Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

RCC Institute of Information Technology

Department of Applied Science

PHYSICS LAB MANUAL PH 191/291

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

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Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Instructions for Laboratory

- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and an attitude of learning.
- You need to come well prepared for the experiment
- Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements!) and equally share the work with your partners.
- Be honest in recording and representing your data. Never make up readings or doctor them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the tables have to be faithfully displayed on the graph.
- All presentations of data, tables and graphs calculations should be neatly and carefully done.
- Bring necessary graph papers for each of experiment. Learn to optimize on usage of graph papers.
- Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.
- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

Department of Applied science
RCC Institute of Information Technology, Kolkata
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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

List of Experiments

Group 1: Experiments on General Properties of Matter (Part A)

1. Determination of Young's Modulus of elasticity of the material of a bar by the method of Flexure.
2. Determination of modulus of rigidity of the material of a rod by static method.
3. a) Determination of rigidity modulus of the material of a wire by dynamic method 1.

   b) Determination of rigidity modulus of the material of a wire by dynamic method 2.
4. Determination of co-efficient of viscosity by Poiseuille's capillary flow method

Group 2: Experiments on Optics (Part A)

5. Determination of wavelength of a monochromatic light by Newton's ring method
6. Determination of wavelength of the given laser source by diffraction method .
7. Determination of dispersive power of the material of a given prism.

Group 3: Experiments on Electricity & Magnetism (Part A &B)

8. Determination of resistivity of material of the wire & unknown resistance using Carey-Foster's Bridge.
9. Determination of dielectric constant of a given dielectric material.

Group 4 : Experiments on Quantum Physics (Part B)

10. Determination of Stefan-Boltzman constant using vacuum tube diode.
11. Determination of Planck constant using photocell.
12. Determination of Band gap of semiconductor by four probe method.
13. Determination of Rydberg constant by studying Hydrogen spectrum.
14. Verification of Bohr's atomic orbital theory by Franck - Hertz Experiment.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Part A

Department of Applied science
RCC Institute of Information Technology, Kolkata
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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of Young's Modulus of elasticity of the material of a bar by the method of Flexure

Theory

$$y = \frac{logitudinal\ stress}{logitudinal\ strain} = \frac{\frac{Restoring\ force}{unit\ area}}{change\ in\ diamenssion} = \frac{F/A}{dl/L}$$ within the elastic limit

If a load of mass *m* is attached to the hanger, the depression of the bam is given by

$$x = \frac{mgl^3}{4ybd^3} \ \ or\ \ y = \frac{gl^3}{4bd^3}\left(\frac{m}{x}\right)$$

Where

Y is the young's modulus of the material of the beam (dyne/cm^2)

g is the acceleration due to gravity

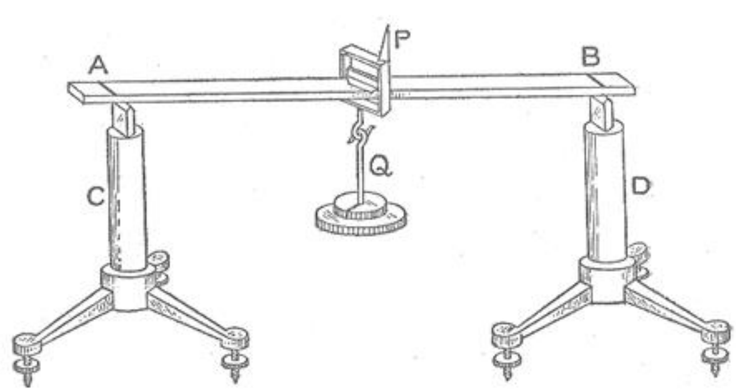
l is the length of the bar

b is the breadth of the bar

d is the depth of the bar

m mass per unit length

x is the depression of the bar



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Principle of experiments:

A rectangular bar resting on knife edges symmetrically placed w.r.t. the mid-point and loaded at the mid-point will bend producing certain sag at the mid-point. This depression depends on other factors of the specimen. Hence finding the 'x' the Young's modulus Y can be determined.

Procedure:

1. Measure the Vernier constant of Slide calipers and Traveling microscope.

2. Measure the breadth and depth of the rectangular bar.

3. Mark the midpoint of the beam with the help of a chalk.

4. Focus the traveling microscope on the indicator of the hanger. Take the reading of the vernier scale. This is the depression with no load.

5. Apply 0.5 kg load and find the shifted reading of the indicator.

6. Increase the load up to 3 kg in steps of 0.5 kg and the reading of the indicator in each case.

7. Reduce the load in step of 0.5 kg and take reading.

Apparatus Table:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	A bar of uniform rectangular cross-section (AB)	Length – 1 metre (brass / Iron)	
2.	Two iron stands with leveling screw at the base and a sharp knife edge fixed at the top (C, D)		
3.	A rectangular stirrup with a knife edge and a vertical pointer (P)		
4.	A travelling microscope	V.C.=	
5.	Standard weights (few)	500 gms.	

6.	A hanger (Q)		
7.	Spirit level		
8.	Metre scale	1 smallest div=	
9.	Screw gauge	L.C.=	
10.	Slide callipers	V.C.=	

Measurements:

1. Measure the Vernier constant of Slide calipers and Traveling microscope

Vernier constant of the Slide calipers :

Smallest division in the main scale (x) : ………. cm

No. of division in the vernier scale (n) : ……….

No. of coincident Main scale division (m) : ……….

Vernier constant = x((n-m)/n) : ………. cm

Vernier constant of the Traveling microscope:

Smallest division in the main scale (x) : ………. cm

No. of division in the vernier scale (n) : ……….

No. of coincident Main scale division (m) : ……….

Vernier constant = x((n-m)/n) : ………. Cm

2. Measure the breadth and depth of the rectangular bar

Length of the Bar between two knife edge ………. Cm

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

	No. of Obs.	Mean Scale reading in cm	Vernier Coincidence	Vernier Scale reading in cm (VC X LC)	Total reading (cm)	Mean in cm
Breadth	1					
	2					
	3					
Depth	1					
	2					
	3					

3. Load-Depression table

No. of Obs.	Loading (kg)	Reading when increasing (a) (cm)			Reading when decreasing (b) (cm)			Mean ½ (a+b) cm	Depression 'x' (cm)
		M.S.R.	V.S.R.	Total	M.S.R.	V.S.R.	Total		
0	0								
2	0.5								
3	1.0								
4	1.5								
5	2.0								
6	2.5								
7	3.0								

4. Plot a curve of depression Vs. load. This should be straight line passing through the origin. Determine the slope of the curve.

5. Find out Young's modulus $x = \frac{mgl^3}{4ybd^3}$ or $y = \frac{gl^3}{4bd^3}\left(\frac{m}{x}\right)$

Discussion:

1. As length and depth of the bar are in their third power in the formula, they should be measured very carefully otherwise slight error in the measurement of length or depth will cause much error in the final result.

2. The beam should be made horizontal and the load must be suspended from a point exactly mid-way between the knife-edges.

3. While measuring depression, to avoid back-lash error the microscope screw should always be rotated in the same direction.

3. Instead of microscope or cathetometer, depression of the bar can also be measured by optical lever arrangement.

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim:- Determination of modulus of rigidity of the material of a rod by static method.

Working formula:

The modulus of rigidity n of the given rod is given by

$$n = \frac{180\, M\, g\, D(l_1 \sim l_2)}{\pi^2 r^4 (\theta_1 - \theta_2)}$$

where, M = load suspended

g = acceleration due to gravity

D = diameter of the pulley

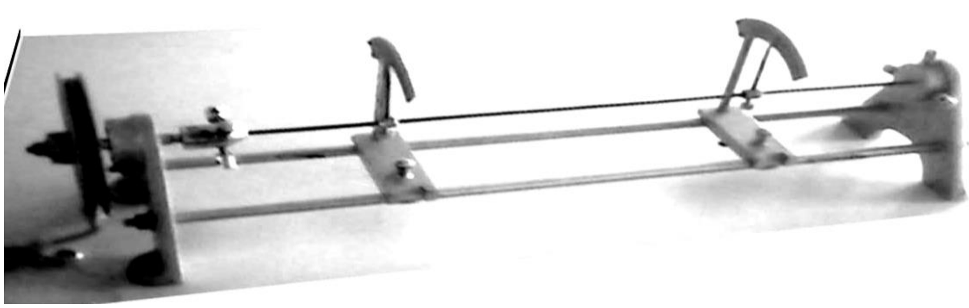
r = radius of the experimental rod

$(l_1 \sim l_2)$ = the length of the rod suffering twist (distance between the two pointers)

$(\theta_1 - \theta_2)$ = difference of the angular twist produced in the rod.

Principle of experiments:

On the basis of elasticity property, measuring the angle of twist produced in the rod at static equilibrium and other parameters we can measure rigidity modulus of the rod.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Apparatus Table:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	horizontal pattern of apparatus		
2.	Screw gauge	L.C. =	
3.	Given experimental rod	Steel / Brass/Aluminium	
4.	Metre scale		
5.	Load	500 gm.	
6.	Wire (to measure perimeter of pulley)		
7.	Hanger		
8.	Thin and strong chord		

Observation:

A) Determination of effective length of the rod:

Table – I

No. of obs.	Scale reading for the left end of the rod (l_1 cm)	Scale reading for the right end of the rod (l_2 cm)	Length ($l_1 \sim l_2$) cm
1			

B) Determination of radius of the rod:

One smallest division of the linear scale = ……….. cm

Total number of circular scale = ………….

Least count of screw gauge = $\dfrac{\text{Screw pitch}}{\text{Total circular scale division}}$ = …………

= ……..cm

Zero error of the screw gauge = ………..div. = ……… cm.

Table – IV

No. of obs.	Reading along any direction			Reading along perpendicular direction			Diameter (X + Y)/2 (cm)	Mean diameter d (cm)	Corrected diameter d_c = d - error	Mean radius $r=d_c/2$ (cm)
	L.S.R (cm)	C.S. Div	Total reading X(cm)	L.S.R (cm)	C.S. Div	Total reading Y(cm)				

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

C) Determination of the twist:

Table - III

Sl. No.	Mass on the hanger (gm)	Twist for first pointer					Twist for first pointer				
		Pointer reading during load increasing (deg)	Pointer reading during load decreasing (deg)	Mean pointer reading (deg)	Angle of twist θ_1 for 1500 gms. (deg)	Mean θ_1 for 1500 gms. (deg)	Pointer reading during load increasing (deg)	Pointer reading during load decreasing (deg)	Mean pointer reading (deg)	Angle of twist θ_1 for 1500 gms. (deg)	Mean θ_1 for 1500 gms. (deg)
1	500										
2	1000										
3	1500										
4	2000										
5	2500										
6	3000										

D) Determination of the diameter of the pulley:

Perimeter of the pulley (P = $2\pi rl$) = …. cm

Diameter of the pulley $D = \frac{P}{\pi}$ = ….. cm

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Result:

Hence the modulus of rigidity n of the given rod is given by

$$n = \frac{180\, M\, g\, D(l_1 - l_2)}{\pi^2\, r^4(\theta_1 - \theta_2)} = \ldots\ldots\ldots\ldots \text{ dyne /cm}^2$$

Discussion:

1. The rod should be straight and long as much as possible (at least 40 cm)
2. The rod should be twisted through a very small angle
3. The radius of the rod should be measured very accurately as it occurs in fourth power in the formula.
4. The pulley should be frictionless
5. Load should be increased or decreased gradually and gently
6. The load should never exceed, the maximum permissible value
7. The diameter of the pulley should be very carefully measured.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim:- Determination of rigidity modulus of the material of a wire by dynamic method 1.

Working formula:

The modulus of rigidity ή of the material of the wire is given by

$$\eta = \frac{\pi l (M_S - M_H) L^2}{r^4 (T_2^2 - T_1^2)}$$

within the elastic limit

Where, l is the length of the experimental wire

L is the length of the brass tube

r is the radius of the wire

M_S is the mass of each of the solid cylinder

M_H is the mass of each of the hallow cylinder

T_1 is the time period when solid cylinder are placed in the middle

T_2 is the time period when hallow cylinder placed in the middle

Principle of experiments:

Within elastic limit, during torsional oscillation shearing couple for the cylinder is equal and opposite to that of the suspension wire.

Procedure:

1. Measure the Least count of screw gauge
2. Measure the length of the suspension wire from the support till the cylindrical bob and radius of the wire at several places with the help of screw gauge
3. Mass of the hollow cylinders M_H = 66 gm and mass of the solid cylinder M_S = 223gm. Length of the cylindrical bob (L) = 39.5 cm

4. Place the solid and hollow cylinder inside the cylindrical bob.
5. Rotate the cylindrical bob at a small angle about the suspension wire and the leave. This will initiate a torsional oscillation in the bob. Measure the time period of this oscillation with the help of stopwatch.
6. Change the position of solid and hollow cylinder inside the cylindrical bob and repeat step 5.
7. Draw a graph of no. of oscillation vs. Time taken for n oscillation.
8. Calculate Modulus of Rigidity from the formula

$$\eta = \frac{\pi l (M_S - M_H) L^2}{r^4 (T_2^2 - T_1^2)} \quad \text{Dyne/cm}^2$$

Apparatus Table:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Torsional pendulum		
2.	Steel tape		
3.	Stop watch		
6.	Slide callipers	V.C. = …..	
7.	Screw gauge	L.C. = …..	

Observation:

A) Determination of effective length of the wire

Length of the suspension wire (l) = ………. cm

B) Determination of radius of the wire:

One smallest division of the linear scale = ……….. cm

Total number of circular scale = ………….

Least count of screw gauge = $\dfrac{\text{Screw pitch}}{\text{Total circular scale division}}$ = ………… cm

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Zero error of the screw gauge = ………..div. = ……… cm.

Table – I

No. of obs.	Reading along any direction			Reading along perpendicular direction			Diameter (X + Y)/2 (cm)	Mean diameter d (cm)	Corrected diameter D = d – error (cm)	Mean Radius r=D/2 (cm)
	L.S.R (cm)	C.S.Div	Total reading X (cm)	L.S.R (cm)	C.S.Div	Total reading Y (cm)				

C) Determination of the time periods:

Table – II

Solid cylinder inside

No. of oscillation m	Time taken t (sec)	Time period T = t/m (sec)	Mean T (sec)

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Table – III

Hollow cylinder inside

No. of oscillation m	Time taken t (sec)	Time period T = t/m (sec)	Mean T (sec)

Draw a graph of no. of oscillation vs. Time taken for n oscillation.

Result:

Hence modulus of rigidity n of the material of the wire is

$$\eta = \frac{\pi d(M_S - M_H)L^2}{r^4(T_2^2 - T_1^2)} = \ldots\ldots\ldots\ldots \text{ dyne /cm}^2$$

Discussion:

1. The wire should be fairly thin and long
2. It should be free from kinks
3. The wire should be twisted through a very small angle.
4. The motion of the Maxwell's needle should be purely rotational
5. The tube should remain horizontal throughout the whole experiment.
6. No portion of cylinders should project outside.
7. The radius of the wire should be measured very accurately as it occurs in fourth power in the formula.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of rigidity modulus of the material of a wire by dynamic method 2.

Working formula:

The modulus of rigidity 'n' of the material of the suspension wire is given by

$$n = \frac{8\pi l}{r^4 T^2} \times I = \frac{8\pi l}{r^4 T^2} \times \frac{1}{2} M R^2$$

where, l = length of the suspension wire

r = radius of the wire

T = time period of torsional oscillation

I = moment of inertia of the cylinder about the suspension wire as axis

M = mass of the solid cylinder

R = radius of the cylinder

Principle of experiments:

Within elastic limit, during torsional oscillation shearing couple for the cylinder is equal and opposite to that of the suspension wire.

Apparatus Table:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Torsional pendulum		
2.	Steel tape		

3.	Stop watch		
4.	Physical balance		
6.	Slide callipers	V.C. = …..	
7.	Screw gauge	L.C. = …..	

Observation:

A) Determination of mass of cylinders:

Mass of the cylinder **M = 3200(gm)**

B) Determination of effective length of the wire:

Table – I

No. of obs.	Scale reading for the top end of the wire (x cm)	Scale reading for the bottom end of the wire (y cm)	Length (y ~ x) cm	Mean length (l cm)
1				
2				
3				

C) Determination of radius of the wire:

One smallest division of the linear scale = ……….. cm

Total number of circular scale = ………….

Least count of screw gauge = $\dfrac{\text{Screw pitch}}{\text{Total circular scale division}}$ = ………… cm

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Zero error of the screw gauge = ………..div. = ……… cm.

Table – III

No. of obs.	Reading along any direction			Reading along perpendicular direction			Diameter	Mean diameter	Corrected diameter D = d – error (cm)	Mean Radius r=D/2 (cm)
	L.S.R (cm)	C.S.Div	Total reading X (cm)	L.S.R (cm)	C.S.Div	Total reading Y (cm)				

D) Determination of radius of the cylinder:

1 smallest reading of main scale = ____ cm

___No. of vernier division =____ no. of smallest division of main scale.

1 ,, ,, = ……. ,, ,, ,, ,, ,,

Vernier constant (v.c) of **Slide calipers**

= (1 main scale division – 1 vernier scale division) × 1 smallest reading of main scale

= ………....cm

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Table – IV

No. of obs.	Diameter of the Cylinder				Instrumental error (cm)	Corrected mean diameter D (cm)	Corrected mean reading radius r = D/2 (cm)
	Main scale reading (cm)	Vernier div	Total reading (cm)	Mean reading D (cm)			
1							
2							
3							

C) Determination of the time periods:

Table – V

No. of oscillation m	Time taken t (sec)	Time period T = t/m (sec)	Mean T (sec)

Draw a graph of no. of oscillation vs. Time taken for n oscillation.

Result:

Hence modulus of rigidity n of the material of the wire is

$$n = \frac{8\pi l}{r^4 T^2} \times I = \frac{8\pi l}{r^4 T^2} \times \frac{1}{2} MR^2 = \text{............ dyne /cm}^2$$

Discussion:

1. The wire should be fairly thin and long
2. It should be free from kinks
3. The wire should be twisted through a very small angle.
4. The motion of the Maxwell's needle should be purely rotational
5. The tube should remain horizontal throughout the whole experiment.
6. No portion of cylinders should project outside.
7. The radius of the wire should be measured very accurately as it occurs in fourth power in the formula.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of the coefficient of viscosity of water by Poiseuille's method

Working formula:

Flowing water through the capillary tube we can find out the co-efficient of viscosity of water at steady state

$$\eta = \frac{P\pi r^4}{8vl} = \frac{h\rho g\pi r^4}{8vl}$$

where, P = Pressure difference between the two ends of the capillary tube
h = Difference of water levels in the two arms of the U-tube
ρ = Density of water at the environmental temperature during experiment
g = gravitational acceleration
r = Radius of capillary tube
v = Volume of water collected per second coming out through the capillary tube
l = Length of the capillary tube

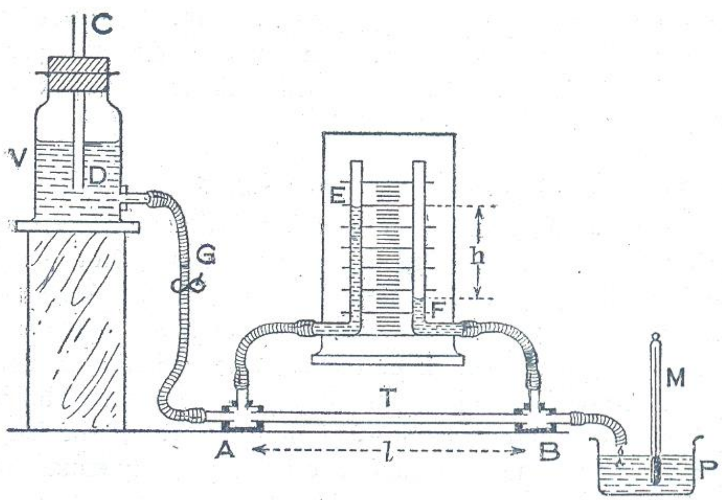
Principle of experiments:

Rate of flow of a liquid through a capillary tube depends upon the radius and length of the tube, pressure difference across its two ends and on the physical property of the liquid which is known as VISCOSITY. By making a suitable arrangement with a capillary tube and allowing the liquid to flow through it by establishing a suitable pressure difference, viscosity can be measured.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Apparatus:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Viscosity apparatus		
2.	Travelling microscope	V.C. =	
3.	A capiliary tube	Glass -made	
4.	Measuring cylinder	… c.c or ml.	Lower reading…., Upper reading…., 1 smallest div.=…..
5.	Stop-watch		
6.	Metre-scale	Wood / steel / tape	
7.	Thermometer	Centigrade	Lower reading…., Upper reading…., 1 smallest div.=…..
8.	Pinch-cock		



Procedure:

1. Place the water tank of the viscosity apparatus at a certain level. Allow the water to come out of the tube at a very low rate (drop by drop). Wait until the water level at the two arms of the manometer take steady values. Take reading of the two tube.

2. Collect water from the output end in a measuring cylinder for a fixed time, say T = 2 minutes. Measure the volume. Again repeat this for three times. From that calculate the volume of water collected per second.

3. Change the height of the water tank several times and repeat steps 1 and 2.

4. Draw a graph with h in the abscissa and V in the ordinate. The curve should be straight line passing through origin. Use the linear portion to calculate the slope h/V.

5. Calculate viscosity

$$\eta = \frac{\pi g \rho r^4}{8l}\left(\frac{h}{V}\right)$$

where g = acceleration due to gravity
ρ = density of the liquid (water)
r = Radius of the capillary tube = 0.068 cm
l = Length of the capillary tube = 25.7 cm
h/V = slope from the graph

Observation:

A) Determination of length of the capillary tube:

Table – I

No. of obs.	Scale reading for the left end of the capillary tube (l_1 cm)	Scale reading for the right end of the rod capillary tube (l_2 cm)	Length ($l_1 \sim l_2$) cm
1			

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

B) Pressure difference from manometer readings and corresponding rate of flow of water:

Table – III

No. of Obs.	Reading of the manometer in cm			Volume of water collected in 3 min's (c.c)				Volume of water collected per sec (cc/sec)
	h_1	h_2	$h = h_1 - h_2$	I	II	III	Mean	
1. 2. ……								

D) Table for drawing graph between h and v [obtained from Table (C)]

Table – IV

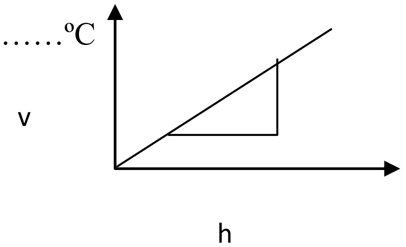
Quantity	1	2	3	4	5	6
v (ml/sec)						
h (cm)						

Plot 'v' vs. 'h graph:

Result:

Hence co-efficient of viscosity of water at temperature ……ºC

$$\eta = \frac{P\pi r^4}{8vl} = \frac{h\rho g\pi r^4}{8vl}$$ =………. Poise.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Discussion:

1. Pressure difference between the ends of the capillary tube should not be high as otherwise the flow of liquid through it will not be stream-line but turbulent.

2. The capillary tube should be horizontal; its diameter should not be more that 2 mm; otherwise the flow of water will not be stream-line.

3. As viscosity of water depends on the temperature, the temperature of water during the experiment should be noted.

4. The radius of the capillary tube occurs in its fourth power in the expression of η and hence it ·demands special care during measurement.

5. For the measurement of volume of water collected, a graduated cylinder of small least count may be used.

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

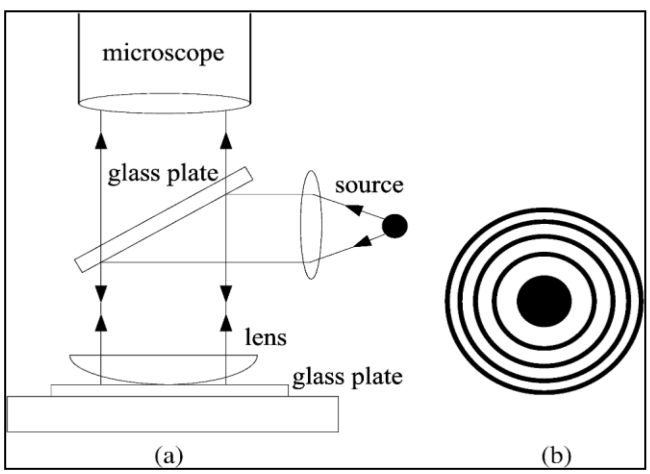
Aim: - Determination of wavelength of given light by Newton's rings method

Theory:

Newton's rings are a system of interference fringes discovered by Isaac Newton. The phenomenon is usually illustrated by the arrangement shown in Figure 1. Monochromatic light is reflected by the glass plate fixed at 45° to the horizontal so that it falls normally on the air film formed between the convex lens and the flat glass plate. The thickness of the air film gradually increases outwards from B to C but is the same at all points on any circle with centre B. Interference occurs between light reflected from the lower surface of the lens and the upper surface of the glass plate. A series of concentric bright and dark rings is seen when a travelling microscope is focused on the air film.

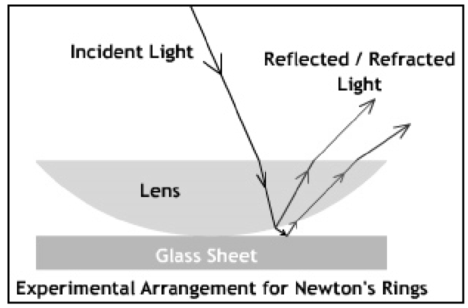
WHY NEWTON'S RINGS ARE FORMED

Newton's rings are formed due to interference between the light waves reflected from the top and bottom surfaces of the air film formed between the lens and glass sheet.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

For destructive interference (Not required for Laboratory Note Book)
To satisfy the condition of nth order minima of interference fringe for a light of wavelength λ

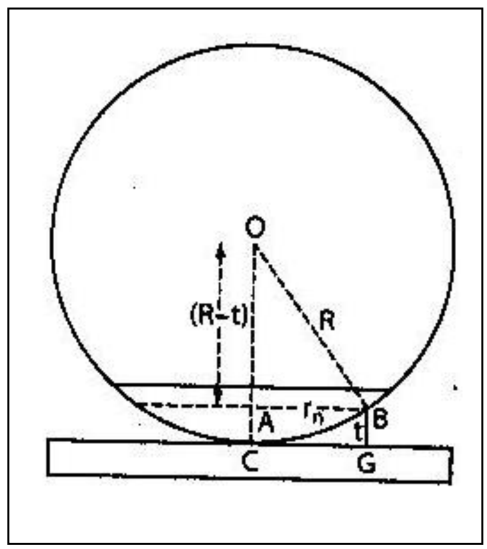


Path difference = $2\mu t\cos(r-\theta)\pm\frac{\lambda}{2}=(2n\pm1)\frac{\lambda}{2}$

Or, $$2\mu t\cos(r-\theta)=2n\frac{\lambda}{2}=n\lambda$$

Where r = angle of refraction and θ = wedge angle. For normal incidence, r = 0 and θ is very very small,

$\therefore\ 2\mu t=n\lambda$, where n = 0,1,2,3,…



Since the optical path difference depends upon thickness of the film (*t*) so, the fringes will be characteristic of equal thickness. Since the thickness is constant at a certain distance away from the contact point of plano-convex lens and plane glass plate along a circular path, so the fringes will be circular.

Now we have to find out the value of '*t* ' geometrically.
From the ΔOAB,
$R^2=r_n^2+(R-t)^2=r_n^2+R^2-2Rt+t^2$
where R = radius of curvature of plano-convex lens and r_n = the radius of the nth ring.
or, $r_n^2\approx 2Rt$ (as t is very small, so t^2 negligible)

$$\therefore t=\frac{r_n^2}{2R}$$

For destructive interference or dark fringe,

$$\therefore\quad 2\mu\frac{r_n^2}{2R}=n\lambda$$

or, $r_n^2=n\frac{\lambda R}{\mu}$ and $D_n^2=4n\frac{\lambda R}{\mu}$

where D_n be the diameter of nth ring.

$$\therefore r_n = \sqrt{n}\sqrt{\frac{\lambda R}{\mu}}$$

So, $r_1 = \sqrt{1}\sqrt{\frac{\lambda R}{\mu}}$, $r_2 = \sqrt{2}\sqrt{\frac{\lambda R}{\mu}}$, $r_3 = \sqrt{3}\sqrt{\frac{\lambda R}{\mu}}$ etc….

so, $(r_2 - r_1)>(r_3 - r_2)>(r_4 - r_3)$……

i.e., dark rings are crowded more and more

Again for central ring, n = 0; which satisfy equation $2\mu t = n\lambda$, when t = 0. Thus the central ring is dark at the point of contact B.

The central ring can however be made bright by introducing a liquid or suitable material between the convex surface of the lens and plate whose μ is greater than that of lens but less than that of the plate.

Working formula:

Diameter for nth order dark ring,→ $D_n^2 = 4n\frac{\lambda R}{\mu}$ and

Diameter for (m + n)th order dark ring, → $D_{m+n}^2 = 4(m+n)\frac{\lambda R}{\mu}$

$$\therefore D_{m+n}^2 - D_n^2 = 4(m+n)\frac{\lambda R}{\mu} - 4n\frac{\lambda R}{\mu} = 4m\frac{\lambda R}{\mu}$$

or, $\lambda = \frac{D_{m+n}^2 - D_n^2}{4mR}\mu$

If the thin layer is made of air, refractive index of air μ = 1 and then

Wavelength of given light $\lambda = \frac{D_{m+n}^2 - D_n^2}{4mR}$

Where

R = Radius of curvature of plano-convex lens

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Principle of experiments:

Newton's rings are formed due to interference by division of amplitude. Here interference takes place between the light waves reflected from the top and bottom surfaces of the thin air film formed between the lens and glass sheet. Since the thickness is constant at a certain distance away from the contact point of plano-convex lens and plane glass plate along a circular path, so the fringes will be circular.

Apparatus:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Newton's ring apparatus consist of a) a plano-convex lens b) a optically plane glass plate	Radius of curvature R = ……….. cm	
2.	Na-vapory lamp	Low pressure lamp	
3.	Convex lens		
4.	Wooden bench		
5.	Travelling Microscope	L.C. = ……	
6.	Table lamp		
7.	Spirit level		

Observation:

A. Measurement of the diameters of the rings:

1 smallest linear division of travelling microscope = ……… cm
…… circular division = ……. Smallest division of main scale
1 circular division = …….. ,, ,, ,, ,, ,, = ……. cm
Least count (l.c) of traveling microscope = ……..cm

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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

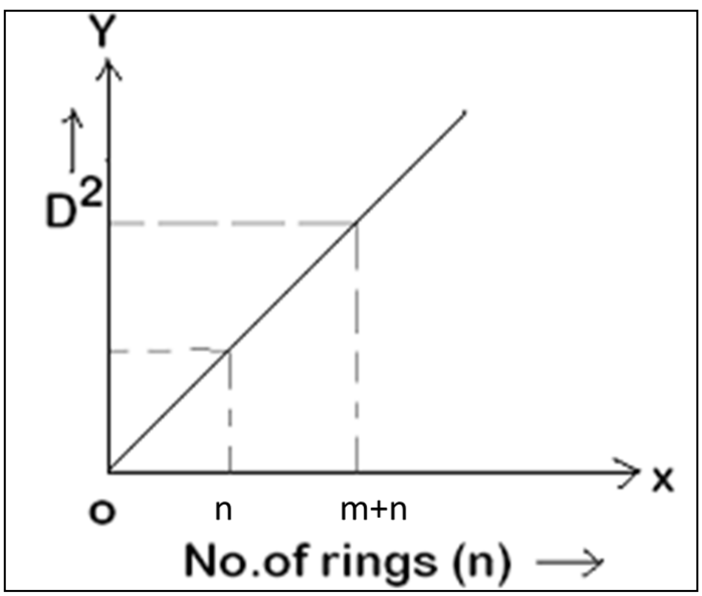
Table – I

No. of rings m	Microscope reading						$D_d = x \sim y$ in cm	D_d^2 in cm^2
	Left side (x)			Right side (y)				
	M.S.R. (cm)	V.S.R. (cm)	Total (cm)	M.S.R. (cm)	V.S.R. (cm)	Total (cm)		
5								
10								
15								
20								
25								

Result:

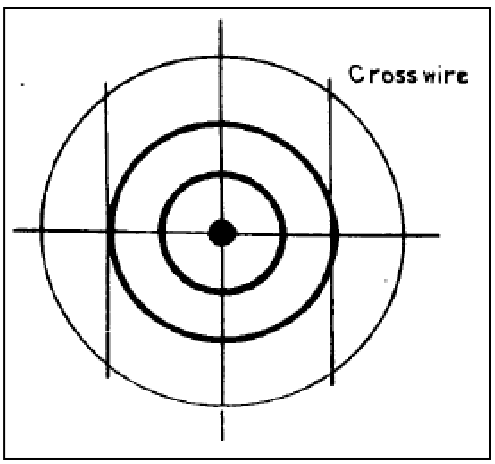
Hence the wavelength of given light

$$\lambda = \frac{D_{m+n}^2 - D_n^2}{4mR} = \text{……….cm.} = \text{……………..Å}$$



Discussion:

1. The set up must not be disturbed in any way during experimentation.
2. The traveling microscope must always be moved in one direction to avoid any backlash error.
3. If we place the cross wire tangential to the outer side of a perpendicular ring on one side of the central spot then the cross wire should be placed tangential to the inner side of the same ring on the other side of the central spot.
4. It is convenient to take the difference or ring numbers (m) as 4 or 5 .
5. The plano-convex lens should be of large radius of curvature.
6. The plano-convex lens and the glass plate should be set in such a way that the central point appears as dark.
7. The success of this experiment depends on the proper illumination arrangement. Accordingly, the source of light, the plate an the convex lens on the wooden bench should be appropriately set to have the maximum and proper illumination incident on the lens–plate system.



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Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of the dispersive power of the material of the given prism

Theory:

The slit of the collimator is illuminated with light. The telescope is turned to view the image of the slit and the collimator screws are adjusted such that a clear image of the slit is obtained without parallax in the plane of the cross-wires. The slit of the collimator is also adjusted to the vertical & narrow.

The refractive index of the material of the prism is given by

$$\mu = \frac{\sin(\frac{A+\delta_m}{2})}{\sin(\frac{A}{2})}$$

Where A is the angle of the equilateral prism and
D is the angle of minimum deviation.

When the angle of incidence is small, the angle of deviation is large. As the angle incidence is slowly increased, the angle of deviation begins to diminish progressively, till for one particular value of the angle of incidence, the angle of deviation attains a least value. This angle is known as the angle of minimum deviation D.

The dispersive power (ω) of the material of the prism is given by

Dispersive power = $(\mu_b - \mu_r) / (\mu - 1)$ where $\mu = (\mu_b + \mu_r) / 2$

Where $\mu_b = \dfrac{\sin(\dfrac{A+\delta_{mb}}{2})}{\sin(\dfrac{A}{2})}$ and $\mu_r = \dfrac{\sin(\dfrac{A+\delta_{mr}}{2})}{\sin(\dfrac{A}{2})}$

Where μ_B= the refractive index of the blue rays

μ_R = the refractive index of the red ray and

μ the mean of μ_B and μ_R

Noting the angle of minimum deviation D, for blue & red rays μ_B and μ_R are calculated using equation (1). Using equation (2) the dispersive power of the material of the prism is calculated.

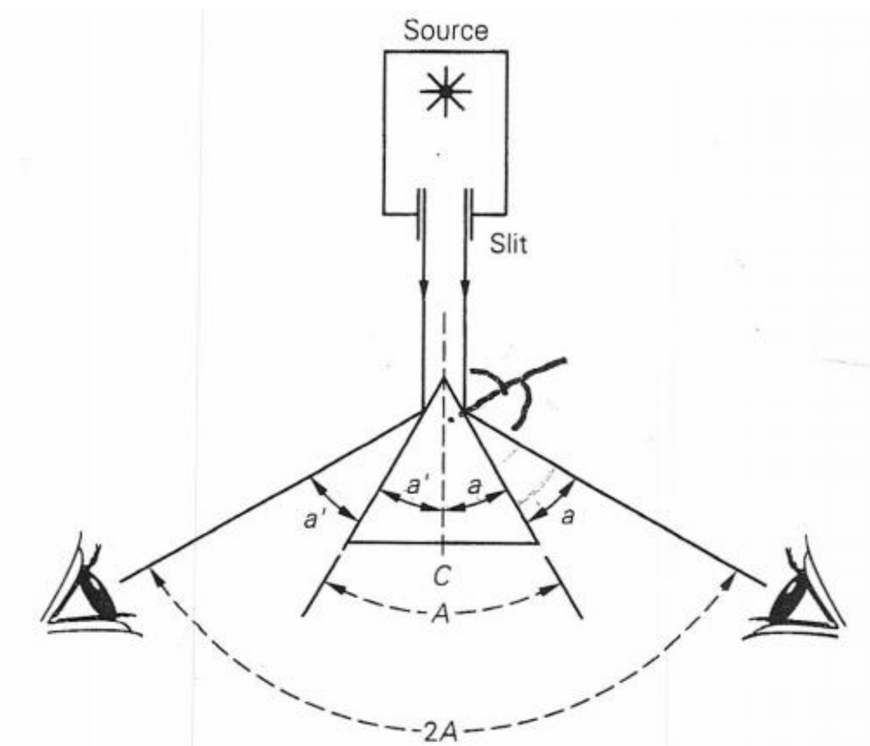

Fig. 1: Angle of the Prism

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

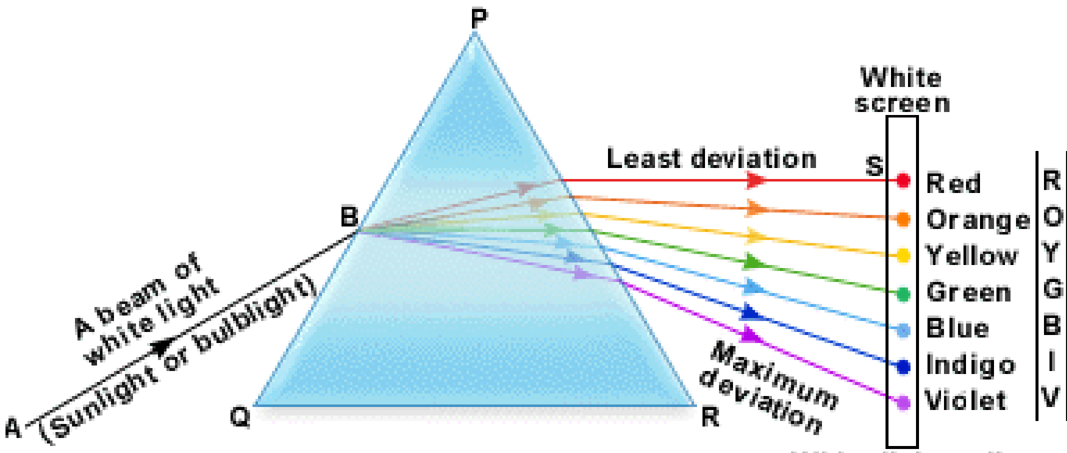

Fig.2: Dispersion of the light

Apparatus:

1. Prism
2. Spectrometer

Observation:

Determination of the vernier constant of the spectrometer:

1 smallest division in main scale = ….degree

….   vernier division = ……   main scale division

1   ….   = .. ………

Vernier Constant (v.c) = 1 main scale division – 1 vernier scale division

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Table I: Determination of the angle of the prism (A)

No of Vernier	Reading with telescope on Left side (R_1) (Degree)			Reading with telescope on Right side (R_2) (Degree)			Difference $2A = R_1 \sim R_2$ (Degree)	Mean 'A' (Degree)
	M.S.R	V.S.R.	Total	M.S.R	V.S.R.	Total		
Vernier 1								
Vernier 2								

Table II: Determination of the angle of minimum deviation

Colour of Light	Vernier 1				Vernier 2				Mean δ_m (Degree)
	M.S.R (Deg)	V.S.R	Total V_1 (Deg)	**$\delta_m = V_1 - V_{01}$ (Degree)**	M.S.R (Deg)	V.S.R	Total V_2 (Deg)	**$\delta_m = V_2 - V_{02}$ (Degree)**	
Blue									
Red									
Direct			V_{01}					V_{02}	

Calculation

Refractive index of the material of the prism for blue colour = $\mu_b = \dfrac{\sin(\frac{A+\delta_{mb}}{2})}{\sin(\frac{A}{2})}$

Refractive index of the material of the prism for red colour = $\mu_r = \dfrac{\sin(\frac{A+\delta_{mr}}{2})}{\sin(\frac{A}{2})}$

where δ_{mb} and δ_{mr} are the angles of minimum deviation for blue and red colour.

Dispersive power = $(\mu_b - \mu_r) / (\mu - 1)$ where $\mu = (\mu_b + \mu_r) / 2$

Discussions:

1. Prism table should not be tilted.
2. Axis of the collimator and telescope should be in the same line during direct reading.
3. During rotation of the prism table utmost care should be taken not to disturb the prism
4. Main scale and vernier scale readings should be taken with care.
5. Minimum deviation position should be maintained while observing the spectra

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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of the wavelength of the given laser light by diffraction method

Working Formula:

The grating equation is $d \sin \theta_m = \pm m\lambda$

If 1/d = N′, then

The wavelength of the given light is given by the formula

$$\lambda = \frac{Sin\theta}{N'm}$$

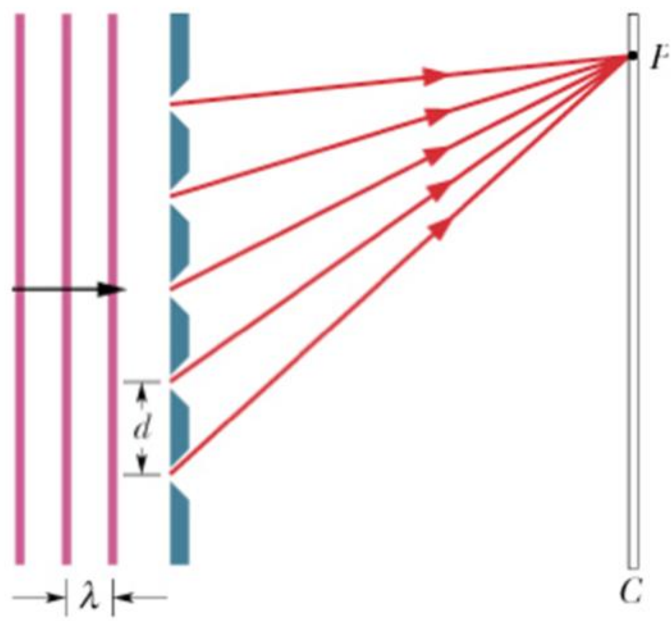
where

d = the grating spacing or slit separation

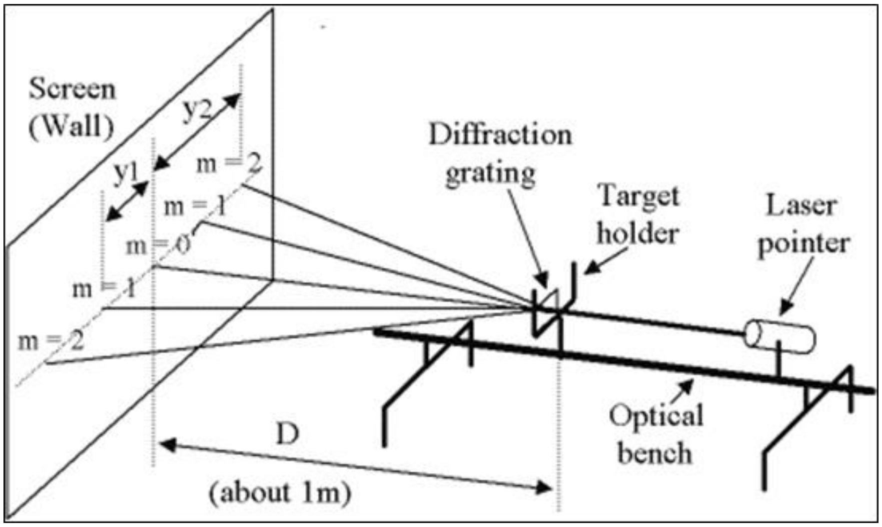
N′ = number of rulings per unit length of the grating,

m = order of the diffraction maximum with respect to the central maximum (taken as the zeroth order),

θ_m = angle of diffraction corresponding to m^{th} order maximum.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even



Principle of Experiment:

Diffraction of light wave by N-slits

Apparatus:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Prism Spectrometer consist of a) Collimator b) Prism table c) Telescope d) Circular angular scale e) Two vernier scales fitted diametrically opposite to one another	V.C. =	0 - 360˚, 1 smallest div. =
2.	Diode laser		
3.	Diffraction Grating	N′ = LPI = lines/cm	
4.	Spirit level		

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Observations:

A) Diffraction angles for different orders

Table I:

<table>
<tr><td rowspan="3">Order No. m</td><td rowspan="3">Vernier No.</td><td colspan="6">Readings for the diffracted images with the telescope at</td><td rowspan="3">Difference between the left and the right readings, $2\theta_m$ (deg)</td><td rowspan="3">Mean θ_m (deg)</td></tr>
<tr><td colspan="3">Left</td><td colspan="3">Right</td></tr>
<tr><td>MSR (deg)</td><td>VSR</td><td>Total (deg)</td><td>MSR (deg)</td><td>VSR</td><td>Total (deg)</td></tr>
<tr><td rowspan="2">1</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
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<tr><td rowspan="2">3</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

B) Estimation of wavelength

Table II:

<table>
<tr><td>Order No. (m)</td><td>θ_m (deg)</td><td>sin θ_m</td><td>$\lambda = \frac{Sin\theta}{N'm}$ (cm)</td><td>Mean wavelength λ (nm)</td></tr>
<tr><td></td><td></td><td></td><td></td><td rowspan="3"></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Result:

The measured value of wavelength of laser light is

$\lambda = \dfrac{Sin\theta}{N'm}$ = ……………….. cm = …………………. Å = ………………… nm.

Discussions:

1. Prism table should be properly leveled.
2. Grating surface is never touched while handling it.
3. Grating should be mounted with its lines parallel to the slit or vertical wire of the cross wire.
4. Prism table should not be disturbed while rotating the telescope to receive images of different orders.
5. Telescope should be rotated slowly; otherwise there is a possibility of missing an order.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Experiment No. :- **Date:-**

Aim: - Determination of the average resistance per unit length of a meter bridge wire by Carey Foster's method and hence to determine the value of an unknown resistance

Working formula:

If the null point is obtained at a length l_1 measured from the left and of the bridge wire, then from Wheatstone bridge principle,

$$\frac{P}{Q} = \frac{X + \alpha + l_1\rho}{Y + \beta + (100 - l_1)\rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where α and β are end corrections and ρ is the resistance per unit length.

If the positions of X and Y are interchanged and a null point is obtained at a length l_2 from left end then,

$$\frac{P}{Q} = \frac{Y + \alpha + l_2\rho}{X + \beta + (100 - l_2)\rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Solving equations (1) and (2) we get

$$\rho = \frac{X - Y}{l_2 \sim l_1}$$

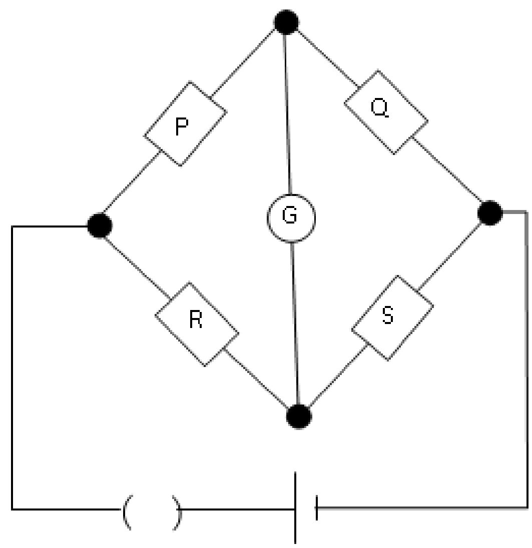
or, $$\boxed{Y = X - (l_2 \sim l_1)\rho}$$

Now, for thick metal strip Y = 0, $$\boxed{\rho = \frac{X}{(l_2 \sim l_1)}}$$

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Principle of experiments:

Wheatstone bridge circuit



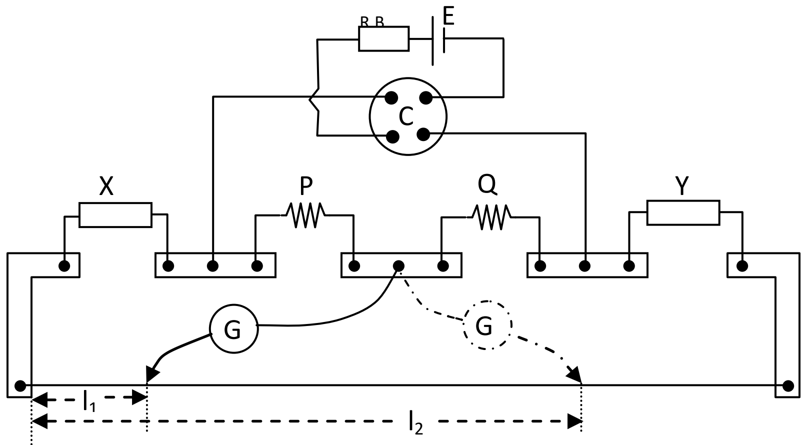
According to Wheatstone bridge principle $\frac{P}{Q} = \frac{R}{S}$.

In this experiment,
$P = P$,
$Q = Q$,
$R = X + l_1 \rho$ and
$S = Y + (100 - l_1) \rho$

Apparatus:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Carey Foster's bridge	A metre bridge with four gaps	
2.	Two almost equal resistances (P & Q)	~ 1 ohm	
3.	Resistance box with fractional resistances (X)		

4.	Rheostat (Rh) / Resistance box (R.B)		
5.	Galvanometer (G)		
6.	Power supply (E)	D.C, 2 volt, 1 amp.	
7.	Commutator (C)		
8.	Connecting wires		
9.	Unknown resistance (Y)		



Procedure:

1. Connect the circuit. Put the fractional resistance box in the extreme left gap and the copper strip in the extreme right gap.

2. Put zero resistance in the box and measure the null point.

3. Put a small value in the box. Measure the null point.

4. Repeat step 3 with other values of the resistance to get null point around 15 to 30 cm. These values should be noted as l_1

5. Interchange the resistance box and the copper strip. Repeat step 3 & 4 with the same values of the resistance. These values should be noted as l_2

6. Put the resistance box in the left gap and unknown resistance box in the right gap. Put some resistance in the box and find out the null point.

7. Repeat step 7 with other values of resistance. These will be treated as values of l_1.

8. Interchange the resistance box and unknown resistance. Repeat steps 6 and 7 for the same values of resistance. These will be treated as values of l_2.

9. Draw a graph 'S' vs. $(l_2 - l_1)$

Observation:

A) Measurement of ρ:

Table – I

No. of obs.	S in Ohm	Position of null point when the copper strip in		$(l_2 - l_1)$	Mean ρ 1/ slope (Ohm/cm)
		Extreme right gap (cm)	Extreme left gap (cm)		
		Direct (l_1)	Direct (l_2)		
1. 2. ……..					

B) Determination of the value of the unknown resistance:

Table – II

Values of P and Q: $P = Q = 1\ \Omega$

No. of Obs.	S in Ohm	Position of null point when the unknown resistance in		$(l_2 - l_1)$ in cm	$R = s - \rho\,(l_2 - l_1)$ in ohm	Mean R ohm
		Extreme right gap (cm)	Extreme left gap (cm)			
		Direct (l_1)	Direct (l_2)			
1. 2. ….						

Result:

Hence resistance per unit length of the bridge wire is $\rho = \dfrac{X}{(l_2 \sim l_1)}$ = …………..Ω/cm

and unknown resistance value is $R = s - \rho\,(l_2 - l_1)$ = …………… Ω

Discussion:

1. In this experiment, the end corrections of the bridge wire need not be considered; they are automatically eliminated.

2. If the values of ρ obtained at different positions of the wire be not same, the wire is not of uniform cross-section. Hence, this experiment gives us a method to check the uniformity of the wire.

3. At the beginning, it should be seen whether with $X = Y = 0$, the null point is obtained at a point very near the 50 cm mark. If the null point is obtained more on the right of 50 cm mark, the resistance P is defective. If, on the other hand, the null point is more on the left of 50 cm mark, the resistance Q is defective.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Part B

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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Expt. No. - **Date:**

Aim: Determination of the band gap of a semiconductor by four probe method and identify the semiconductor material

Theory:

The energy level corresponding to the top of the valance band in an intrinsic semiconductor is denoted as E_v. The energy band which includes free electrons is known as the conduction band. The energy level corresponding to the bottom of the conduction band in an intrinsic semiconductor is denoted by E_c.

The energy gap between the top of the valance band and the bottom of the conduction band is known as band gap $E_g = E_c - E_v$

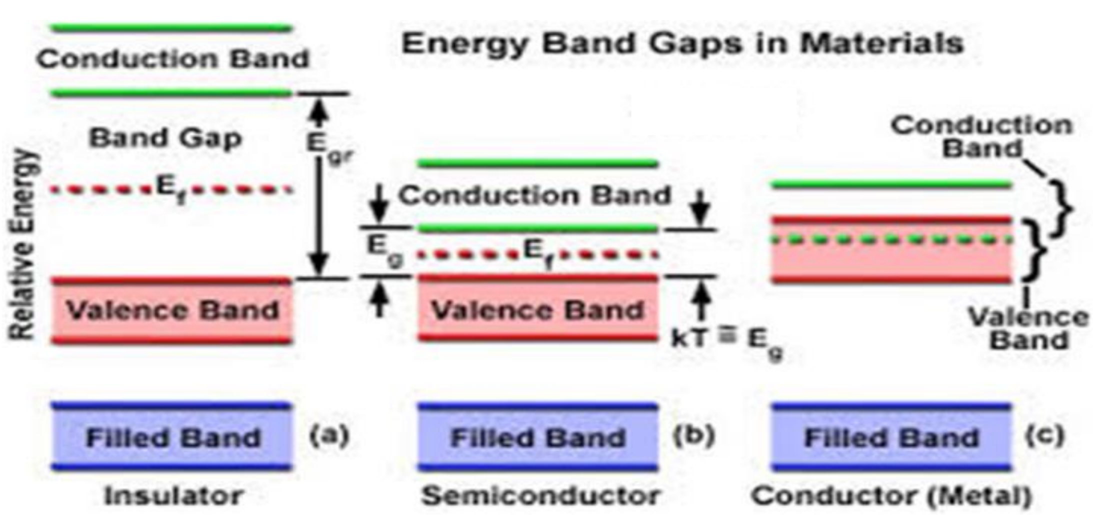
The band gap of a semiconductor can be found out by the following formula:

$$\log_e \rho = \frac{E_g}{2kT} - \log_e A$$

Where, ρ is the resistivity of the semiconductor,

E_g is the band gap of the semiconductor, k is the Boltzmann constant (value is 1.38×10^{-23} J/K)

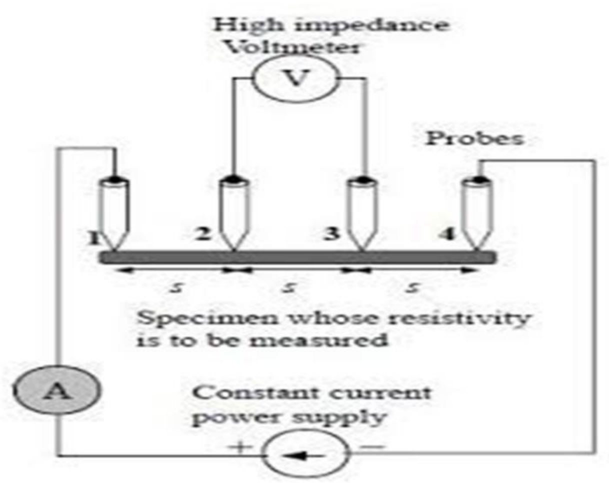
T is the absolute temperature, A is a constant

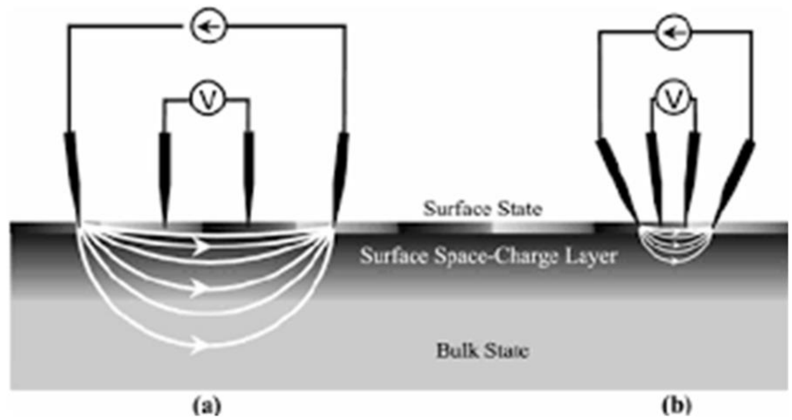


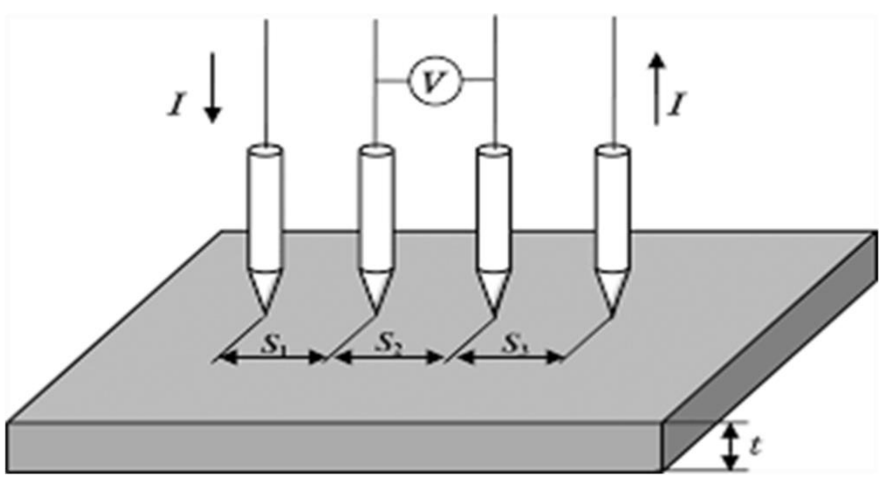
Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Principle of experiment:

The resistivity depends on the temperature of the sample, the band gap on the other hand depends on the resistivity. Hence by changing the temperature of the sample, the resistivity can be altered, a relation between temperature-resistivity data and band gap of the semiconductor. The temperature of course should be given in absolute scale.







Procedure:

1. Insert the thermometer through the hole of the oven
2. Turn on the apparatus. Set the current on 4 mA.
3. Note down the temperature and the voltage obtained.
4. Turn on the oven. Record the temperature and the voltage starting from 30^{o}C at an interval of 5^{o}C up to at least 120^{o}C.
5. Turn off the oven. Record the voltages at the same temperature while temperature is decreasing.
   Calculate the average voltage at each temperature.
6. Draw a graph from the given table
7. Calculate G(W/S) from the graph. Calculateρ. Convert the temperature into Kelvin.
8. Plot a graph of log ρ vs 1/T. Determine the slop from the linear part
9. Eg/2K = slope of the graph

Working formula:

The resistivity of the given semiconductor is given by $\rho = \frac{\rho_0}{\{G(\frac{W}{S})\}}$ where *G(W/S)* is the correction factor and the value of the experiment is **5.89**, which is expressed as

$$G\left(\frac{W}{S}\right) = \frac{2S}{W}\log_e 2$$

Again $$\rho_0 = \frac{V}{I}2\pi S$$

Where *V* is the applied voltage

I is the current

W is the thickness of the crystal whose value is supplied

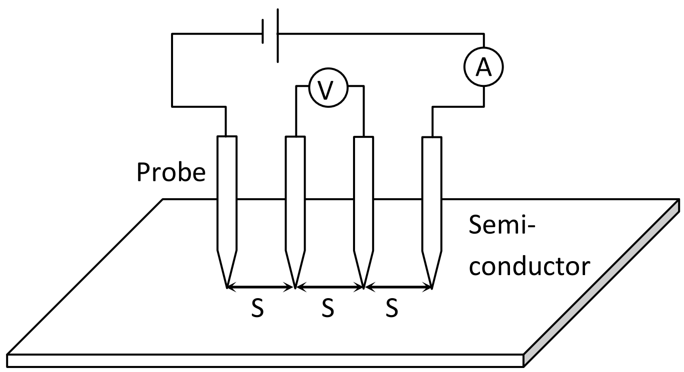
S is the distance between the probes, value of which is supplied.

Band gap energy $E_g = 2 \times k_B T \times (\log_{10} \rho)$

Or, $E_g = 2 \times 8.6 \times 10^{-5} \times (\log_{10} \rho)/ T^{-1}$

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

k_B = Boltzman constant = 8.62 x 10^{-5} eV/^{0}K



Where the resistivity $\rho = \rho_0 / G_7$

Here $\rho_0 = (V/I)\ 2\pi S$

V= potential difference between inner probes

I = Current flowing through outer probes

$G_7 \equiv G_7(W/S)$ is the correction term (i.e. correction factor is function of W & S) = 5.89

S = distance between two successive probes = 0.2 cm

W = Thickness of the crystal = 0. 05 cm

T = Temperature of the sample in K

Thickness of the crystal (w) = 0.07 cm

Distance between the prob (s) = 0.2 cm

The value of K = 1.38 x 10^{-23} J/K

Standard value of Eg in Joule = 1.12 X 10^{-20} J = 0.3 eV

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

1eV = 1.6 x 10^{-19} J

Apparatus:

Sl. No.	Name of apparatus	Specification	Range and resolution
1.	Semiconductor wafer		
2.	Four probe arrangement		
3.	Thermometer	Centigrade	0 – 150^{o} C
4.	oven		

Observation Table:

A) To determine the resistivity (ρ) at different temperature (T) during cooling at constant current I = 4 mA.

B) Table - I

Sl No	Temp (^{o}C)	Voltage (temp increasing) (mV)	Voltage (temp decr-easing) (mV)	Avg Volt. (mV)	Temp in Kelvin	T^{-1} (10^{-3})	$\rho_0 = \frac{V}{I}(2\pi s)$ (Ω - cm)	Resistivity $\rho = \frac{\rho_0}{\{G(\frac{W}{S})\}}$ (Ω - cm)	log ρ
1	40								
2	45								
3	…..								

Result:

$E_g = 2 \times 8.6 \times 10^{-5} \times (\log_{10} \rho) / T^{-1}$

$E_g = 2 \times 8.6 \times 10^{-5} \times$ (slope of the graph $\log_{10} \rho$ vs. T^{-1})

Discussion:

1) The probes should be just touching the wafer
2) The temperature should be taken at intervals of ~ 10^0C
3) The current should be kept constant at ~ 4 mA
4) The maximum temperature should be about 120 K
5) When the current starts to vary, the data should no further be taken.

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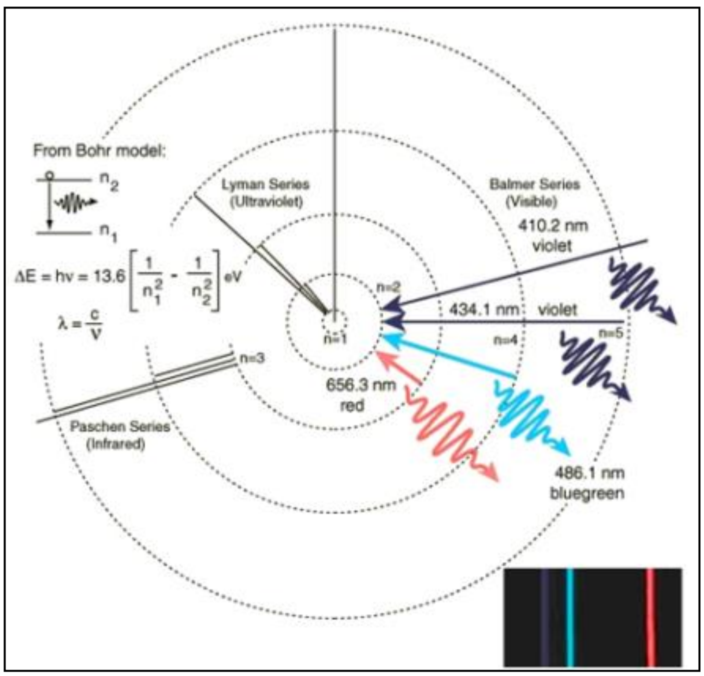
Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Expt. No. - **Date:**

Aim: To determine the Rydberg's constant by studying Hydrogen spectrum (with the help of diffraction grating)

Theory:

Balmer series is the emission spectrum associated with the transition of electrons from states with principal quantum number n > 2 to the state with n = 2. When an electron jumps from outer orbit to the second orbit , we obtain the Balmer series i.e., this a series for which $n_1 = 2$ and $n_2 = 3,4,5,\ldots$etc. this series lies in the visible region of the spectrum.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

WORKING FORMULA

The wavelength of the corresponding lines are expressed by a formula

$$\frac{1}{\lambda} = R_h \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \quad \text{......... (1)}$$

Where, $n_1 = 2$ and $n_2 > 2$,
In hydrogen spectrum there are lines, namely

H_α : n2 = 3; Colour = red
H_β : n2 = 4; Colour = blue-green
H_γ : n2 = 5; Colour = violet

In the present experiment wavelengths of these lines are determined by measuring the angle of diffraction by a transmission grating using the formula

$$(a+b)\sin\theta = n\lambda$$

Here 'a' is the width of the opaque line in the grating and 'b' is the width of the transparent region between two opaque lines and consequently (a+b) = 1/N, where N is the number of rulings per unit length of the grating. 'N' is the order of the spectrum and θ is the angle of diffraction.

Knowing λ, n_1 & n_2 , R_H can be determined from eqn. (1).

<u>To find wavelength λ:</u>

$$\lambda = \frac{\sin\theta}{nN}$$

where, θ = angle of diffraction
n = order of primary maximum.
N = number of lines per cm ruled on the grating

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Apparatus:

Item No.	Name of apparatus	Specification	Range & Resolution
1	Spectrometer		
2	Grating	Glass/plastic ………. Lines/cm	
3	Hydrogen discharge tube		
4	Induction coil		

Observation:

Determination of the vernier constant of the spectrometer:

Smallest division in main scale m	Number of division in the vernier scale n	No of coincident div. in the main scale w	Vernier Constant m(1 – w/n)

Determination of angle of diffraction:

n_1=2 and n_2 =……….. (…………….colour)

“n” is the no. of rulings per inch

No. of rulings N = ------------ per cm

Table: 1

Order of spectrum	Colour	Vernier	Left spectrum			Right spectrum			Difference 2θ	Avg θ
			MSR	VSR	Total	MSR	VSR	Total		
First	Red	V1								
		V2								
	Blue-Green	V1								
		V2								
		V2								

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Result: Hence the Rydberg constant $R_H = \frac{1}{\lambda} \times \frac{1}{\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$ = ………….. m^{-1}.

Discussion:

1. Before performing the experiment, the spectrometer should be adjusted.

2. Grating should not be touched by fingers.

3. Grating should be set normal to the incident light.

4. Both verniers should be read.

5. While taking observations, telescope and prism table should be kept fixed.

Verification of R_H :

$$\Delta E = hc\left(\frac{m_e e^4}{8\varepsilon_0^2 h^3 c}\right)\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Where, m = mass of an electron = 9.106×10^{-28} gm
e = electronic charge = 4.8025×10^{-10} e.s.u
h = Planck's constant = 6.625×10^{-27} ergs-sec
c = speed of light in vacuum = 2.998×10^{10} cm/sec.

Standard value of $R_H = 1.0973 \times 10^7$ m^{-1}

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Expt. No. - **Date:**

Aim: TO DETERMINE THE DIELECTRIC CONSTANT OF A CAPACITOR

Theory:

When the dielectric material is introduced between two gold-plated brass discs of a parallel plate capacitor, it is found that the capacitance increase by a factor ε_1 which is the relative permittivity/ dielectric constant of the material. It is the ratio of actual permittivity of the medium to that of air.

WORKING FORMULA

The capacitance of a parallel plate capacitor having air between the plate is given by $C_o = \varepsilon_0 A/d$ (in F) where ε_0 = permittivity of air = $10^9/36\pi$, A = Area of each plates of parallel capacitor = πr^2, d = distance between parallel plates.

Now $Co = r^2 / (36d \times 10^9) = r^2 / 36d$ nF
Where r represents the radius of gold-plated brass disc and d represents the thickness of the sample.
Then $\varepsilon_1 = C_T/C_o$ where C_o represents the capacitance of dielectric cell with the plates separated by air whose thickness is the same as the thickness of the sample material and C_T represents the capacitance with sample.

ATTN (α) = Attenuation α constant
INT = Integrator with R = 680 KΩ and $\boldsymbol{C_T = \frac{V_S(PP)\alpha T}{8Ri\, V_0(p)}}$

T = 1/F
F1 = 1.47 KHz, F2 = 0.76 KHz, F3 = 0.53 KHz
α = 1/11, Ri = 680 KΩ, Vs(PP) = 20 V

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Procedure & Results:

1. Find the vernier constant of Slide Callipers

2. Find the thickness of each material (Teflon, Bakelite, Plywood, Rubber and Glass)

Material	Observation	M.S.R. (cm)	V.S.R.(cm)	Average Thickness (cm)	Average Thickness (m)
	1. 2. 3.				

3. Measure the circumference of the material and from this find out the radius of the material in **<u>meter unit</u>** (Circumference = $2\pi r$)

4. Find Co each of the material.

5. Insert each of the material inside the parallel plate capacitor. Take Vs (pp) = 20 V. For each frequency find out the Vo (p).

Material	Frequency (kHz)	Vo(p) (volt)
1.	F1	
	F2	
	F3	
2.	F1	
	F2	
	F3	
3.	F1	
	F2	
	F3	
4.	F1	
	F2	
	F3	

6. Find out C_T and find out ε_1 from the formula

$$C_T = \frac{V_S(PP).\alpha.T}{8R_i V_0(PP)}, \qquad \varepsilon_1 = \frac{C_T}{C_0}$$

Discussion:

1. Describe how we make sure the overlapping area of the parallel plates is consistent throughout the experiment?
2. Propose a method to reduce the error in measuring the thickness of the paper / plastic films.
3. Justify whether it is reasonable to assume the thickness for every sheet of paper / plastic film is the same as far as the dielectric constant measurement method concerned.
4. Justify whether the measurement results are satisfactory.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

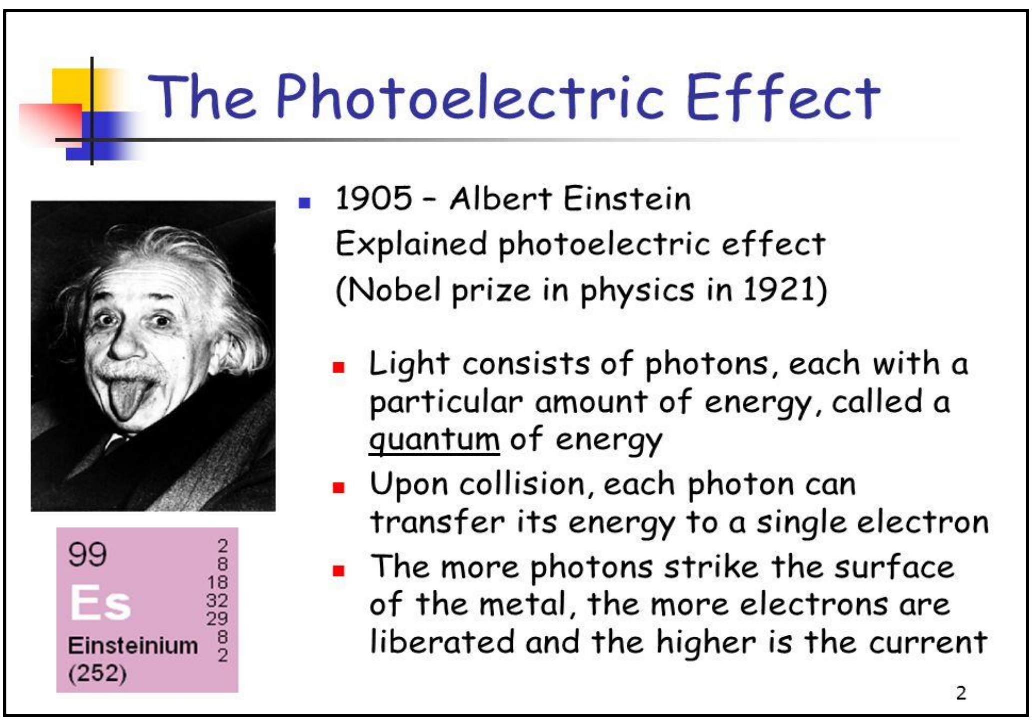
EXPT. NO. - **DATE:**

Aim: Determination of Planck's constant 'h' by measuring radiation in a fixed spectral range

Theory:

The Planck constant (denoted *h*), also called Planck's constant, is a physical constant reflecting the sizes of quanta in quantum mechanics. It is named after Max Planck, one of the founders of quantum theory, who discovered it in 1899.

To account for the distribution of energy in the spectrum of black body radiation plank developed the quantum theory of radiation. According to this theory, radiation can be emitted or absorbed only in discrete unit corresponds to an energy E. Given by E = hv,
where v = is the frequency of radiation
h = is the plank's constant, h = 6.625 x 10^{-34}js.



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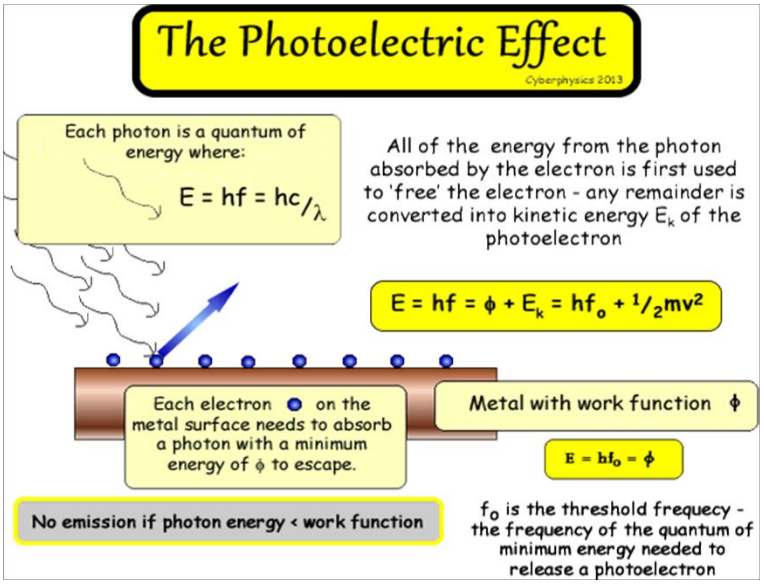
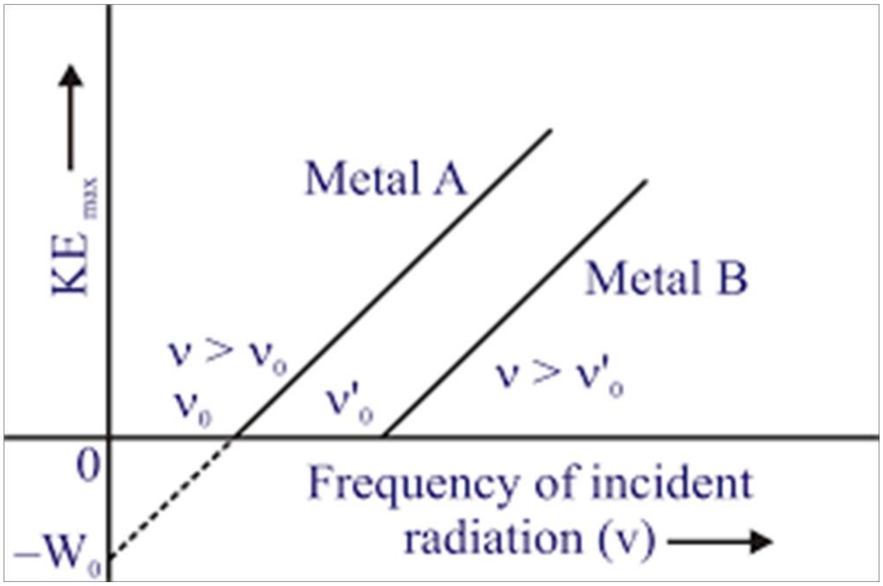
Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even





Principle of experiments:

The Planck constant was first described as the proportionality constant between the energy (E) of a photon and the frequency of its associated electromagnetic wave (ν). This relation between the energy and frequency is called the Planck relation or the Planck–Einstein equation:

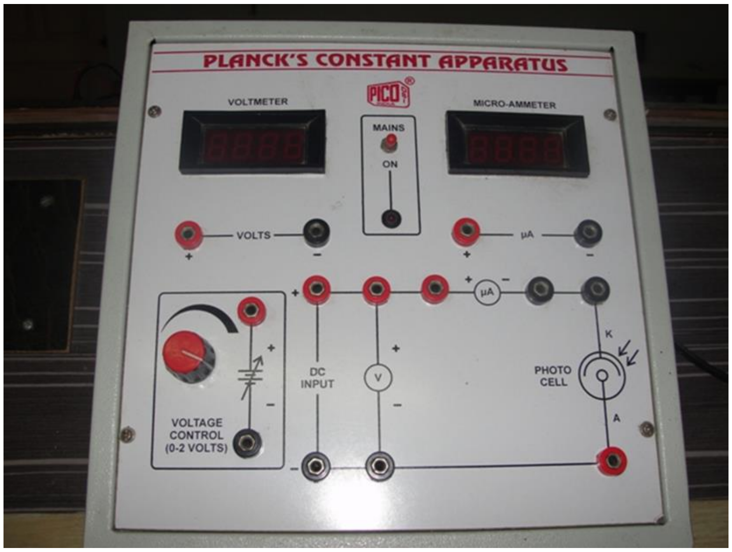
From Einstein equation we know

$$h\nu = h\nu_0 + eV_s$$

Where,
ν = incident frequency
ν_0 = threshold frequency
V_s = stopping potential
h = Planck's constant

A graph is then plotted between the frequency of light and the corresponding stopping potential. A straight line is obtained. Slope will give the value of (*h/e)*, hence *h* can be calculated from the slope.

$$h = -\frac{\lambda k}{c}\left(\frac{d(ln\theta)}{d(\frac{1}{T})}\right)$$



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RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Apparatus:

Name of apparatus	Specification	Range and Resolution
Planck's constant kit having a) Photodiode b) Filament bulb c) Potentiometer d) Ammeter e) Voltmeter f) Micro ammeter	 Single point 12 V, DC DC, Analog DC, Analog Digital	 0 - …… , …….. A 0 -……. , …….. V 0 - ……, …….. µA

Procedure & Results:

1. Turn on the system. Turn on the voltage control knob an very carefully observe when exactly the knob start glowing. Note the voltage and current and hence resistance of the knob. This is Rg.

Table to find Rg

No. of Obs.	Voltage (V)	Current (A)	Resistance (R_g) (Ohm)	Avg. Resistance (R_g) (Ohm)
1.				
2.				
3.				

2. Increase the voltage in small steps (0.5 V) and record the current and hence calculate the resistance. These are the values of R. Note also the photocurrent, θ.

Table to find the resistance and hence temperature

Voltage (V)	Current (A)	Resistance R(ohm)	R/R_g	T from equation 1	1/T (10^{-4}) (K^{-1})	Photocurrent θ	Inθ

3. From the below table of *R/Rg* and T draw a graph *(T vs R/R_g)*. Use this graph to determine the temperature; T of the filament from the experimentally observed value of R/Rg obtained in step 1 and 2. Calculate 1/T.

$$T = 150.141 + 634.007\left(\frac{R}{R_g}\right) \text{ -------- (1)}$$

4. Draw a graph of *$ln\theta$ vs. 1/T.*

5. Determine h from the slope of this curve and from the equation

$$\boldsymbol{h = -\frac{\lambda k}{c}\left(\frac{d(ln\theta)}{d(\frac{1}{T})}\right)}$$

Where,

λ = 6000 X 10^{-10} m, k = 1.38 X 10^{-23} J/K, c = 3 X 10^{8} m/s

Standard value of Plank constant is 6.6 X 10^{-34} Js

Discussions:

1. The setup should be initialized as follows: the light source should be turned away from the photocell and the ammeter dial adjusted so that it reads 0 for zero input voltage in presence of laboratory light.
2. The source light is then turned towards the photocell and the value of I for V = 0 recorded.
3. For small increments of V, I is recorded. After I saturates (or even before that, as all we are interested in is the stopping potential), we stop taking readings for increasing V. V is returned to the value V=0, the polarity of the connections to the photocell reversed by switching the wires, and V is again changed in small steps until I=0. The value of V obtained now is the stopping potential V_S.
4. Precaution should be taken so that no external light falls on the photodiode.
5. The voltage should not exceed limit so that the filament gets detached after long exposure.

Department of Applied science
RCC Institute of Information Technology, Kolkata
Canal South Road, Kolkata - 700015

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

EXPT. NO. - **DATE:**

Aim: DETERMINATION OF STEFAN'S CONSTANT USING A VACUUM TUBE DIODE (TYPE EZ-81 EMISSION)

Theory:

The **Stefan–Boltzmann law**, also known as **Stefan's law**, states that the total energy radiated per unit surface area of a black body per unit time (known variously as the black-body **irradiance**, **energy flux density**, **radiant flux**, or the **emissive power**), j^*, is directly proportional to the fourth power of the black body's thermodynamic temperature *T* (also called **absolute temperature**):

$$j^{\star} = \sigma T^4.$$

The constant of proportionality σ, called the Stefan–Boltzmann constant or **Stefan's constant**, derives from other known constants of nature. The value of the constant is

$$\sigma = \frac{2\pi^5 k^4}{15c^2h^3} = 5.670400 \times 10^{-8}\,\mathrm{J\,s^{-1}m^{-2}K^{-4}},$$

where k is the Boltzmann constant, h is Planck's constant, and c is the speed of light in a vacuum. Thus at 100 K the energy flux density is 5.67 W/m^2, at 1000 K 56,700 W/m^2, etc.

To find the total absolute power of energy radiated for an object we have to take into account the surface area, A(in m^2):

$$P = Aj^{\star} = A\varepsilon\sigma T^4.$$

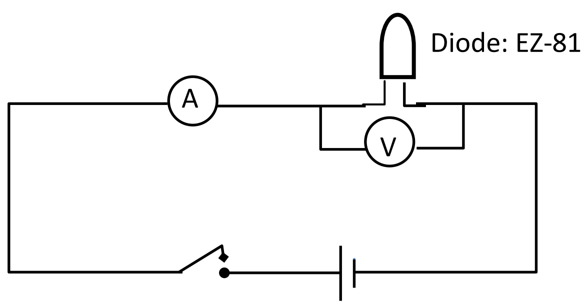
Emissivity: The ratio of the radiation emitted by a surface to the radiation emitted by a perfect blackbody radiator at the same temperature.

Emissive Power/Emittance: The power radiated per unit area of a radiating surface.

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Black Body: Substance which absorbs all the incident radiations completely and the body appear black whatever be colour of the incident radiations on it is called black body. Since a perfect absorber is also a perfect emitter, the body emits radiation of all wavelengths. In fact no substance possesses strictly the property of an ideal black body.
If a black body is placed in an isothermal enclosure it will attain thermal equilibrium with the enclosure and emit full radiation characteristic of temperature but independent on the nature of the substance. Hence the thermal radiation from an isothermal enclosure is identical with that from a black body at the same temperature.

Principle of experiments:
Applying Stefan's law to the heated cylindrical cathode due to tungsten filament, we can determine Stefan's constant from the knowledge of the surface area and the emissivity of the cathode which is less than unity in this case as the radiation from cathode by thermionic emission process is not from an ideal black body.



WORKING FORMULA

From Stefan's Law, we get

$$P = E\sigma ST^n$$

$$\boldsymbol{logP = \log(E\sigma S) + nlogT}$$

And R-T relation for tungsten is

$$\frac{R_T}{R_{273}} = \left[\frac{T}{273}\right]^{1.2}$$

Where $P = V_f I_f =$ Power radiated by cathode

V_f = filament voltage
I_f = filament current

ε = emissivity of the cathode surface = 0.24
S = $2\pi r\, l$ = surface area of the cathode
r = radius of the cathode = 0.12 x 10^{-2} m = 0.0012 m
l = length of the cathode = 3.12 x 10^{-2} m = 0.0312 m
T = Temperature of tungsten filament in Kelvin
R_T = Temperature coefficient of resistance

APPARATUS:

Item No.	Name of Apparatus	Specification	Range & Resolution
1.	Stefan's constant kit having a) Vacuum diode made of main components as i. cylindrical cathode made of nickel and coated with BaO &SrO mixture outside. ii. electrically insulated tungsten heater filament with a thin coating of plaster of paris, closely fitted with the nickel cathode and placed inside it. b) Power supply c) Voltmeter d) Ammeter	Diode model: EZ-81 DC Digital Digital	

Observation:

Calculation of temperature from these relations

$$T = 144.57 + 187.316\left(\frac{R_T}{0.6}\right)$$

A) **Characteristics of filament:**

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Table - II

Sl. No.	V_f (volt)	I_f (amp)	$R_T = V_f / I_f$ (Ω)	$P = V_f I_f$ (watt)	$R_T/0.6$	T (K)	Log P	Log T
1	0.2							
2	0.4							
3	0.6							
4	0.8							
5	1							
6	2							
7	3							
8	4							
9	5							

Result:

Hence measured value of Stefan's constant σ = ……………………… w m^{-2} K^{-4}

Discussions:

1. In taking readings between V_f and I_f every reading should be taken after getting steady state or the time difference between each reading should be approximately 3 to 4 minutes.

2. In plotting the graph between log P and log T the experimental point at the lower end of temperature state lies outside the straight line graph, since corrections due to heat power loss are neglected. At high temperature these losses are not negligible and so in fig.-2 the straight line is drawn through such points.

3. It should be necessary to determine the slope of the straight line as accurately as possible to verify the Stefan's law within experimental errors.

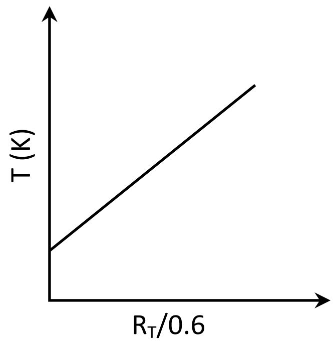


Fig.-1

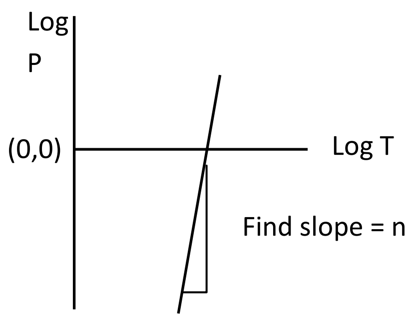


Fig.-2

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Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Expt. No. - **Date:**

Aim: VERIFICATION OF BOHR'S ATOMIC ORBITAL THEORY

Theory:

Bohr's Atomic Model:

Assumption:

- Electron has only *certain* energies in the hydrogen atom
- Bohr called these *allowed energy levels*
- The atom can occasionally jump between energy levels, emitting a photon when it makes a transition to a lower energy state and absorbing a photon when jumping to a higher energy level
- *The difference in the energy between the two levels is* $\Delta E = nh$
- *So have discrete lines observed in hydrogen spectrum*

Postulate 1: Only certain orbits are stable. These are *stationary* or more precisely *quasi-stationary states*. An electron *does not* emit EM radiation when in one of these states (orbits)

Postulate 2. If the electron is initially in an allowed orbit (stationary state), *i*, having the energy, E_i, goes into another allowed orbit, *f*, having energy, E_f ($< E_i$), EM radiation is emitted, with *energy* and *frequency*

Postulate 3. The electron can only have an orbit for which the angular momentum of the electron, *L*, takes on discrete values (the orbits are quantized)

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

$$h\nu = E_i - E_f$$

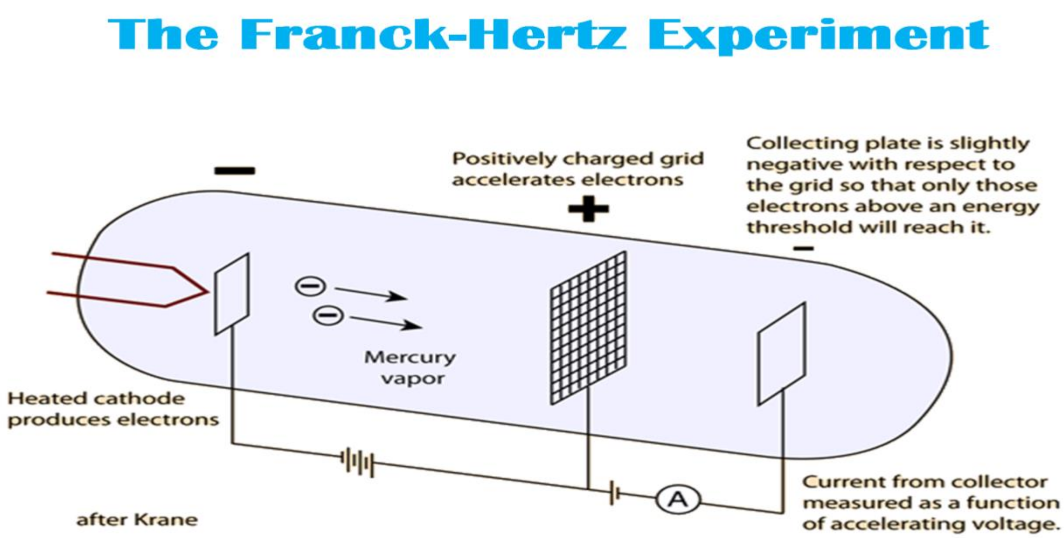
$$\nu = \frac{E_i - E_f}{h}$$

$$L = m_e vr = n\hbar$$

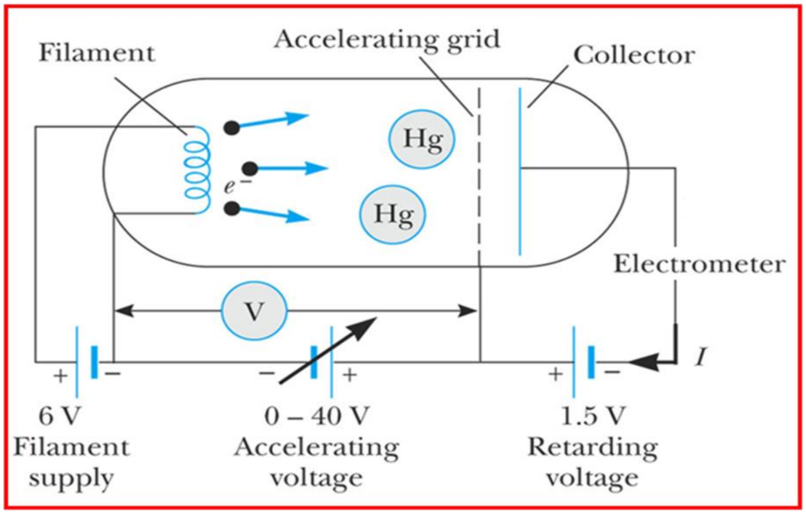
$$\hbar = \frac{h}{2\pi}$$

Principal of experiment:

In 1914, **James Franck and Gustav Hertz** performed an experiment which demonstrated the existence of excited states in mercury atoms, helping to confirm the quantum theory which predicted that electrons occupied only **discrete, quantized energy states**. Electrons were accelerated by a voltage toward a positively charged grid in a glass envelope filled with mercury vapor. Past the grid was a collection plate held at a small negative voltage with respect to the grid. The values of accelerating voltage where the current dropped gave a measure of the energy necessary to force an electron to an excited state.



Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even



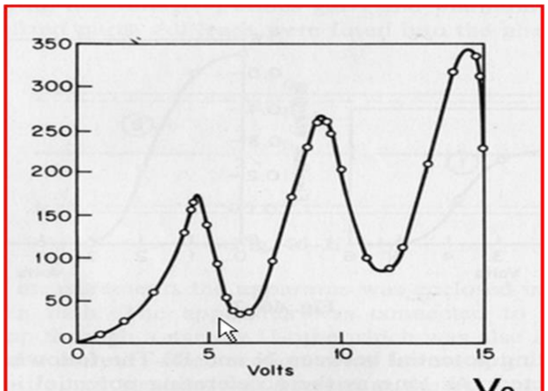


Fig. 46–3.

Procedure & Results:

1. Turn on the system after confirming that all control knows is in their minimum position.
2. Turn on the ‘manual/ auto’ switch to manual
3. Turn the voltage display sector to and adjust the V_{G1k} control knob to 1.5V.
4. Selecting the appropriate display set V_{G2k} to 7.5V.
5. Change the value of V_{G2k} in small steps and record the current reading.

V_{G1k} = 1.5V, V_{G2k} = 7.5V

V_{G2k} in volts	Plate current (I) X10^{-7} in amp

6. Draw graph showing the variation of current as a function of accelerating voltage.
7. Turn the ‘manual/ auto’ switch to auto.
8. Connect the instrument’s Y, G, X sockets to the corresponding ports of the oscilloscope. Set the oscilloscope to x-y mode and the trigger to external x.
9. Adjust the shift and the gain switches to obtain a clear waveform. Apply the maximum scan range through the instrument.

To measure the excitation potential from the CRO – NA

No. of obs	Distance between the peaks (no. of divisions) n	Gain factor (volts/div) g	Excitation potential ng (eV)	Average excitation potential (eV)

10. Measure the average horizontal distance between the peaks. This would give the value of Argon atom’s first excitation potential in eV.

To measure the excitation potential from the graph

No. of Obs	Distance between peaks to peaks (V)	Average distance between peaks to peaks (V)	Average excitation potential energy (eV)
1	2 – 1 =		
2	3 – 2 =		
3	4 – 3 =		
4	5 – 4 =		
5	6 – 5 =		
6	7 – 6 =		

Paper Name: Physics -1 Laboratory
Paper Code: BS-PH 191/ BS-PH 291
Semester: Odd / Even

Discussions:

1. Potential sources of error:

   a) Recommended retarding voltage too low
   b) Filament voltage possibly incorrect

2. Discuss and give examples of the effect of varying the various parameters on:

   (a) the number of visible peaks, (b) the contrast between peaks and valleys
   (c)the first visible peak. (d) spacing between peaks