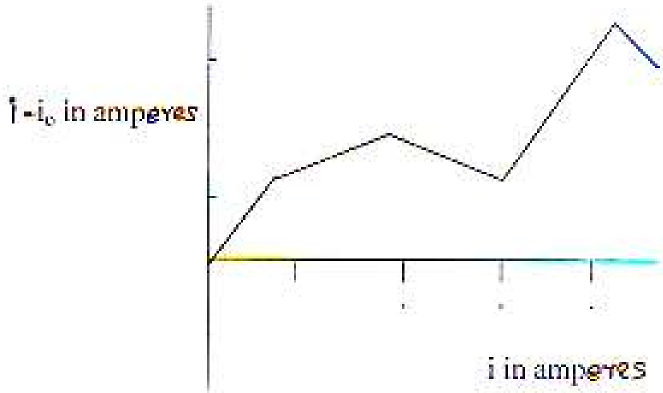
$$i_o R / E = l / l_0$$

$$i_0 = E l / R l_0$$

The experiment is repeated for currents of 0.2, 0.3, ……1 amp in the ammeter and the corresponding balancing lengths are measured. The observations are tabulated. If i be the ammeter reading i_0 the corresponding calculated value of current, then $i - i_0$ is the correction.

A graph is drawn taking the ammeter reading i along the x axis and the corresponding corrections $i - i_0$ along the y axis.

Model graph:



L_0 = cm R =1Ω E = v

S.No	Ammeter Reading (i_0)amperes	Balancing length (L) x 10^{-2}m	Calculated current $i = (\frac{E}{R} \times \frac{L}{L_0})$ amperes	Correction $(i - i_0)$ amperes

Observations:

Balancing length for the Daniel cell L_0 = m

E.m.f of Daniel cell E = v

Resistance R = Ω

Calculation:

Calculated current $i_0 = \frac{E}{R} X \frac{L}{L_0}$ amperes

Correction: $(i - i_0)$ amperes

Result:

The given ammeter is calibrated using potentiometer and the calibration curve is drawn.

10. POTENTIOMETER – SPECIFIC RESISTANCE

Aim:

To determine the specific resistance of the given coil of wire using a potentiometer.

Apparatus required:

Potentiometer, accumulator, battery, high resistance, galvanometer, resistance box, the unknown resistance coil, rheostat, plug keys and double pole double throw (DPDT) switch.

Formula:

The specific resistance of the given coil of wire $\rho = \frac{\pi r^2 x}{L}$ ohm-metre

Where,

ρ - specific resistance of the given coil of wire (ohm-metre)

L - length of the coil of wire (m)

r - radius of the coil of wire (m)

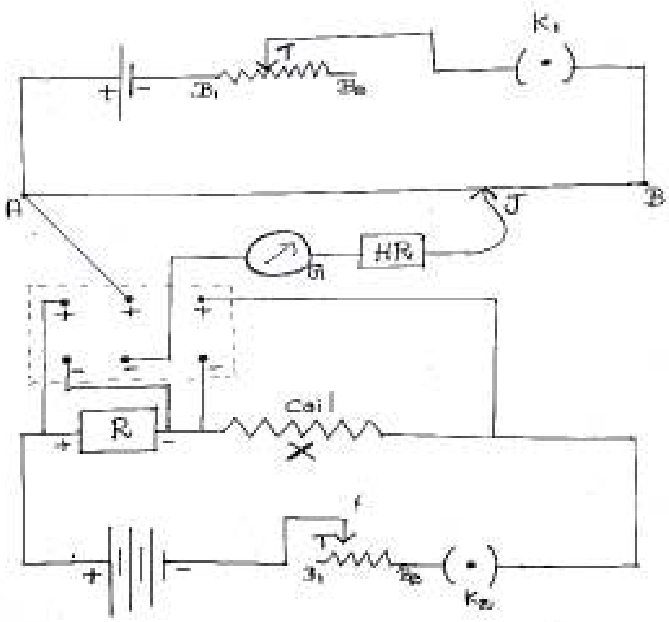
X - mean résistance of the unknown coil of wire (m)

L_1 - balancing length for the p.d. across X (m).

L_2 - balancing length for p.d. across R (m).

R - Resistance (Ω)

Circuit Diagram:



Procedure:

The positive terminal of an accumulator is connected to A of the potentiometer wire and the other terminal is connected to B through a plug key. Another circuit is formed with a battery, rheostat, resistance box R, the given coil of wire X and another plug key all connected in series. The ends of R and he ends of X are connected to a DPDT switch in such a way that the p.d. between their ends can successively be balanced against that of the potentiometer wire.

The circuits are closed and the rheostat is adjusted for a suitable current. Suitable resistance is introduced in R. the balancing length l_1 for the p.d. across X is found accurately. For the same current the balancing length l_2 for p.d. across R is determined.

Now $\frac{X}{R} = \frac{L_1}{L_2}$; $X = \frac{L_1}{L_2} R$

The nearest value of x obtained is put in R and the observations are repeated. The experiment is repeated for different currents by adjusting the rheostat. The readings are tabulated and the mean value of x is found out.

To find the mean résistance of the unknown coil of wire (m):

S. No	**Balancing length (m)**		$X = \frac{L_1}{L_2} R$ **ohm**
	for X L_1 **m**	**for R** L_2 **m**	
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Mean(X) =

To determine the radius (r)of the wire using screw gauge:

LC = 0.01 mm **Z. E =** **Z.C =**

S. No	P.S.R mm	H.S.C. div	O. R= (P. S. R+ {H.S.C× LC}) mm	C.R = (O. R+Z. C) mm
1.				
2.				
3.				
4.				
5.				
			Average d	

Observations:

Length of the wire L = m

Radius of the coil of wire r = d/2 = m

Mean résistance of the unknown coil of wire X = m

Calculation:

The specific resistance of the given coil of wire $\rho = \frac{\pi r^2 x}{L}$ ohm-metre

Result:

The specific resistance of the material of the wire = ohm-metre

11. DEFLECTION AND VIBRATION MAGNETOMETER

Aim:

To determine the magnetic moment of the given magnet and the horizontal component of the earth's magnetic field.

Apparatus required:

Deflection magnetometer, vibration magnetometer, bar magnet, stop clock, physical balance and a metre scale.

Formula:

Moment of inertia of the bar magnet $\mathbf{I} = \mathbf{mass\ X}\left(\frac{L^2 + B^2}{12}\right) \mathrm{Kg\ m^2}$

Time period of oscillations of the bar magnet $\mathbf{T} = 2\pi\sqrt{\frac{I}{MH}}$ sec

$$MH = \frac{4\pi^2 I}{T^2}$$

$$\frac{M}{H} = \frac{4\pi\mu_0 (d^2 - l^2)^2 \tan\theta}{2d} \quad \text{Weber m}^2 / \text{amp turns}$$

Where

I - moment of inertia of the bar magnet (Kg m^2)

L - length of the bar magnet (m)

B - breath of the bar magnet (m)

T - time period of oscillations of the bar magnet (s)

M - moment of the magnet (Weber metre)

H - horizontal intensity of earth's magnetic field (Amp turns/metre)

μ_0 - permeability of the free space ($4\pi \times 10^{-7}$ H/m)

d - distance between the center of the bar magnet to one of the arms of deflection magnetometer (m)

l - semilength of the bar magnet (m)

θ - deflection of the magnet (degree)

Description:

Box type vibration magnetometer consists of a stirrup suspended by means of torsion head T in a wooden box provided with glass windows. The magnet can be placed in the stirrup. A vertical line is made on the glass window to arrange the vibration magnetometer in the magnetic meridian.

Procedure:

(i) To find MH

The given magnet is placed on the stirrup. The vibration magnetometer is adjusted such that the axis of the magnet and the vertical line of the glass window are in the same plane. The suspended magnet is made to oscillate with same amplitude with the help of a small iron piece. The time for 20, 25 oscillations is noted successively and average period of oscillation is calculated.

The mass, the length L and breadth B are found. The moment of inertia of the bar magnet $I = mass\ X\ \frac{L^2 + B^2}{12}$ if M is the moment of the magnet and H is horizontal intensity of the earth's magnet field then, the period T is given by

$$T = 2\pi\sqrt{\frac{I}{MH}}\ ,\quad \frac{M}{H} = \frac{4\pi\mu_0(d^2 - l^2)^2 \tan\theta}{2d}$$ let it be x.

(ii) To find M/ H

The deflection magnetometer is arranged for Tan A position. The given bar magnet is placed at a suitable d on one of the arms with its axis parallel to the arms i.e. perpendicular to the magnetic meridian. The readings of the pointer are noted. The magnet is reversed in its position and two more readings are taken. The observations are repeated by transferring the magnet to the opposite arm for the same distance. The average deflection is found.

Now $$\frac{2Md}{4\pi\mu_0(d^2 - l^2)^2} = H\tan\theta\ ;\quad \frac{M}{H} = \frac{4\pi\mu_0(d^2 - l^2)^2 \tan\theta}{2d}$$

The experiment is repeated for different distances and the mean value of is found. Let it be Y.

$$M = \sqrt{MH\ X\ \frac{M}{H}} = \sqrt{XY} \qquad H = \sqrt{\frac{MH}{\frac{M}{H}}} = \sqrt{\frac{X}{Y}}$$

Observations:

S.No	Distance d m	Deflection of the magnet								Mean θ	M/H Web.m²/ amp. turns
		θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8		
1.											
2.											
3.											
4.											

Mean **M/H=**

To determine the breadth of the magnet using vernier caliper.

L.C = 0 .01 cm Z.E = Nil

S. No	M.S.R cm	V.S.C. div	O. R= (M. S. R+ (V.S.C× LC) cm	C.R = O.R cm
1.				
2.				
3.				
4.				
5.				
6.				
			Average	

To determine the period of oscillation of the magnet.

S.No	Number of oscillations	Time taken in secs	Period T secs
1.			
2.			
3.			
4.			
5.			
6.			
		Mean T =	

Observations:

Length of the bar magnet L = m

Breath of the bar magnet B= m

Time period of oscillations of the bar magnet T = s

Permeability of the free space $\mu_0 = 4\pi x 10^{-7}$ H/m

Distance between the center of the bar magnet to one of the arms of deflection magnetometer d = m

Semilength of the bar magnet l = m

Calculations:

Moment of inertia of the bar magnet $I = \text{mass} \, X\left(\frac{L^2 + B^2}{12}\right) Kg \, m^2$

Time period of oscillations of the bar magnet $T = 2\pi\sqrt{\frac{I}{MH}}$ sec

$$MH = \frac{4\pi^2 I}{T^2}$$

$$\frac{M}{H} = \frac{4\pi\mu_0 (d^2 - l^2)^2 \tan\theta}{2d} \quad \text{Weber } m^2 / \text{amp turns}$$

Result :

The magnetic moment of the given magnet = Weber metre

The horizontal intensity of the earth's magnetic field = Amp turns/m

12. AIR WEDGE – THICKNESS OF WIRE

Aim:

To determine the thickness of a very thin wire by the interference method.

Apparatus required:

Two optically plane glass plates, Sodium vapour lamp, condensing lens, microscope, reading lens.

Formula:

Thickness of the thin wire $\mathbf{t} = \frac{\mathbf{L\lambda}}{\mathbf{2\beta}} \quad m$

Where,

L - distance between the tied end and the wire (m)

t - thickness of the thin wire (m)

β - fringe width = s/30 (m).

λ - wavelength of the light source (5893×10^{-10} m)

Procedure :

Two optically plane glass plates of the same size are taken. They are tied together at one end A. At the other end B or very near to it, the thin wire W is introduced with its length perpendicular to the length of the plate. The plates are tightly tied together at this end also. If 't' is thickness of the wire and 'L' its distance from A, then the angle of the air wedge $\theta = t / L$.

To obtain the interference pattern, a parallel beam of monochromatic light is allowed to fall on a glass plate M, kept at an inclination of 45° to the horizontal. The reflected beam falls on the air wedge at normal incidence. The air wedge is placed on black paper vertically below M. a traveling of equigaped alternately dark and bright fringes will be obtained. A traveling microscope is arranged above M to view the interference fringes. A system of equigaped alternately dark and bright fringes will be obtained. The fringe width β is determined as accurately as possible by measuring the average distance between 30 fringes if λ is the wavelength of the light used, the angle of the wedge $\theta = \lambda$

/ 2β. Comparing the two expressions for θ, we find that $t / L = \lambda / 2\beta$ and so $t = L \lambda / 2\beta$ Hence t, the thickness of the wire can be calculated.

To determine the fringe width:

L.C = 0.001cm

Order of the fringe	Microscope reading(cm)			Width of 30 fringes, S cm
	MSR cm	VSC div	CR = (MSR + VSC X LC) cm	
n				
n+5				
n+10				
n+15				
n+20				
n+25				
n+30				
n+35				
n+40				
n+45				
n+50				
n+55				
n+60				
n+65				
n+70				
n+75				
n+80				
n+85				
n+90				
n+95				
n+100				

Average S = m.

Observations:

Fringe width $\beta = S/30$ = m

Distance between the tied end and the wire L = cm

$\lambda = 5893 \times 10^{-10}$ m

Calculation:

Thickness of the thin wire = $L\lambda / 2\beta$ m

Result :

The thickness of a very thin wire by air wedge method = m

13. SPECTROMETER – SOLID PRISM

Aim:

To determine the refractive index of the given solid prism.

Apparatus required:

Spectrometer, sodium vapour lamp, solid prism, reading lens, spirit level.

Formula:

Refractive index of the solid prism $\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

Where

μ - Refractive index of the solid prism

A - angle of the prism in degrees

D - angle of minimum deviation in degrees

Description:

The essential parts of a spectrometer are the collimator, the prism table and the telescope. The collimator consists of two metallic tubes with one sliding on the other is permanently mounted with the axis horizontal. It carries a convex lens at one end and a fine adjustable slit at the other, the distance between the slit and lens being altered by a side screw. The telescope which is of the astronomical type is capable of rotating about the central axis of the instrument. The axes of telescope and collimator lie in the same horizontal plane. A circular graduated disc is attached to the telescope and hence rotates with it. The telescope can be fixed in any desired position by a clamping screw, while fine adjustments can be made with a tangential screw. The prism table, is made up of two similar circular platforms, one above the other, connected together by three small leveling screws. There are a number of straight lines on the top surface of the platform, all drawn parallel to the line joining two of the leveling screws. These lines are useful in leveling the prism table. The table can rotate about the same central axis as the telescope and can be fixed in any position by means of a long screw. A circular disc with slots in which two verniers are fixed, is attached to the prism table and moves over the circular graduated scale as the prism table is rotated. There is also a tangential screw for the linear adjustments. The main scale is graduated in half degrees. There are 30 divisions and hence the least count of the vernier is $1/30^{th}$ of half a degree $=1/60^{th}$ of a degree = 1 minute.

Procedure :

Before taking measurements with the spectrometer it is essential to make the following preliminary adjustments.

(i) The telescope and collimator should be adjusted for parallel rays:

The telescope is turned to a white wall and the eye-piece is gently pulled out or pushed in to get the clearest image of the cross-wires. To adjust the telescope for parallel rays, it is directed to a distant object and the distance between the objective and the eye piece is altered till a clear well defined image of the distant object is seen in the focal plane of the eye-piece without parallax.

To adjust the collimator for parallel rays, the slit of the collimator is illumined with a monochromatic source, say, sodium light. The telescope is turned to be in the same line as the collimator in order to catch the image of the slit in the telescope. The distance between the collimating lens and the slit is altered to get the clearest image of the slit to coincide with the cross – wires without parallax. Since the telescope has already been adjusted for parallel rays, the light emerging from the collimator will be a parallel beam.

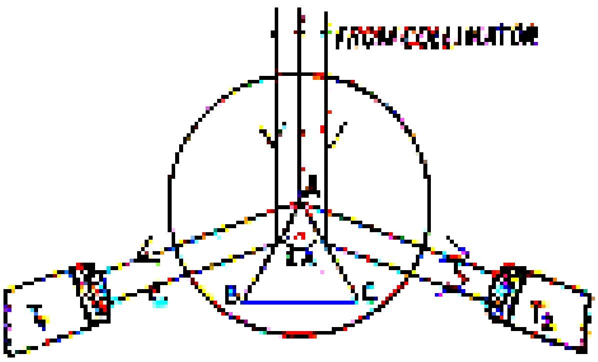
(ii) Levelling of the prism – table:

This may be done with a spirit level or optically. The prism is mounted on the table with its refracting edge as near as possible to the center of the table. The prism stable is turned until the refracting edge of the prism faces the collimator and the two faces of the prism are of the prism are symmetrical with the collimator.

The image of the slit of reflection from the face AB is caught in the telescope. For this, the image is first of all viewed with the naked eye and the telescope is brought into the position to view the image. If the reflected image is seen raised or lowered, it means that the table is not horizontal. The two leveling screws at the ends of a line are adjusted until the image is divided equally by the horizontal cross – wire of the telescope. If the image is not in the proper position, the third leveling screw alone is adjusted. Thus, the prism table is leveled and the refracting edge made vertical and parallel to the slit.

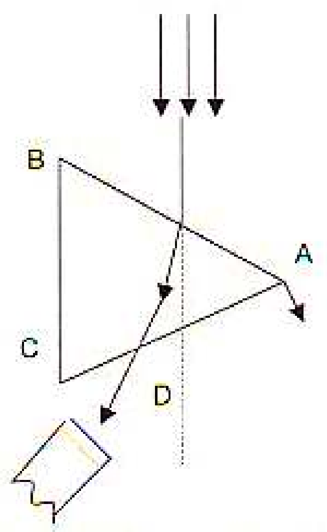
The angle of the prism:

The telescope is turned to catch the reflected image from one face. Fixing it in that position, the tangential screw is adjusted till the point of intersection of the cross-wires coincides with the fixed edge of the slit. The corresponding reading is taken with the scale and vernier, making use of both verniers A and B. Similarly, the image from the other polished face is viewed through the telescope and the corresponding reading is taken. Half the difference between the two readings gives the angle of the prism.



The angle of minimum deviation:

The prism table is rotated till light from the collimator is incident on one polished face of the prism, gets refracted through the prism and emerges out of the other. To begin with, the angle of incidence is kept large and the refracted images is caught in the field of view of the telescope. If the prism table is rotated in one direction, to decrease the angle of incidence, the image is found to move towards the direct reading position, i.e., the angle of deviation decreases. By rotating prism table further, it is found that at a certain stage the image begins to retrace its path i.e. the angle of deviation begins to increase. The angle of deviation is minimum when the image just turns back. The prism table is fixed there and refracted ray reading is taken. The reading of the direct ray is also taken. The difference between these two gives the angle of minimum deviation.



If A is the angle of the prism and D the angle of minimum deviation, the refractive index of the material of the prism is calculated from the formula.

To find Angle of the Prism (A):

Least Count = 1’

Ray	Telescope readings						2A		A deg
	V.A			V.B			V.A deg	V.B deg	
	M.S.R deg	V.C div	C.R deg	M.S.R deg	V.C div	C.R deg			
Reflected from I face									
Reflected from II face									

To find angle of minimum deviation (D):

Least Count = 1'

<table>
<tr><th rowspan="3">Ray</th><th colspan="6">Telescope readings</th><th colspan="2">D</th><th rowspan="3">D
deg</th></tr>
<tr><th colspan="3">V.A</th><th colspan="3">V.B</th><th rowspan="2">V.A
deg</th><th rowspan="2">V.B
deg</th></tr>
<tr><th>M.S.R
deg</th><th>V.C
div</th><th>C.R
deg</th><th>M.S.R
deg</th><th>V.C
div</th><th>C.R
deg</th></tr>
<tr><td>Minimum deviated ray</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Direct ray</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Result :

The refractive index of the material of the prism =

14. SPECTROMETER – WAVELENGTH DETERMINATION

Aim:

To determine the wavelengths of prominent lines of mercury spectrum by normal incidence method.

Apparatus required:

Spectrometer, mercury vapor lamp, solid prism, reading lens, spirit level.

Formula:

Wavelengths of the prominent lines of the mercury spectrum

$$\lambda = \frac{\sin\theta}{mN} \ \text{Å}$$

Where

λ - Wavelength of the prominent lines of the mercury spectrum (m)

m - order of the spectrum (For first order m = 1)

θ - angle of diffraction (degrees)

Description:

The preliminary adjustment of the spectrometer namely the adjustment of eyepiece for clear vision of crosswire and telescope and collimator for parallel rays are made initially. The spirit level is used to make the prism table exactly horizontal.

(i) Standardization of grating:

The slit is made narrow and illuminated by mercury vapor lamp. The direct reading is noted. The telescope is rotated through exactly 90°C and fixed. The grating is mounted on the prism table and it is rotated to get the reflected image through the telescope. The fixed edge of the brightest reflected image is made to coincide with the vertical cross wire of the telescope. Without disturbing the telescope, the vernier screw is released and it is rotated through exactly 45° so that the grating is normal to the incident beam. Here after the grating should not be disturbed.

(ii) Determination of wave lengths:

The grating for normal incidence is not disturbed. The telescope is brought round to view the for first order spectrum. The vertical cross wire of the telescope is made to coincide successively with each one of the prominent lines and the readings are taken. Similarly, the corresponding readings of the same prominent lines for the first order on the other side are taken. The observations are tabulated. The angle of diffraction θ for each prominent line is determined as before. The value of N is calculated by substituting the angle of diffraction θ of green spectral line and its standard wavelength (5461×10^{-10} m) in the following formula.

$$\mathbf{N = \frac{Sin\ \theta_g}{m\lambda_g}}$$

Where

m - order of the spectrum. For first order diffraction m = 1

θ_g - angle of diffraction for green spectral line (degrees)

λ_g - wavelength of green spectral line (5461×10^{-10} m)

By substituting N value, the wavelengths of the lines of the mercury spectrum are calculated.

To determine the wavelengths of the lines of the mercury spectrum:

LC = 1'

Color of the lines	Telescope reading				2θ		Mean θ	$\lambda = \frac{\sin\theta}{mN}$ Å
	Left		Right					
	V_A	V_B	V_A	V_B	V_A	V_B		
Violet 1								
Violet 2								
Blue								
Bluish green								
Green								
Yellow 1								
Yellow 2								
Direct Ray								

Result:

The wavelengths of prominent lines of mercury spectrum are determined.

15. NEWTON' S RINGS

Aim:

To determine the radius of curvature of the given long focus convex lens by the Newton's rings method.

Apparatus required:

Long focus convex lens, optically plane glass plate, sodium vapor lamp and Vernier microscope.

Formula:

The radius of curvature of the given convex lens

$$R = \frac{r_{n+15}2 - r_n2}{S\,\lambda} \quad m$$

Where

λ - wavelength of the light source (5893 X 10^{-10} m)

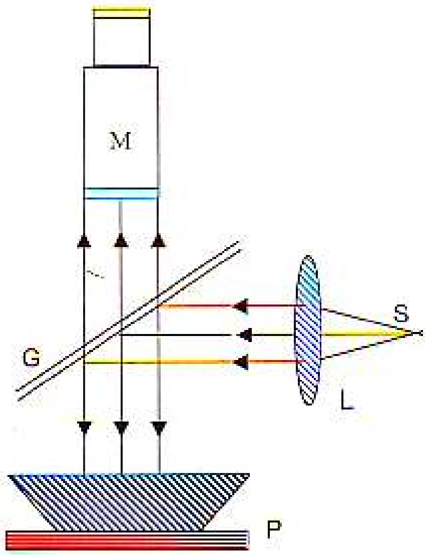
r - radius of the n^{th} ring (m).

S - shift in the order of the rings (m)

n - order of the rings.

Description:

The long focus convex lens 'L' is placed on the optically plane glass plate 'P'. Light from sodium vapor lamp 'S' is rendered parallel by convex lens and made to fall on the glass plate G kept inclined at an angle of 45^0 to the horizontal. The partially reflected right travels vertically downwards and it is incident on optically plane glass plate combination. The interference pattern consisting of a series of bright and dark concentric circles is formed due to the plano concave air film between the lens and optically plane glass plate. This is viewed by a vernier microscope arranged above the glass plate G.



Procedure:

The center of the ring system is brought to the field of view of the microscope. The first few rings near the center may be ill defined and hence it is difficult to fix the absolute order of the right. So, the first well defined dark ring near the center is taken as the n^{th} dark ring. The microscope is moved to one side, say right so that the reading of the microscope is noted. The microscope is then carefully moved by working its screw till the cross- wire is tangential to the $(n + 30)^{th}$, dark ring and the reading is taken. Similarly the readings corresponding to the $(n+21)^{th}$ $(n+18)^{th}$ etc., dark rings are noted. Now the microscope is moved to the other side and corresponding readings are taken and they are tabulated. The microscope is always moved in the same direction to avoid any backlash error. The difference between the micro scope readings on either side for a given order gives the diameter of the particular order of ring. From this the radius of the ring and hence the square of the radius is calculated.

The values in the last column are obtained by the method of successive difference. They are found to be a constant. The mean value of the last column is determined. Let R is the radius of curvature of the lens surface in contact with the glass plate and λ is the wavelength of the source of light. In the case of sodium light $\lambda = 5893 \times 10^{-10}$ metre. Hence the radius of curvature R is calculated.

To find the radius of curvature of rings: **L.C=0.001cm**

Order of rings	Microscope Reading Cm		Diameter (2r) Cm	Radius (r) Cm	r^2 10^{-4} m^2	$r_{n+15}^2 - r_n^2$ 10^{-4} m^2
	Left	Right				
n						
n + 3						
n + 6						
n + 9						
n + 12						
n + 15						
n + 18						
n + 21						
n + 24						
n + 27						
n + 30						

Mean=

Observation:

Wavelength of the source of light $\lambda = 5893 \text{ X } 10^{-10}$ m
Shift in the order of the rings S = m

Calculation:

The radius of curvature of the given convex lens $\mathbf{R} = \frac{r_{n+15}^2 - r_n^2}{S\,\lambda}$ **m**

Result:

The radius of curvature of long focus lens = m

16. THERMAL CONDUCTIVITY – LEE'S DISC

Aim:

To determine the thermal conductivity of a bad conductor such as card board or ebonite.

Apparatus required:

Lee's disc apparatus, thermometer, stop-clock, Card board disc.

Formula:

Thermal conductivity of a bad conductor $K = \frac{MSRd\ (2h+r)}{\pi r^2 (T_1 - T_2)(2h+2r)}$ W/m/K

Where,

M – Mass of the brass disc (Kg)
R – Rate of fall of temperature (S^{-1})
d – Thickness of the bad conductor-card board (m)
h – Thickness of the brass disc (m)
r – Radius of the brass disc (m)
T_1 – Temperature of the steam chamber (deg)
T_2 – Steady temperature of the brass disc (deg)
S – Specific heat capacity of brass disc (0.081 x 4200 J/Kg/K)

Description:

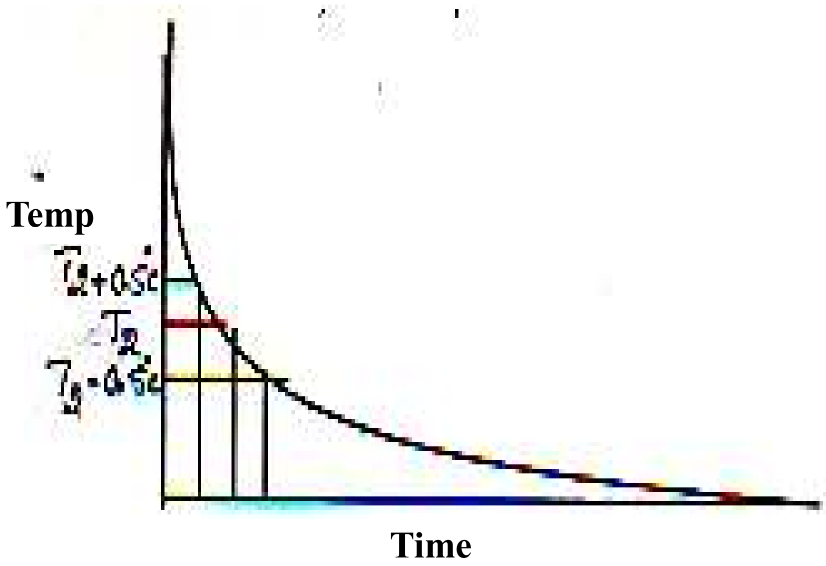
It consists of thick brass disc. A suspended horizontally by strings from a metal ring attached to a retort stand. The card board disc C of the same diameter is placed on the brass disc. A steam chamber B of the same cross – section as the brass disc is placed on the card board. The thermometers T_1 and T_2 inserted into the holes A and B to record the temperature on the two sides of the card board.

Procedure:

The mean thickness of the card board disc is determined using a screw gauge. The radius 'r' of the lower metallic disc A is found using a slide calipers. The mean thickness 'h' of the lower metallic disc is found using a screw gauges. The mass 'M' of the lower metallic disc is also found. The apparatus is arranged as shown in the figure. Steam is allowed to pass through the steam chamber.

Heat is conducted through the card board to the metal disc A. The thermometers indicate rise in temperature. The temperature of A and B are noted for an interval of 5 minutes. When the temperature indicated by T_1 and T_2 remain steady for 2 or 3 consecutive intervals, it means that the whole arrangement has reached steady state. In this steady state, heat conducted into the lower slab through the card board disc is just equal to the radiated by the curved side and flat bottom of the lower slab A. The steady temperatures T_1 and T_2 respectively recorded by the thermometers are noted.

The card board disc is now removed and A is heated in direct contact with the steam chamber B until its temperature rises by about 10°c above the steady temperature T_2. The slab A is suspended separately and allowed to cool. When its temperature reaches $(T_2 + 5)^o$ c stop clock is started and the time is recorded for every one degree fail of temperature until its temperature reaches $(T_2 - 5)^o$ c. A graph is drawn taking time along the x-axis and temperature along the y-axis. By drawing a tangent to the graph at the steady temperature T_2, the corresponding rate of fall of temperature R of the brass disc A can be found.



To determine the fall in temperature:

S. No	Time in seconds	Temperature in degrees
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

To determine the thickness of the card board using Screw gauge (d):

LC = 0.01 mm **Z. E =** **Z.C =**

S. No	P.S.R mm	H.S.C. div	O. R= (P. S. R+ {H.S.C× LC}) mm	C.R = (O. R±Z. C) mm
1.				
2.				
3.				
4.				
5.				
			Average	

To measure the thickness of the Lee's disc using Vernier caliper (b):

S. No	M.S.R cm	V.S.C. div	O. R= (M. S. R+ V.S.C× LC) cm	C.R = O.R cm
1.				
2.				
3.				
4.				
5.				
			Average	

L.C = 0 .01 cm **Z.E = Nil**

Observations:

Mass of the brass disc	M	=	Kg.
Radius of the brass disc	r	=	m.
Thickness of the brass disc	h	=	m.
Thickness of the bad conductor	d	=	m.
Specific heat capacity of brass disc	s	=	J/Kg/K.
Temperature of steam chamber,	T_1	=	^{o}C.

Steady temperature of the brass disc, T_2 = ^{o}C

Rate of fall of temperature, R = 1/ t = S^{-1}

Calculation:

Thermal conductivity of a bad conductor $$\mathbf{K} = \frac{\mathbf{MSRd\ (2h+r)}}{\mathbf{\pi r^2 (T_1 - T_2)(2h+2r)}}$$ W/m/K

Result:

The thermal conductivity of the given bad conductor =   W/m/K.