1. DE-SAUTY BRIDGE

Object: To determine the capacitance of two capacitors by De-Sauty bridge.

Apparatus Used: De-Sauty bridge, connecting wire, Head phone.

Formula Used: The following formula is used for the determination of self inductance of coil.

$$C_x = \frac{P}{Q} C_0$$

Where, *Cx*: capacitance of unknown capacitor; C_0: capacitance of unknown capacitor;

P and *Q*: resistances

Circuit Diagramme:

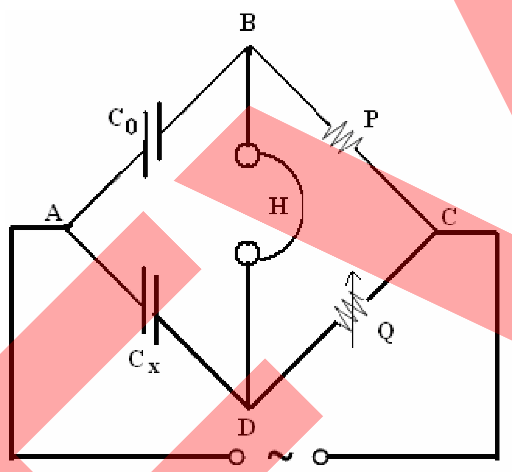


Fig: Circuit diagram of De-Sauty Bridge

Observation:

1. C_0=0.1μf
2. **Table for value of P and Q for Ist capacitor**

Sr. No.	P(Ω)	Perception of sound with Q	Q (Ω) (At no sound)	C(μf) $C_x = \frac{P}{Q}C_0$	Mean C(μf)
1.	120	50-sound 60- no sound 70- sound	60	0.2	0.2
2.	240	110-sound 120- no sound 130- sound	120	0.2	
3.	360	170- sound 180- no sound 190- sound	180	0.2	
4.	480	230- sound 240- no sound 250- sound	240	0.2	

3. Table for value of P and Q for IInd capacitor

Sr. No.	P(Ω)	Perception of sound with Q	Q (Ω) (At no sound)	C(μf) $C_x = \frac{P}{Q}C_0$	Mean C(μf)
1.	120	30- sound 40- no sound 50- sound	40	0.3	0.3
2.	240	70-sound 80- no sound 90- sound	80	0.3	
3.	360	110- sound 120- no sound 130- sound	120	0.3	
4.	480	150- sound 160- no sound 170- sound	160	0.3	

4. Table for value of P and Q for IIIrd capacitor

Sr. No.	P(Ω)	Perception of sound with Q	Q (Ω) (At no sound)	C(μf) $C_x = \frac{P}{Q}C_0$	Mean C(μf)
1.	120	20- sound 30- no sound 40- sound	30	0.4	0.4
2.	240	50-sound 60- no sound 70- sound	60	0.4	
3.	360	80- sound 90- no sound 100- sound	90	0.4	
4.	480	110- sound 120- no sound 130- sound	120	0.4	

Result:

1. Capacitance of Ist capacitor = 0.2μf
2. Capacitance of IInd capacitor =0.3μf
3. Capacitance of IIIrd capacitor = 0.4μf

Precaution:

1. Connections should not be loose.
2. The resistances should be high.
3. If there is found no sound in head phone for a range of Q resistance then total range should be noted and mean of them should be taken for Q at no sound.

2.Wavelength of LASER Source with diffraction

Object: To determine the wavelength of given LASER source.
Apparatus Used: Laser source, meter scale and grating.
Formula Used: The following formula is used for the determination the wavelength of given LASER source .

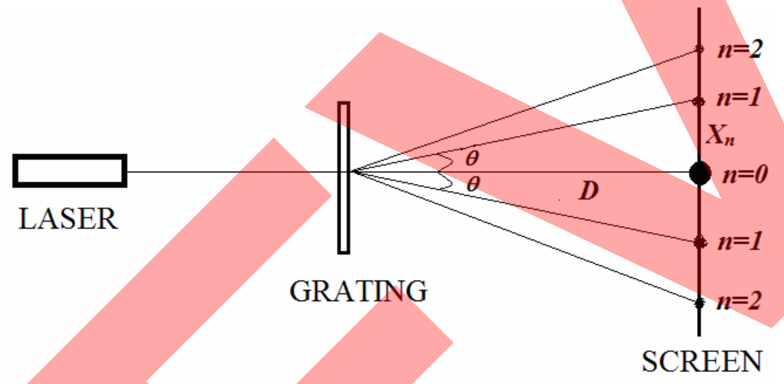
$$(e+d)\sin\theta = n\lambda$$

$$\lambda = \frac{(e+d)\sin\theta}{n}$$

Where, $(e+d)$=grating element, θ=angle of diffraction,
n =order of diffraction , λ = wavelength of LASER source

$$\sin\theta = \frac{X_n}{\sqrt{X_n^2 + D^2}}$$

Ray Diagram:



Observation:

1. number of line per inches of grating (N)=15000
2. grating element=$(e+d) = \frac{2.54}{N} = \frac{2.54}{15000} = 1.7\times10^{-4}\,cm$
3. Table for D and X_n

Sr.No.	D (cm)	n	X_n (cm) Left side	Right side	Xn
1.	35	1	14.5	14.5	14.5
		2	44.0	45.0	44.5
2.	55	1	23.0	23.0	23.0
		2	71.0	72.0	71.5
3.	75	1	31.0	31.0	31.0
		2	98.0	99.0	98.5

Calculation:

1. For D=35cm and n=1

$$\sin\theta_1 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{14.5}{\sqrt{14.5^2 + 35^2}} = \frac{14.5}{\sqrt{210.25 + 1225}} = \frac{14.5}{\sqrt{1435.25}} = \frac{14.5}{37.89} = 0.3827$$

$$\lambda_1 = \frac{1.7\times10^{-4}\times0.3827}{1} = 0.6506\times10^{-4}\,cm = 6506\times10^{-8}\,cm = 6506\ \text{Å}$$

2. For D=35cm and n=2

$$\sin\theta_2 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{44.5}{\sqrt{44.5^2 + 35^2}} = \frac{44.5}{\sqrt{1980.25 + 1225}} = \frac{44.5}{\sqrt{3205.25}} = \frac{44.5}{56.62} = 0.7859$$

$$\lambda_2 = \frac{1.7\times10^{-4}\times0.7859}{2} = \frac{1.336\times10^{-4}}{2} = 0.6680\times10^{-4}\,cm = 6680\times10^{-8}\,cm = 6680\ \text{Å}$$

3. For D=55cm and n=1

$$\sin\theta_3 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{23.0}{\sqrt{23^2 + 55^2}} = \frac{23.0}{\sqrt{529 + 3025}} = \frac{23.0}{\sqrt{3554}} = \frac{23.0}{59.62} = 0.3858$$

$$\lambda_3 = \frac{1.7\times10^{-4}\times0.3858}{1} = 0.6559\times10^{-4}\,cm = 6559\times10^{-8}\,cm = 6559\ \text{Å}$$

4. For D=55cm and n=2

$$\sin\theta_4 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{71.5}{\sqrt{71.5^2 + 55^2}} = \frac{71.5}{\sqrt{5112.25 + 3025}} = \frac{71.5}{\sqrt{8137.25}} = \frac{71.5}{90.21} = 0.7926$$

$$\lambda_4 = \frac{1.7\times10^{-4}\times0.7926}{2} = \frac{1.3474\times10^{-4}}{2} = 0.6737\times10^{-4}\,cm = 6737\times10^{-8}\,cm = 6737\ \text{Å}$$

5. For D=75cm and n=1

$$\sin\theta_5 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{31.0}{\sqrt{31^2 + 75^2}} = \frac{31.0}{\sqrt{961 + 5625}} = \frac{31.0}{\sqrt{6586}} = \frac{31.0}{81.15} = 0.3820$$

$$\lambda_5 = \frac{1.7\times10^{-4}\times0.3820}{1} = 0.6494\times10^{-4}\,cm = 6494\times10^{-8}\,cm = 6494\ \text{Å}$$

6. For D=75cm and n=2

$$\sin\theta_6 = \frac{X_n}{\sqrt{X_n^2 + D^2}} = \frac{98.5}{\sqrt{98.5^2 + 55^2}} = \frac{98.5}{\sqrt{9702.25 + 5625}} = \frac{98.5}{\sqrt{15327.25}} = \frac{98.5}{123.8} = 0.7956$$

$$\lambda_6 = \frac{1.7\times10^{-4}\times0.7956}{2} = \frac{1.3525\times10^{-4}}{2} = 0.6762\times10^{-4}\,cm = 6762\times10^{-8}\,cm = 6762\ \text{Å}$$

$$\text{Mean }\lambda = \frac{\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + \lambda_6}{6}$$

$$\lambda = \frac{6506 + 6680 + 6559 + 6737 + 6494 + 6762}{6} = \frac{39738}{6} = 6623\ \text{Å}$$

Result: The wavelength of given laser source is 6623Å

Precaution:

1. Laser light and grating should be normal.
2. Diffracted points should be in a line on screen.
3. Diffracted points in diffraction pattern should have approximately equal/ equal distance from central point.

3.'G' by P. O. Box

Object: To determine the galvanometer resistance with Post office Box.

Apparatus Used: P. O. Box, cell, rheostat, galvanometer, connecting wires.

Formula Used: The following formula is used for the determination of galvanometer resistance.

$$G = \frac{Q}{P} R$$

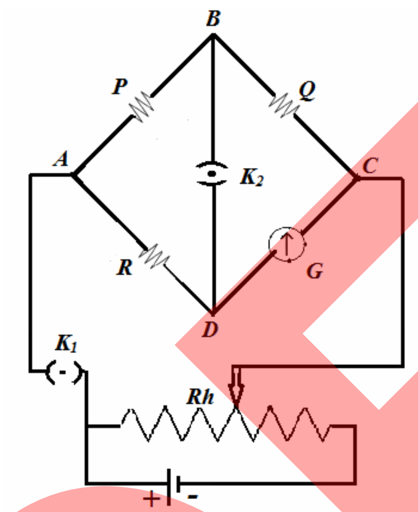
Here, G: galvanometer resistance (CD arm resistance of P. O. Box)

P: AB arm resistance of P. O. Box

Q: BC arm resistance of P. O. Box

R: AD arm resistance of P. O. Box

Circuit Diagram:



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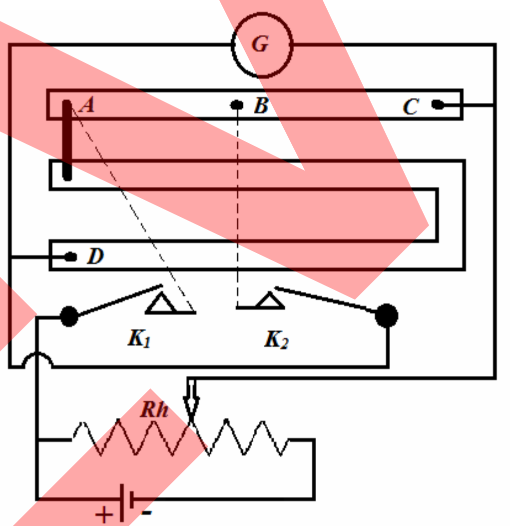


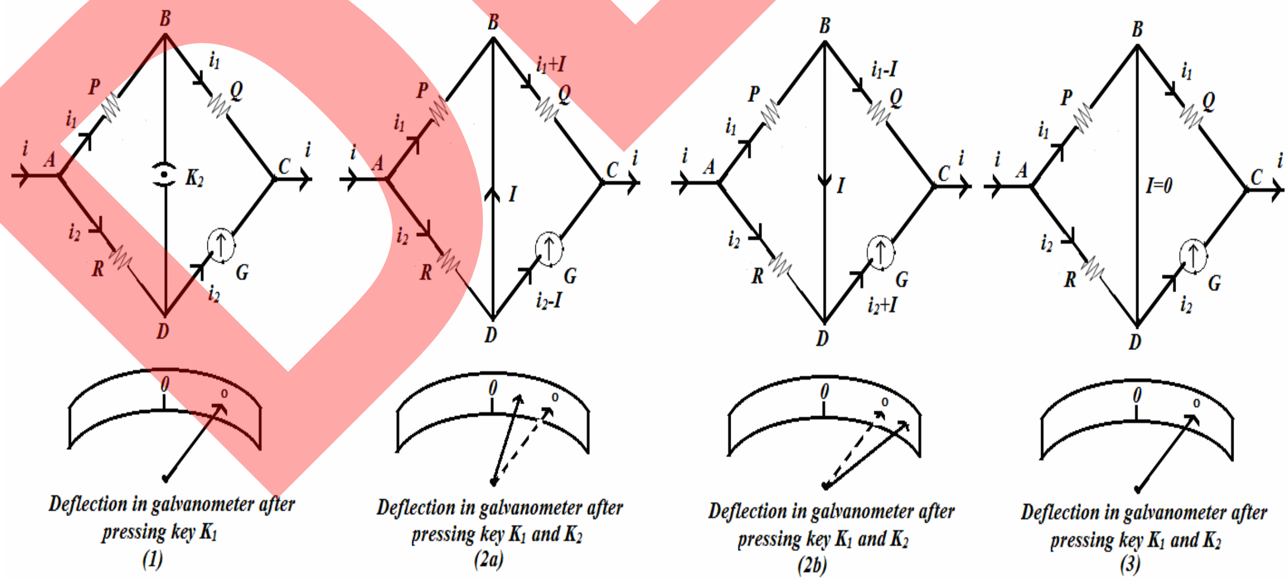


Figure (1) Figure (2a) Figure (2b) Figure (3)

Observation:

1. Table for the value of P, Q and R resistances

Sr. No.	P (Ω)	Q (Ω)	Deflection in Galvanometer with R	R(Ω) (at no change in deflection)	G(Ω)
1.	10	10	R=59Ω, left deflection R=60Ω, no change in deflection R=61Ω, right deflection	60	$\frac{10}{10}\times 60 = 60.0$
2.	100	100	R=58Ω, left deflection R=59 to 60Ω, no change in deflection R=61Ω, right deflection	59.5	$\frac{100}{100}\times 59.5 = 59.5$
3.	1000	1000	R=58Ω, left deflection R=59 to 61Ω, no change in deflection R=62Ω, right deflection	60	$\frac{1000}{1000}\times 60 = 60$
4.	100	10	R=586Ω, left deflection R=587 to 613Ω, no change in deflection R=614Ω, right deflection	600	$\frac{10}{100}\times 600 = 60$
5.	1000	100	R=584Ω, left deflection R=585 to 613Ω, no change in deflection R=614Ω, right deflection	599	$\frac{100}{1000}\times 599 = 59.9$

Calculation: Mean $G = \frac{60+59.5+60+60+59.9}{5} = \frac{299.4}{5} = 59.88\,\Omega$

Result: Galvanometer resistance= 59.88 Ω ≈ 60 Ω

Precaution:

1. Connections should not be loose.
2. Key K_2 should be always pressed after pressing key K_1.
3. If there is found a range of no deflection then total range should be noted and mean of them should be taken for R at no deflection.
4. In P.O. Box the keys should be very tight.
5. Avoid pressing keys for large time otherwise cell will be discharged.

4. Nodal slide

Object: To verify the expression for the focal length of a combination of two lenses.

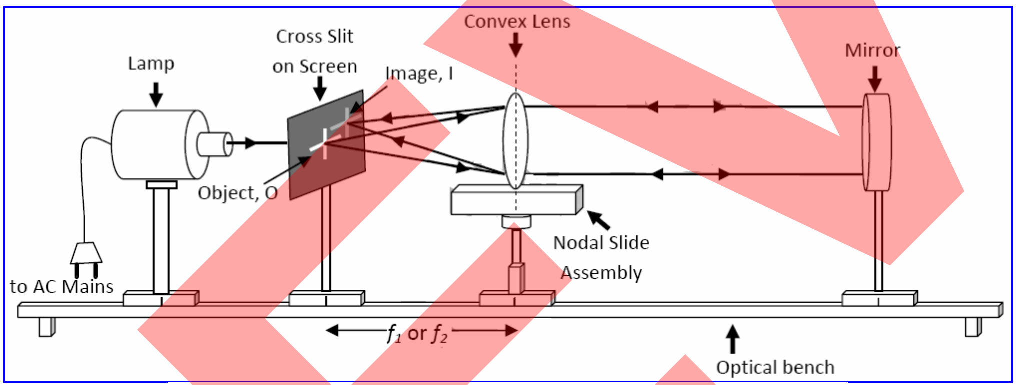
Apparatus Required: Two convex lenses of different focal length and an optical bench with uprights; a lamp of narrow opening, a cross-slit screen, nodal slide assembly and a plane mirror

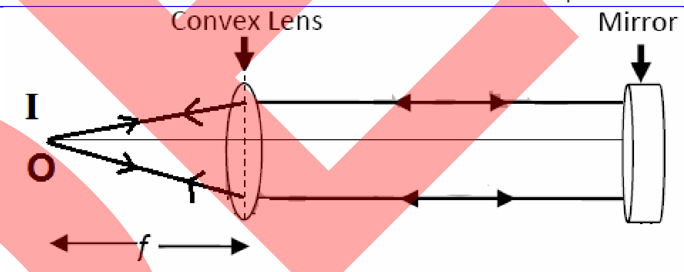
Formula Used: The focal length of a combination of two convex lenses is given by,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

where, f_1 and f_2 are focal lengths of two lenses, d is the distance between lenses and F is focal length of combination of two lenses.

Figure and Ray Diagramme:





Observation:

1. *Table for determination of f_1 and f_2:*

Lens	*Light incident on the*	*Position of upright (in cm)*		*f of lens f=a-b (in cm)*	*Mean of f (in cm)*
		Cross slit (a)	*Nodal slide (b)*		
First	One face	129.4	113.7	15.7	f_1=16.3
	Other face	128.3	111.4	16.9	
second	One face	125.0	114.2	10.8	f_2=10.3
	Other face	124.2	114.5	9.7	

2. *Table for determination of f_1 and f_2:*

d (cm)	Light incident on the	Position of upright (in cm) Cross slit (a)	Nodal slide (b)	f of lens f=a-b (in cm)	Mean of f (in cm)
6	One face	37.0	29.0	8.0	8.1
	Other face	37.0	28.8	8.2	
8	One face	37.0	28.1	8.9	8.8
	Other face	37.0	28.3	8.7	
10	One face	37.0	27.0	10.0	10.1
	Other face	37.0	26.8	10.2	

Calculation:

(1) *For f_1=16.3cm, f_2=10.3cm and d=6cm*

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{6}{16.3\times 10.3}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{6}{167.89}$$

$$\frac{1}{F}=0.0613+0.0971-0.0357=0.1584-0.0357=0.1227$$

$$F=\frac{1}{0.1227}=8.15\approx 8.2\text{ cm}$$

(2) *For f_1=16.3cm, f_2=10.3cm and d=8cm*

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{8}{16.3\times 10.3}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{8}{167.89}$$

$$\frac{1}{F}=0.0613+0.0971-0.0476=0.1584-0.0476=0.1108$$

$$F=\frac{1}{0.1108}=9.02\approx 9.0\text{ cm}$$

(3) *For f_1=16.3cm, f_2=10.3cm and d=10cm*

$$\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{10}{16.3\times 10.3}=\frac{1}{16.3}+\frac{1}{10.3}-\frac{10}{167.89}$$

$$\frac{1}{F}=0.0613+0.0971-0.0596=0.1584-0.0596=0.0988$$

$$F=\frac{1}{0.0988}=10.12\approx 10.1\text{cm}$$

Result: *Focal length of Ist lens =16.3cm*
Focal length of IInd lens =10.3cm

Verification table

d (cm)	Observed Focal length (cm)	Calculated Focal length (cm)	Difference (cm)
6	8.1	8.2	0.1
8	8.8	9.0	0.2
10	10.2	10.1	0.1

The calculated and experimental values of focal length of the combination of lenses are approximately equal the formula $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}-\frac{d}{f_1 f_2}$ ***is verified.***

Precaution:

1. *All the uprights should be exactly at same height and at same horizontal axis.*
2. *The cross slit must be properly illuminated by the intense light coming from lamp.*
3. *Lenses should be of small aperture to get well defined and sharp image.*
4. *The mirror employed must be truly plane mirror.*

5. Conversion of Galvanometer to Voltmeter

Object: To convert Weston galvanometer to a voltmeter of voltage range 0 to 3 volts.

Apparatus Used: battery, resistance box, galvanometer, voltmeter, rheostat, keys, connecting wires.

Formula Used: For the conversion of galvanometer to voltmeter (G→V) a high resistance 'R' is connected in series of galvanometer. The value of R is determined by following expression.

$$R = \frac{V}{I_g} - G$$

Here, V= maximum value of voltage range; G= galvanometer resistance

I_g =current for full scale deflection in galvanometer; $I_g = C_s$ N

N= total number of divisions in galvanometer

C_s =Current sensitivity of galvanometer or figure of merit; $C_s = \frac{E}{n(R'+G)}$

E= e.m.f. battery or cell; R' = resistance involved in galvanometer circuit

n= deflection in galvanometer on introducing the resistance R' in galvanometer circuit.

Circuit Diagram:

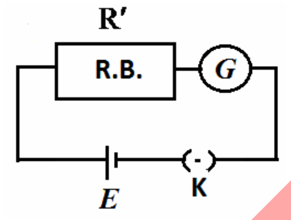


Figure (1)

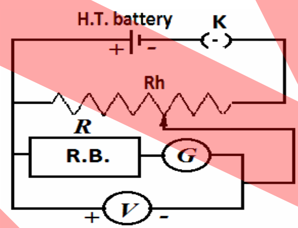


Figure (2)

Observation:

1. E=2volt, G=70 Ω, N= 30
2. Table for I_g

Sr. No.	$R'(\Omega)$	n	$C_s = \frac{E}{n(R'+G)}$ (x10^{-6}amp)	$I_g = C_s$ N (x10^{-6}amp)	mean I_g (in x10^{-6} A or μA)
1.	5000	19	20.76	622.8	$\frac{3067.5}{5}$ =613.5
2.	6000	16	20.59	617.7	
3.	7000	14	20.21	606.3	
4.	8000	12	20.65	619.5	
5.	9000	11	20.04	601.2	

3. ***Calibration of shunted galvanometer***

Least count of voltmeter=1/10=0.1volt

30 division in galvanometer = 3 volt

1 division in galvanometer= 0.1 volt

Sr. No.	Galvanometer reading		Voltmeter reading V (in volt)	Error V'-V (in volts)
	In division	In volt (V')		
1.	3	0.3	0.3	0
2.	6	0.6	0.6	0
3.	9	0.9	0.9	0
4.	12	1.2	1.2	0
5.	15	1.5	1.5	0
6.	18	1.8	1.8	0
7.	21	2.1	2.1	0
8.	24	2.4	2.4	0
9.	27	2.7	2.7	0
10.	30	3.0	3.0	0

Calculation: *Calculation of C_S and I_g*

1. $C_s = \dfrac{2}{19\times(5000+70)} = \dfrac{2}{19\times 5070} = \dfrac{2}{96330} = 20.76\times10^{-6}\,amp$

$I_g = 20.76\times10^{-6}\times 30 = 622.8\times10^{-6}\,amp = 622.8\mu A$

2. $C_s = \dfrac{2}{16\times(6000+70)} = \dfrac{2}{16\times 6070} = \dfrac{2}{97120} = 20.59\times10^{-6}\,amp$

$I_g = 20.59\times10^{-6}\times 30 = 617.7\times10^{-6}\,amp = 617.7\mu A$

3. $C_s = \dfrac{2}{14\times(7000+70)} = \dfrac{2}{14\times 7070} = \dfrac{2}{98980} = 20.21\times10^{-6}\,amp$

$I_g = 20.21\times10^{-6}\times 30 = 606.3\times10^{-6}\,amp = 606.3\mu A$

4. $C_s = \dfrac{2}{12\times(8000+70)} = \dfrac{2}{12\times 8070} = \dfrac{2}{96840} = 20.65\times10^{-6}\,amp$

$I_g = 20.65\times10^{-6}\times 30 = 619.5\times10^{-6}\,amp = 619.5\mu A$

5. $C_s = \dfrac{2}{11\times(9000+70)} = \dfrac{2}{11\times 9070} = \dfrac{2}{99770} = 20.04\times10^{-6}\,amp$

$I_g = 20.04\times10^{-6}\times 30 = 619.5\times10^{-6}\,amp = 601.2\mu A$

Calculation of mean I_g

$$I_g = \frac{622.8+617.7+606.3+619.5+601.2}{5} = \frac{3067.5}{5} = 613.5\,\mu A \approx 613\,\mu A$$

Calculation of R

$$R = \frac{3}{613\times10^{-6}} - 70 = \frac{3000\times10^{3}}{613} - 70 = 4.894\times10^{3} - 70 = 4894 - 70 = 4824\,\Omega$$

Result: *The galvanometer reading and voltmeter reading are approximately same after connecting 4824Ω resistance in series of galvanometer thus the resistance required to convert the given galvanometer in to voltmeter of 0-3volts is 4824Ω.*

Precautions:

1. Resistance in determination of figure of merit should be of high value.
2. Exact high resistance should be connected in series to galvanometer for conversion to voltmeter.
3. Voltmeter should be connected using sign convention.
4. Voltmeter used in calibration of shunted galvanometer should be of nearly same range.
5. In calibration process the readings should be noted from zero.

6. Specific Rotation of sugar

Object: To find the specific rotation of sugar solution by using a polarimeter.

Apparatus Used: Polarimeter, a balance, measuring cylinder, beaker and a source of light. (Sodium lamp for half shade polarimeter and ordinary bulb or mercury lamp for biquartz polarimeter.)

Formula Used: The specific rotation of the plane of polarization of sugar dissolved in water can be determined by the following formula,

$$S = \frac{\theta}{l.c} = \frac{\theta.V}{l.m}$$

Where, θ = rotation produced in degrees.

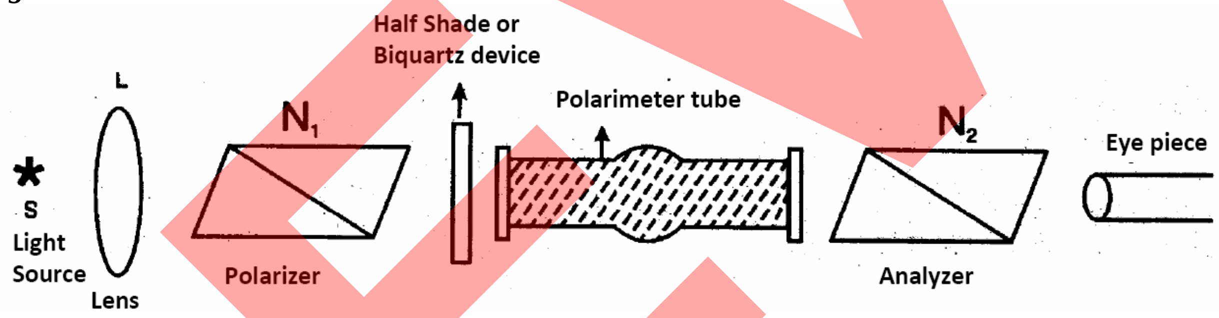
l = length of the tube in decimeter.

$c = m/V$ = concentration of sugar solution.

m = mass of sugar in grams dissolved in water.

V = volume of sugar solution.

Figure



Observation

1. Length of polarimeter tube: 2 decimeter

2. Least cont of analyzer scale$= \frac{\text{value of one div on main scale}}{\text{number of div on vernier scale}} = \frac{1}{10} = 0.1^0$

3. Analyzer reading with water

Sr. No.	For first position		$\theta_1 = \frac{a+a'}{2}$	For first position		$\theta_2 = \frac{b+b'}{2}$
	Clockwise Direction (a)	Anti-clockwise Direction (a')		Clockwise Direction (b)	Anti-clockwise Direction (b')	
1	66.4^0	66.6^0	66.5^0	246.2^0	246.6^0	246.4^0
2	66.6^0	66.4^0	66.5^0	246.6^0	246.8^0	246.7^0
3	66.2^0	66.8^0	66.5^0	246.2^0	246.8^0	246.5^0
4	66.6^0	66.4^0	66.5^0	246.4^0	246.4^0	246.4^0

Mean $\theta_1 = 66.5^0$

Mean $\theta_2 = 246.5^0$

4. *Mass of sugar= 5gm*
5. *Volume of water=100 ml*

6. Analyzer reading with sugar solution

Sr. No.	For first position		$\theta'_1=\frac{a+a'}{2}$	For first position		$\theta'_2=\frac{b+b'}{2}$
	Clockwise Direction (a)	Anti-clockwise Direction (a')		Clockwise Direction (b)	Anti-clockwise Direction (b')	
1	73.2^0	73.0^0	73.1^0	253.2^0	253.2^0	253.2^0
2	73.1^0	72.9^0	73.0^0	253.0^0	253.0^0	253.0^0
3	73.1^0	73.3^0	73.2^0	253.0^0	253.2^0	253.2^0
4	73.1^0	73.3^0	73.2^0	253.4^0	253.2^0	253.3^0

Mean $\theta'_1=73.25^0=73.3^0$

Mean $\theta'_2=253.18^0=253.2^0$

Calculation:

Concentration of sugar solution=5/100 gm/ml=0.05gm/cc

$$\theta=\frac{(\theta'_1-\theta_1)+(\theta'_2-\theta_2)}{2}=\frac{(73.3-66.5)+(253.2-246.5)}{2}=\frac{6.8+6.7}{2}=\frac{13.5}{2}=6.75^0$$

$$S=\frac{\theta V}{lm}=\frac{6.75\times 100}{2\times 5}=67.5^0\ \frac{cc}{decimeter.gm}$$

Result: At temperature 28^0C and at wavelength 5500Å

Specification rotation of sugar (S) $=67.5^0\ \frac{cc}{decimeter.gm}$

Standard value of specification rotation of sugar (S) $=66.67^0\ \frac{cc}{decimeter.gm}$

% error in S= $\frac{|66.67-67.5|}{66.67}\times 100=\frac{0.83}{66.67}\times 100=\frac{83}{66.67}=1.25\,\%$

Precaution:

(i) The polarimeter tube should be well cleaned.
(ii) Water used should be dust free.
(iii) Whenever a solution is changed, rinse the tube with the new solution under examination.
(iv) There should be no air bubble inside the tube.
(v) The position of analyzer should be set accurately.
(vi) The temperature and wavelength of light used should be stated.
(vii) Reading should be taken when halves of the field of view becomes equally illuminated.

7. Conversion of Galvanometer to Ammeter

Object: To convert Weston galvanometer to a ammeter of current range 0 to 1.5 amp.

Apparatus Used: battery, resistance box, galvanometer, ammeter, voltmeter, rheostat, keys, connecting wires.

Formula Used: For the conversion of galvanometer to ammeter (G→A) a low resistance (shunt resistance) 'S' is connected parallel to galvanometer. The value of S is determined by following expression.

$$S = \frac{I_g}{I - I_g} G$$

Here, I= maximum value of current range;
G= galvanometer resistance
I_g =current for full scale deflection in galvanometer; $I_g = C_s N$
N= total number of divisions in galvanometer
C_s =Current sensitivity of galvanometer or figure of merit; $C_s = \frac{E}{n(R'+G)}$
E= e.m.f. battery or cell;
R'= resistance involved in galvanometer circuit
n= deflection in galvanometer on introducing the resistance R' in galvanometer circuit.
l= length of wire is equivalent to resistance S

$$l = \frac{\pi r^2}{\rho} S$$

Here r is radius of wire, ρ (specific resistance)= 1.78×10^{-6} ohm-cm.

Circuit Diagram:

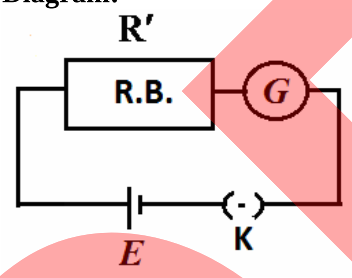


Figure (1)

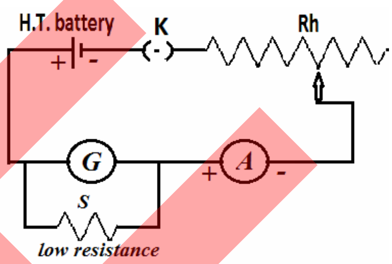


Figure (2)

Observation:

1. E= 2volt,
2. G= 60Ω
3. N= 30
4. **Table for I_g**

Sr. No.	R' (Ω)	n	$C_s = \frac{E}{n(R'+G)}$ ($\times 10^{-6}$amp)	$I_g = C_s N$ ($\times 10^{-6}$amp)	Mean I_g (in $\times 10^{-6}$ A or μA)
1.	5000	21	18.8	564	572
2.	6000	17	19.4	582	
3.	7000	15	18.9	567	
4.	8000	13	19.1	573	
5.	9000	12	18.4	552	
6.	10000	10	19.9	596	

5. Least count of screw gauge = 0.001cm
6. Zero error = -0.005cm (negative)
7. Diameter of wire = (MS +VS x LC)± zero error = (0.0 + 91 x 0.001)+0.005 = 0.096 cm
8. Radius of wire = 0.096/2 = 0.048 cm
9. Least count of ammeter =0.5/10=0.05amp
   30 division in galvanometer = 1.5 amp
   1 division in galvanometer= 0.05 amp

10. Calibration of shunted galvanometer

Sr. No.	Galvanometer reading		Ammeter reading I (in amp)	Error (I′ -I) (in amp)
	In division	In amp (I′)		
1	2	0.1	0.10	0
2	4	0.2	0.20	0
3	6	0.3	0.30	0
4	8	0.4	0.35	0.05
5	10	0.5	0.50	0
6	12	0.6	0.60	0
7	14	0.7	0.70	0
8	16	0.8	0.75	0.05
9	18	0.9	0.90	0
10	20	1.0	0.95	0.05
11	22	1.1	1.10	0
12	24	1.2	1.20	0
13	26	1.3	1.30	0
14	28	1.4	1.35	0.05
15	30	1.5	1.45	0.05

Calculation: *Calculation of C_S and I_g*

1. $C_S = \frac{2}{21\times(5000+60)} = \frac{2}{21\times 5060} = \frac{2}{106260} = 18.8\times10^{-6}\,amp$

$I_g = 18.8\times10^{-6}\times 30 = 564.0\times10^{-6}\,amp = 564.0\mu A$

2. $C_S = \frac{2}{17\times(6000+60)} = \frac{2}{17\times 6060} = \frac{2}{103020} = 19.4\times10^{-6}\,amp$

$I_g = 19.4\times10^{-6}\times 30 = 582.4\times10^{-6}\,amp \approx 582\mu A$

3. $C_S = \frac{2}{15\times(7000+60)} = \frac{2}{15\times 7060} = \frac{2}{105900} = 18.9\times10^{-6}\,amp$

$I_g = 18.9\times10^{-6}\times 30 = 567.0\times10^{-6}\,amp = 567.0\mu A$

4. $C_S = \frac{2}{13\times(8000+60)} = \frac{2}{13\times 8060} = \frac{2}{104780} = 19.1\times10^{-6}\,amp$

$I_g = 19.1\times10^{-6}\times 30 = 572.6\times10^{-6}\,amp \approx 573\mu A$

5. $C_S = \frac{2}{12\times(9000+60)} = \frac{2}{12\times 9060} = \frac{2}{108720} = 18.4\times10^{-6}\,amp$

$I_g = 18.4\times10^{-6}\times 30 = 551.9\times10^{-6}\,amp = 552\mu A$

6. $C_S = \frac{2}{10\times(10000+60)} = \frac{2}{10\times 10060} = \frac{2}{100600} = 19.9\times10^{-6}\,amp$

$I_g = 19.9\times10^{-6}\times 30 = 596.4\times10^{-6}\,amp = 596\mu A$

Calculation of mean I_g $I_g = \frac{564+582+567+573+552+596}{6} = \frac{3434}{6} = 572.3\,\mu A \approx 572\,\mu A$

Calculation of mean S: $S = \frac{I_g}{I-I_g}G = \frac{572\times10^{-6}}{1.5-572\times10^{-6}}\times 60 = \frac{572}{1500000-572}\times 60 = \frac{34320}{1499428} = 0.0228\,\Omega$

Calculation of l: $l = \frac{\pi r^2}{\rho}S = \frac{3.14\times0.048\times0.048}{1.78\times10^{-6}}\times 0.0228 = \frac{164.95\times10^{-6}}{1.78\times10^{-6}} = 92.67cm = 92.7cm$

Result: ***The calibration table indicates that after connecting the wire in parallel combination with galvanometer, the reading in galvanometer and ammeter becomes approximately same. Thus the length of shunt wire required for converting the given galvanometer in to ammeter of range 0 to 1.5 amp is 92.7cm.***

Precautions:

1. Resistance in determination of figure of merit should be of high value.
2. Exact length of wire should be connected parallel to galvanometer.
3. Ammeter should be connected using sign convention.
4. Ammeter used in calibration of shunted galvanometer should be of nearly same range.
5. In calibration process the readings should be noted from zero.

8. Newton's Ring

Object: To find the wavelength of Sodium light by Newton's ring.

Apparatus used: A Plano convex lens of large radius of curvature, optical arrangement for Newton's rings, plane glass plate, sodium vapour lamp and traveling microscope.

Formula used: The wavelength of light is given by the formula

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

Where, D_{n+p} = diameter of $(n+p)^{th}$ ring

D_n = diameter of n^{th} ring,

p = an integer number,

R = radius of curvature of the curved face of the plano- convex lens.

Focal length of plano-convex lens is given by-

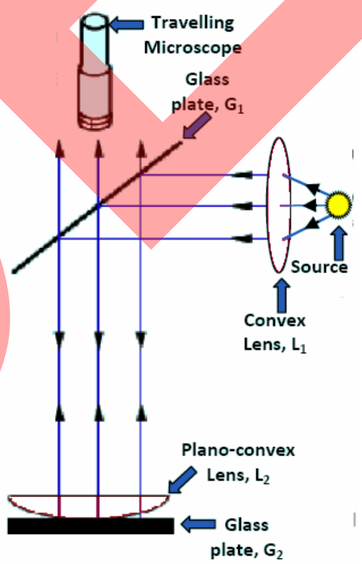
$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = (\mu - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$$

$$\frac{1}{f} = \frac{(\mu - 1)}{R} = \frac{(1.5 - 1)}{R} = \frac{0.5}{R} = \frac{1}{2R}$$

$$\Rightarrow \quad \boxed{R = \frac{f}{2}}$$

Here f is focal length of plano-convex lens.

Figure



Observation:

1. Value of one division on main scale=1/20=0.05 cm
2. Total number of division on Vernier scale=50
3. Least count of microscope=0.05/50=0.001cm

4. Table for diameter of rings

Sr. No.	No. Of fringes	LHS reading (cm)			RHS reading (cm)			$D = L - R$ (cm)	D^2 (cm^2)	$D_{n+p}^2 - D_n^2$ (cm^2) for p=6
		MS (cm)	VS (div)	Total (L)	MS (cm)	VS (div)	Total (R)			
1.	2	3.25	2	3.252	2.95	24	2.974	0.278	0.0773	0.0916
2.	4	3.25	16	3.266	2.90	37	2.937	0.329	0.1082	
3.	6	3.30	4	3.304	2.90	32	2.932	0.372	0.1384	0.0970
4.	8	3.30	14	3.314	2.90	4	2.901	0.411	0.1689	
5.	10	3.35	1	3.351	2.85	48	2.898	0.453	0.2052	0.0853
6.	12	3.35	6	3.356	2.85	33	2.883	0.473	0.2237	

5. Focal length of lens= 130 cm

Calculation:

Radius of curvature=R=f/2=130/2=65cm

$$\textit{Mean of } D_{n+p}^2 - D_n^2 \ (\textit{for } p=6) = \frac{0.0916+0.0970+0.0853}{3} = \frac{0.2739}{3} = 0.0913\,\text{cm}^2$$

$$\lambda = \frac{D_{n+p}^2 - D_n^2}{4pR} = \frac{0.0913}{4\times6\times65} = \frac{0.0913}{1560} = 5.853\times10^{-5}\,cm$$

$$\lambda = 5853\times10^{-8}\,cm = 5853\,\text{Å}$$

Result : The wavelength of sodium light= 5853 Å

Sodium light has two wavelengths 5890 Å and 5896 Å thus,

Standard value for wavelength of sodium light = 5893 Å

$$\%\ \text{error in wavelength} = \frac{|5893-5853|}{5893}\times100 = \frac{40}{5893}\times100 = \frac{4000}{5893} = 0.68\,\%$$

Precaution:

(1) Glass plates and lens should be cleaned thoroughly.
(2) The plano-convex lens should be of large radius of curvature.
(3) The sources of light used should be an extended one.
(4) The range of the microscope should be properly adjusted before measuring the diameters.
(5) Crosswire should be focused on a dark ring tangentially.
(6) The centre of the ring system should be a dark spot.
(7) The microscope is always moved in the same direction to avoid back lash error.
(8) Radius of curvature should be measured accurately.

9. Variation of magnetic field at axis of circular coil

Object: To study the variation of magnetic field with the distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.

Apparatus required: Stewart and Gee's type tangent galvanometer, a battery, a rheostat, an ammeter, a one way key, a reversing key (commutator) , connecting wires.

Formula:

If a current carrying coil is place in y-z plane then its axis will be x-axis. The magnetic field along the axis of coil is given by,

$$B = \frac{\mu_0 NI}{2}\frac{a^2}{(a^2 + x^2)^{3/2}} \qquad (1)$$

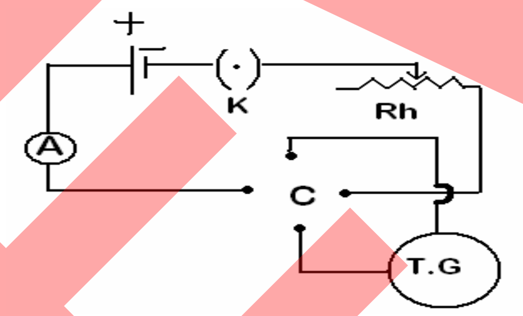
Where, μ_0 (= $4\pi \times 10^{-7}$) is the vacuum permeability, N is the number of turns of the field coil, I is the current in the wire, in amperes, a is the radius of the coil in meters, and x is the axial distance in meters from the center of the coil.

If θ is the deflection produced in magnetometer at a certain position on the axis of coil then magnetic field at that point will be,

$$B = H \tan\theta \qquad (2)$$

The equations (1) and (2) implies that the graph between x and $\tan\theta$ will give the variation of magnetic field at the axis of circular coil.

Figure and Circuit Diagram



Observations.

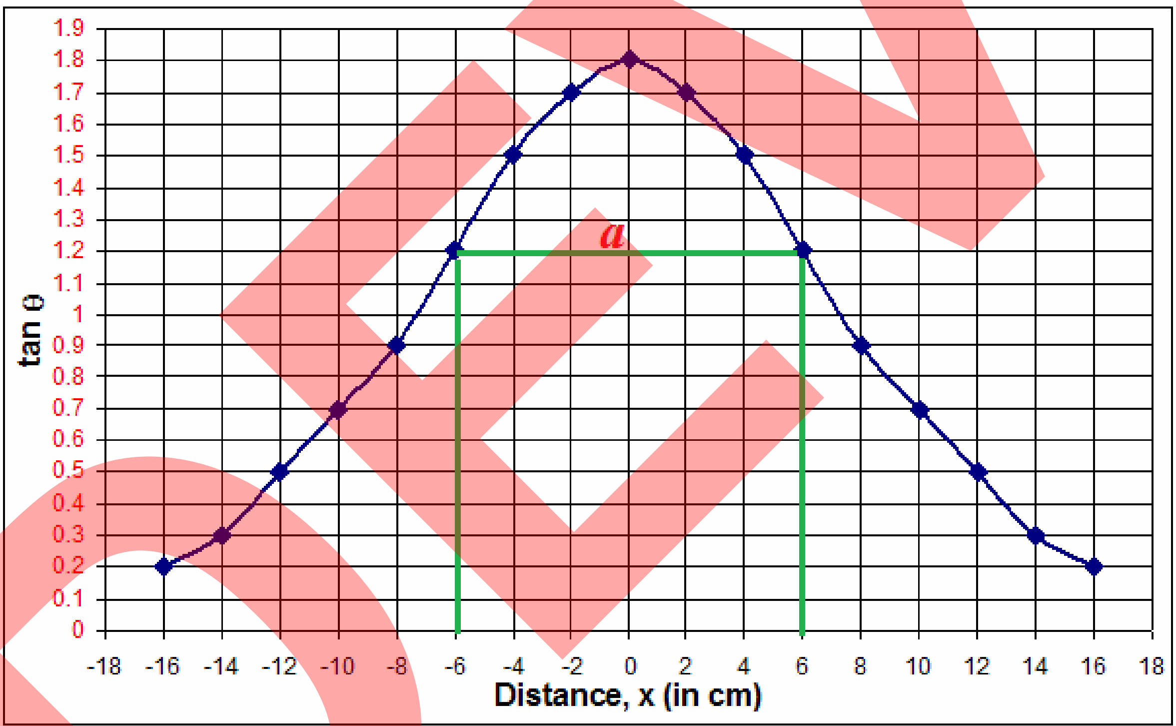
1. Least count of the magnetometer = 1^0
2. Current I = 1 amp
3. ***Table A: Deflection in magnetometer along +axis of coil.***

Sr. No	Distance of needle from centre of centre, ***x (cm)***	Deflection on East arm					***tanθ***
		Current in one direction		Current in reverse direction		Mean θ in deg.	
		θ_1	θ_2	θ_3	θ_4		
1.	0	60	62	60	62	61.0	1.8
2.	2	59	60	58	59	59.0	1.7
3.	4	55	57	56	57	56.3	1.5
4.	6	50	52	49	51	50.5	1.2
5.	8	44	45	42	43	43.5	0.9
6.	10	34	35	33	34	34.0	0.7
7.	12	25	26	23	25	24.8	0.5
8.	14	17	18	15	16	16.5	0.3
9.	16	10	11	9	10	10.0	0.2

4. Table B: Deflection in magnetometer along -axis of coil.

Sr. No	Distance of needle from centre of centre, ***x (cm)***	Deflection on East arm					***tan θ***
		Current in one direction		Current in reverse direction		Mean θ in deg.	
		θ_1	θ_2	θ_3	θ_4		
1.	0	60	62	60	62	61.0	1.8
2.	2	58	60	59	59	59.0	1.7
3.	4	56	57	55	57	56.3	1.5
4.	6	49	52	50	51	50.5	1.2
5.	8	42	45	44	43	43.5	0.9
6.	10	33	35	34	34	34.0	0.7
7.	12	23	26	25	25	24.8	0.5
8.	14	15	18	17	16	16.5	0.3
9.	16	9	11	10	10	10.0	0.2

Plot in *x and tanθ*:



Result: With help of the graph between tan θ and x, following points can be concluded.

1. The intensity of magnetic field has maximum at the centre and goes on decreasing as we move away from the centre of the coil towards right or left.

2. The point on the both side of graph where curve becomes convex to concave (i.e. the curve changes its nature) are called the point of inflection. The distance between the two points of inflexion is equal to the radius of the circular coil.

3. The radius of coil= distance between points of inflection=12cm

Precautions:

1. *There should be no magnet, magnetic substances and current carrying conductor near the apparatus.*

2. *The plane of the coil should be set in the magnetic medium.*

3. *The current should remain constant and should be reversed for each observation.*

10. Resolving Power of telescope

Object: To verify the expression for the resolving power of a Telescope.

Apparatus Required: Telescope, a rectangular adjustable slit with micrometer arrangement, parallel double slit scratched on glass slide, light source of narrow opening and meter scale.

Formula Used:

(i) The theoretical value of the resolving power of telescope is

$$RP_T = \frac{a}{\lambda}$$

(ii) The experimental value of the resolving power of telescope is

$$RP_E = \frac{D}{d}$$

Hence, verify that

$$\frac{a}{\lambda} = \frac{D}{d}$$

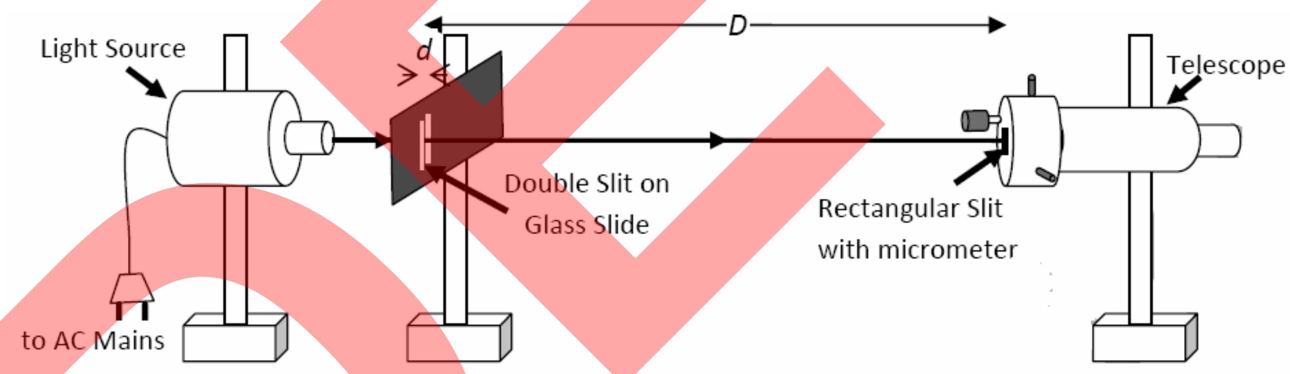
Where, λ = mean wavelength of light employed,

a = width of the rectangular slit for just resolution of two slits,

d = separation between the two nearby slits,

D = distance of the double slits from the objective of the telescope.

Figure:



Observation:

1. Wavelength of light source = 5500×10^{-8} cm
2. Pitch=5/10=0.5mm=0.05 cm
   Total number of division on circular scale=50
   Least count of micrometer=0.05/50=0.001cm

3. **Table for width of rectangular slit for just resolve position:**

Sr. No.	Distance D (cm)	Micrometer reading (cm)						Width of slit $a=x-y$ (cm)
		When two slits merge and appear one			When both slits completely disappear			
		MS (cm)	VS (div)	Total (x)	MS (cm)	VS (div)	Total (y)	
1.	100	0.05	23	0.073	0.00	38	0.038	0.035
2.	120	0.05	31	0.081	0.00	38	0.038	0.043
3.	140	0.05	38	0.088	0.00	38	0.038	0.050
4.	160	0.05	48	0.098	0.00	42	0.042	0.056

4. Pitch=1/10=0.1 cm
Total number of division on circular scale=100
Least count of micrometer=0.1/100=0.001cm

5. **Table for width of rectangular slit for just resolve position:**

Sr. No.	Microscope reading (cm)						Distance between slits $d=X-Y$ (cm)
	For left slit			For right slit			
	MS (cm)	VS (div)	Total (*X*)	MS (cm)	VS (div)	Total (*Y*)	
1.	11.5	25	11.525	11.3	46	11.346	0.159
2.	11.4	5	11.405	11.2	50	11.250	0.155
3.	11.3	1	11.301	11.1	46	11.146	0.155
4.	11.4	3	11.403	11.2	45	11.246	0.158

Mean d = 0.156 cm

Calculation:

1. **For D=100 cm**

$$\frac{a}{\lambda}=\frac{0.035}{5500\times10^{-8}}=\frac{35000}{55}=636.4$$

$$\frac{D}{d}=\frac{100}{0.156}=\frac{100000}{156}=641.0$$

2. **For D=120 cm**

$$\frac{a}{\lambda}=\frac{0.043}{5500\times10^{-8}}=\frac{43000}{55}=781.8$$

$$\frac{D}{d}=\frac{120}{0.156}=\frac{120000}{156}=769.2$$

3. **For D=140 cm**

$$\frac{a}{\lambda}=\frac{0.050}{5500\times10^{-8}}=\frac{50000}{55}=909.1$$

$$\frac{D}{d}=\frac{140}{0.156}=\frac{140000}{156}=897.4$$

4. **For D=160 cm**

$$\frac{a}{\lambda}=\frac{0.056}{5500\times10^{-8}}=\frac{56000}{55}=1018.2$$

$$\frac{D}{d}=\frac{160}{0.156}=\frac{160000}{156}=1025.6$$

Result: *Obtained theoretical and practical resolving powers of the telescope are shown in table-*

D (cm)	$\frac{a}{\lambda}$	$\frac{D}{d}$
100	636.4	641.0
120	781.8	769.2
140	909.1	897.4
160	1018.2	1025.6

Since theoretical and practical resolving powers of the telescope are approximately same thus the expression for resolving powers of the telescope is verified.

Precaution:

(1) The axis of telescope should be horizontal and perpendicular to the plane of the double lit.
(2) The double slit on glass slide and adjustable rectangular slit should be vertical.
(3) Double lit and the telescope should exactly at the same height.
(4) Backlash error in the micrometer screw should be avoided.
(5) The just resolved position of the slits must be exactly located.
(6) The distance *D* should be measured from the rectangular slit of the telescope to the double slit.

11. ANDERSON BRIDGE

Object: To determine the self inductance of a coil by Anderson bridge.

Apparatus Used: Anderson bridge, connecting wires, Head phone.

Formula Used: The following formula is used for the determination of self inductance of coil.

$$L = C\left[RQ + rR\left\{1 + \frac{Q}{P}\right\}\right]$$

Since, $S = \frac{Q}{P}R$ **; thus** $L = C\left[RQ + rR\left\{1 + \frac{S}{R}\right\}\right]$

$$\boxed{L = C[RQ + r\{R + S\}]}$$

If P=Q **then** S=R; **Hence**, $L = C[RQ + 2rR]$

$$\boxed{L = RC[Q + 2r]}$$

Where symbols have their usual meaning as shown in figure.

Circuit Diagram:

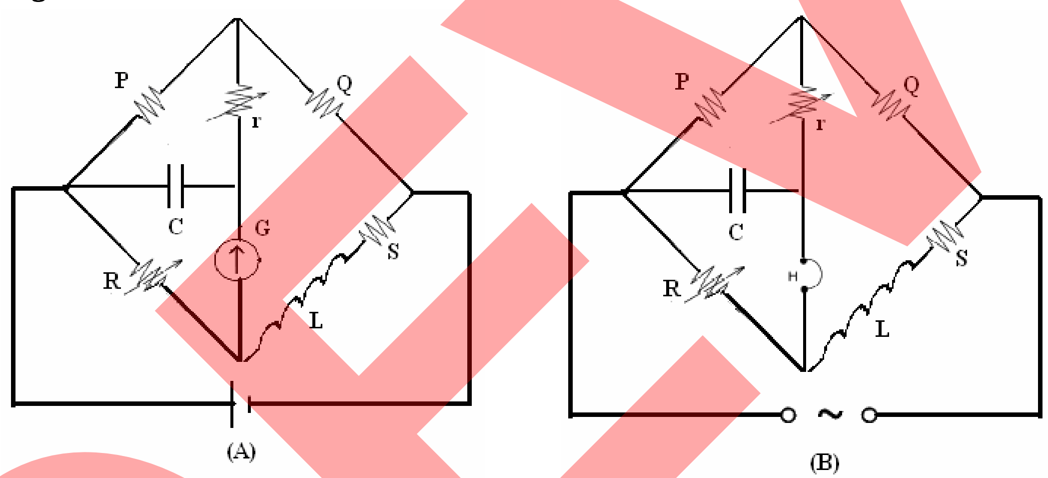


Fig (A): Bridge with DC source and galvanometer
Fig (B): Bridge with AC source and Head Phone

Observation:

2. P=1000 Ω
3. Q= 1000 Ω
4. Table for value of R and r when C= 0.1 μf

Sr.No.	**Inductor**	**R(Ω)** {for zero deflection in Galvanometer (G) under DC balancing}	**rΩ)** {for no sound in Head phone (H) under AC balancing}	**L(mH)** (Inductance) $L = RC[Q + 2r]$
1.	First	54	3220	$L_1 = 40.17$
2.	Second	80	5460	$L_2 = 95.36$
3.	Third	461	5400	$L_3 = 498.0$

5. Table for value of R and r when C=0.2 μf

Sr.No.	**Inductor**	**R(Ω)** {for zero deflection in Galvanometer (G) under DC balancing}	**r(Ω)** {for no sound in Head phone (H) under AC balancing}	**L(mH)** (Inductance) $L = RC[Q + 2r]$
1.	First	54	1720	$L_1{}' = 47.95$
2.	Second	80	2930	$L_2{}' = 94.00$
3.	Third	462	2590	$L_3{}' = 480.5$

Calculation:

A. For C=0.1μf

$$L_1 = 54 \times 0.1 \times 10^{-6}[1000 + 2 \times 3220] = 5.4 \times 7440 \times 10^{-6} = 40.17 \text{ mH}$$

$$L_2 = 80 \times 0.1 \times 10^{-6}[1000 + 2 \times 5460] = 8.0 \times 11920 \times 10^{-6} = 95.36 \text{ mH}$$

$$L_3 = 461 \times 0.1 \times 10^{-6}[1000 + 2 \times 5400] = 46.1 \times 11800 \times 10^{-6} = 498.0 \text{ mH}$$

B. For C=0.2μf

$$L_1' = 54 \times 0.2 \times 10^{-6}[1000 + 2 \times 1720] = 54 \times 0.2 \times 4440 \times 10^{-6} = 47.95 \text{ mH}$$

$$L_2' = 80 \times 0.2 \times 10^{-6}[1000 + 2 \times 2530] = 80 \times 0.2 \times 6060 \times 10^{-6} = 96.96 \text{ mH}$$

$$L_3' = 462 \times 0.2 \times 10^{-6}[1000 + 2 \times 2090] = 462 \times 0.2 \times 5180 \times 10^{-6} = 478.63 \text{ mH}$$

Result:

Inductance of Ist inductor $= \dfrac{L_1 + L_1{}'}{2} = \dfrac{40.17 + 47.95}{2} = \dfrac{88.12}{2} = 44.06 \text{ mH}$

Inductance of IInd inductor $= \dfrac{L_2 + L_2{}'}{2} = \dfrac{95.36 + 96.96}{2} = \dfrac{192.32}{2} = 96.16 \text{ mH}$

Inductance of IIIrd inductor $= \dfrac{L_3 + L_3{}'}{2} = \dfrac{498 + 478.63}{2} = \dfrac{976.63}{2} = 488.31 \text{ mH}$

Precaution:

1. To avoid inductive effect short straight wires should be used.
2. Movement in galvanometer should be free.
3. The resistances should be high and non-inductive.

12. μ by spectrometer

Object: To determine the refractive index of a prism by using a spectrometer.

Apparatus Required: Spectrometer, prism, mercury vapour lamp, spirit level and reading lens.

Formula Used: The refractive index μ of the prism is given by the following formula:

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

Where A = angle of the prism, δ_m = angle of minimum deviation.

Figure:

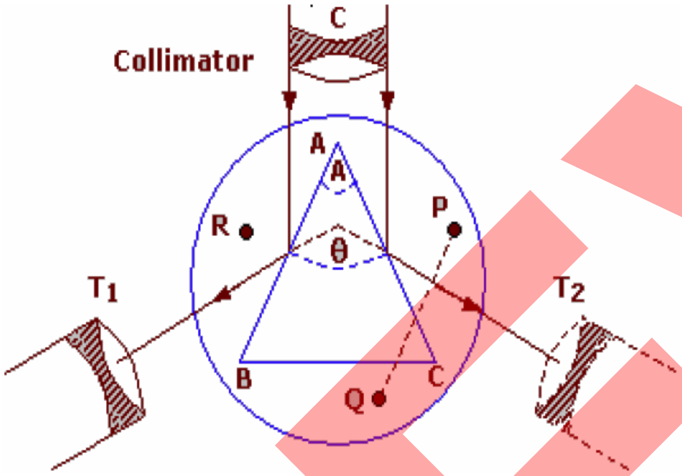


Figure1: For angle of prism

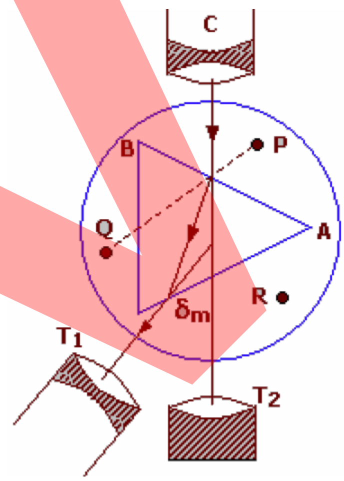


Figure2: For angle of deviation

Observation:

1. Value of one division on main scale$=\frac{10^0}{20}=\left(\frac{1}{2}\right)^0=\left(\frac{1\times 60}{2}\right)'=30'=30\text{ minute}$
2. Number of division on Vernier=60
3. Least count of spectrometer$=\frac{\text{Value of one div on main scale}}{\textit{Number of division on vernier scale}}$

$$=\frac{30'}{60}=\left(\frac{30\times 60}{60}\right)''=30''=30\text{ second}$$

4. ***Table for angle of prism***

Sr. No.	Vernier	Telescope reading for reflection						2A (=a~b)	A
		From first face			*From second face*				
		MSR	*VSR*	*Total (a)*	*MSR*	*VSR (div)*	*Total (b)*		
1.	V_1	$68^0 30'$	$1x30''$	$68^0 30'30''$	$189^0 30'$	$1x30''$	$189^0 30'30''$	121^0	$60^0 30'$
	V_2	$248^0 30'$	$1x30''$	$248^0 30'30''$	$9^0 30'$	$1x30''$	$9^0 30'30''$	121^0	$60^0 30'$
2.	V_1	$68^0 30'$	$2x30''$	$68^0 31'$	$189^0 30'$	$2x30''$	$189^0 31'$	121^0	$60^0 30'$
	V_2	$248^0 30'$	$2x30''$	$248^0 31'$	$9^0 30'$	$2x30''$	$9^0 31'$	121^0	$60^0 30'$

Mean of A=$60^0 30'$

5. *Table for minimum angle of deviation* (δm)

Sr. No.	Colour	Ver -nier	Telescope reading for reflection						δm (=a~b)	Mean δm
			At minimum deviation			*Direct*				
			MSR	*VSR*	*Total (a)*	*MSR*	*VSR (div)*	*Total (b)*		
1.	Voilet	V_1	$206^0 30'$	3x30″	$206^0 31'30''$	162^0	5x30″	$162^0 2'30''$	$44^0 29'$	$44^0 14'30''$
		V_2	$26^0 30'$	3x30″	$26^0 31'30''$	342^0	5x30″	$342^0 2'30''$	$44^0 29'$	
2.	Yellow	V_1	$204^0 30'$	5x30″	$204^0 32'30''$	162^0	5x30″	$162^0 2'30''$	$42^0 30'$	$42^0 30'$
		V_2	$24^0 30'$	5x30″	$24^0 32'30''$	342^0	5x30″	$342^0 2'30''$	$42^0 30'$	
3.	Red	V_1	203^0	37x30″	$203^0 18'30''$	162^0	5x30″	$162^0 2'30''$	$41^0 16'$	$41^0 16'$
		V_2	23^0	37x30″	$23^0 18'30''$	342^0	5x30″	$342^0 2'30''$	$41^0 16'$	

Calculation:

1. $$\mu_V = \frac{\sin\left(\frac{A+\delta_V}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60^0 30' + 44^0 14'15''}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)} = \frac{\sin\left(\frac{104^0 44'15''}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)}$$

$$\mu_V = \frac{\sin(52^0 22'7.5'')}{\sin(30^0 15')} = \frac{0.7919}{0.5038} = 1.572$$

2. $$\mu_Y = \frac{\sin\left(\frac{A+\delta_Y}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60^0 30' + 42^0 30'}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)} = \frac{\sin\left(\frac{102^0 60'}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)}$$

$$\mu_Y = \frac{\sin(51^0 30')}{\sin(30^0 15')} = \frac{0.7826}{0.5038} = 1.553$$

3. $$\mu_R = \frac{\sin\left(\frac{A+\delta_R}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60^0 30' + 41^0 16'}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)} = \frac{\sin\left(\frac{101^0 46'}{2}\right)}{\sin\left(\frac{60^0 30'}{2}\right)}$$

$$\mu_R = \frac{\sin(50^0 53')}{\sin(30^0 15')} = \frac{0.7759}{0.5038} = 1.540$$

Result: $\mu_V = 1.572$ $\mu_Y = 1.553$ $\mu_R = 1.540$

Precaution:

(i) The telescope and collimator should be individually set for parallel rays.
(ii) Slit should be as narrow as possible.
(iii) While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
(iv) Both verniers should be read.
(v) The prism should be properly placed on the prism table for the measurement of angle of the prism as well as for the angle of minimum deviation.

13. LCR-Circuits

Object: To determine the impedance of LCR circuit.

Apparatus Used: resistance, inductor coil, capacitor, connecting wires, a.c. voltmeter, mili-ammeter, low voltage a.c. source.

Formula Used: The following formula is used for the determination of impedance of LCR circuit.

$$Z = \sqrt{R^2 + (X_L \sim X_C)^2}$$

Where, Z : impedance of LCR circuit, R : resistance

X_L : Inductive reactance, X_C : Capacitive reactance

$$R = \frac{dV_R}{dI_R}, \qquad X_L = \frac{dV_R}{dI_L} \quad \textbf{and} \quad X_C = \frac{dV_C}{dI_C}$$

V_R, V_L and V_C are the voltage across R, L and C respectively.
I_R, I_L and I_C are the currents through R, L and C respectively.

Circuit Diagram:

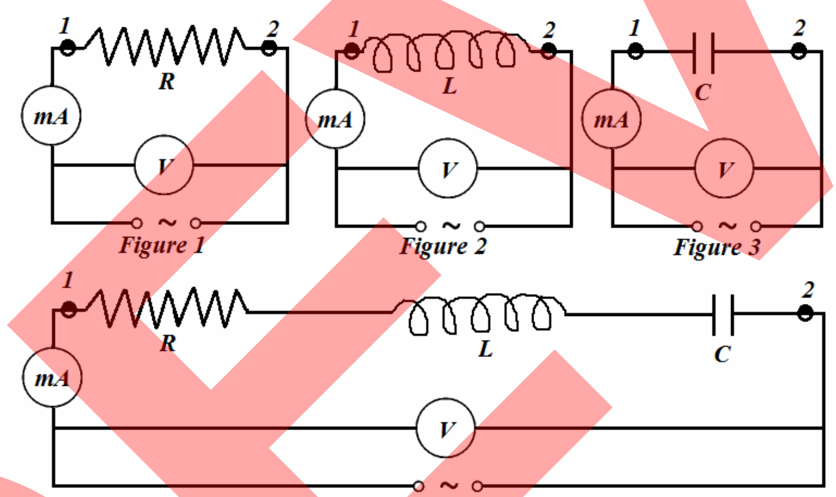


Figure 1 Figure 2 Figure 3 Figure 4

Observation:

1. Least count of voltmeter= 0.2 volts
2. Least count of mili-ammeter= 5 mA
3. Table for value of voltage and current

Sr.No.	R-Circuit		L-Circuit		C-Circuit		LCR-Circuit	
	V_R (volt)	I_R (mA)	V_L (volt)	I_L (mA)	V_C (volt)	I_C (mA)	V (volt)	I (mA)
1.	0.4	20	0.4	5	0.4	10	0.4	15
2.	0.8	40	0.8	10	0.8	20	0.8	25
3.	1.2	60	1.2	15	1.2	30	1.2	35
4.	1.6	80	1.6	20	1.6	40	1.6	45
5.	2.0	100	2.0	25	2.0	50	2.0	50

Graph-

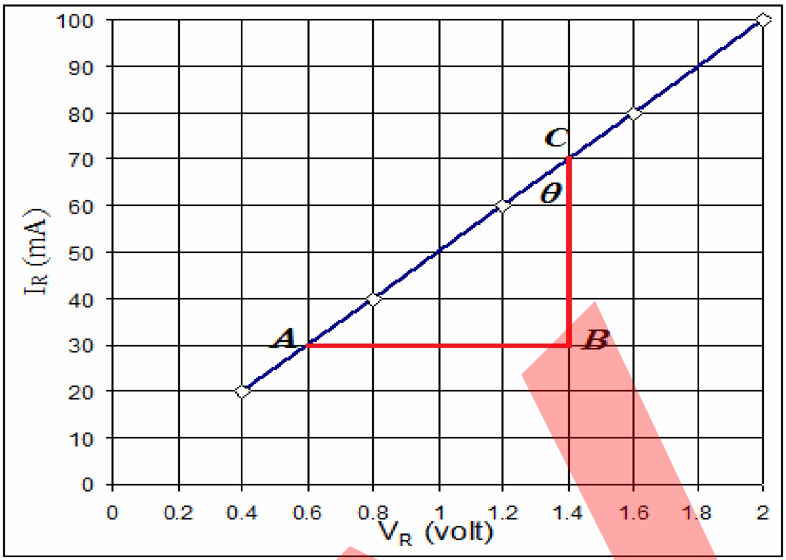


Fig.1

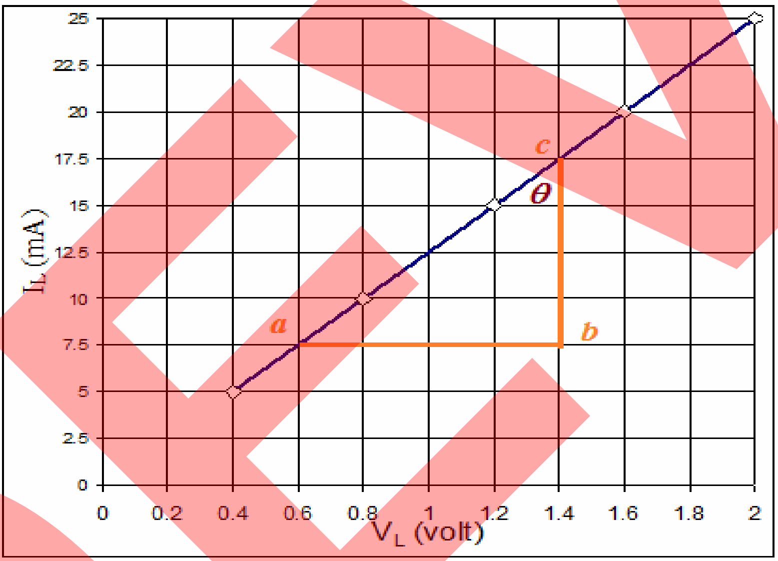


Fig.2

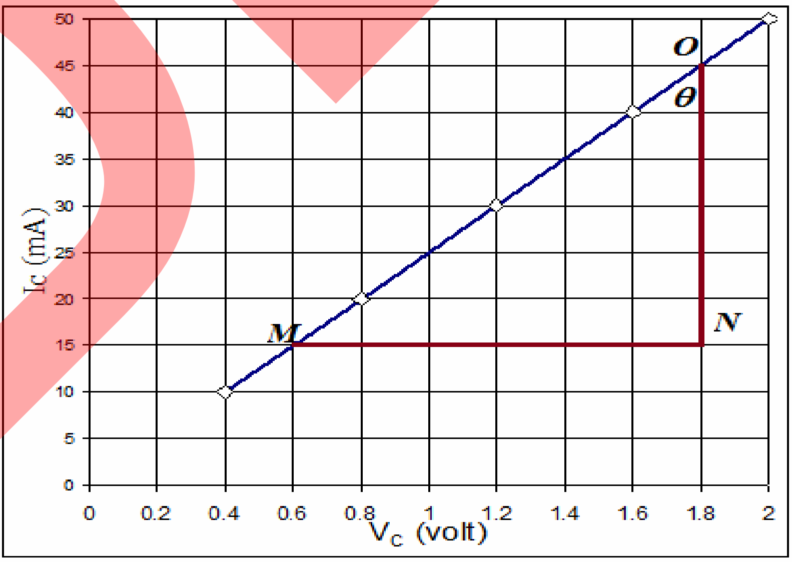


Fig.3

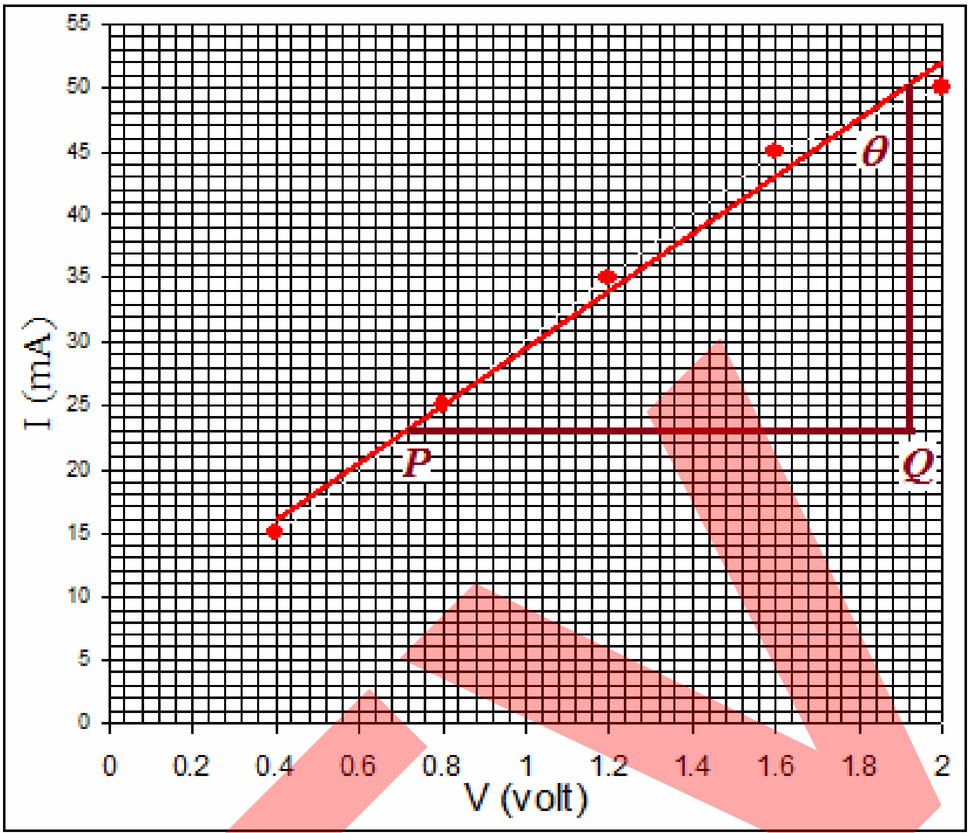


Fig.4

Calculation:

From Fig.1, $R = \tan\theta = \frac{AB}{BC} = \frac{0.8}{40\times10^{-3}} = \frac{800}{40} = 20\Omega$

From Fig.2, $X_L = \tan\theta = \frac{ab}{bc} = \frac{0.8}{10\times10^{-3}} = \frac{800}{10} = 80\Omega$

From Fig.3, $X_C = \tan\theta = \frac{MN}{NO} = \frac{1.2}{30\times10^{-3}} = \frac{1200}{30} = 40\Omega$

From Fig.4, $Z = \tan\theta = \frac{PQ}{QS} = \frac{1.92-0.72}{(50-23)\times10^{-3}} = \frac{1200}{27} = 44.44\Omega$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{20^2 + (80-40)^2} = \sqrt{20^2 + 40^2} = \sqrt{400+1600} = \sqrt{2000} = 44.72\Omega$$

Result:

1. R=20 Ω X_L=80 Ω X_C=40 Ω
2. Z_{graph}= 44.44 Ω $Z_{calculated}$=44.72 Ω

Precaution:

1. Connections should be tight.
2. Variation in voltage should be in slow manner.
3. Reading of voltage and current should be started with zero.

14. λ by grating

Object: To find the wavelength of white light with the help of a plane transmission diffraction grating.

Apparatus required: A diffraction grating, spectrometer, mercury vapour lamp, reading lens and sprit level.

Formula used: The wavelength λ of any spectral lines can be calculated by the formula:

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

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

Where, $(a+b)$ = grating element, θ = angle of diffraction and n = order of the spectrum

Figure:

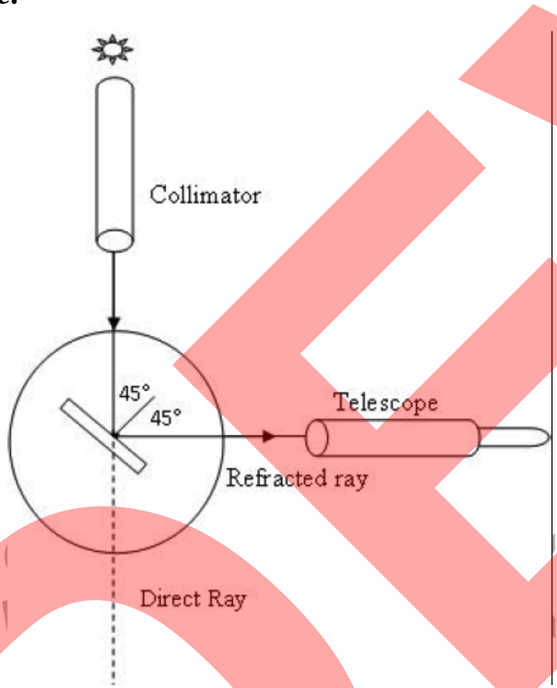


Figure A: normal incidence

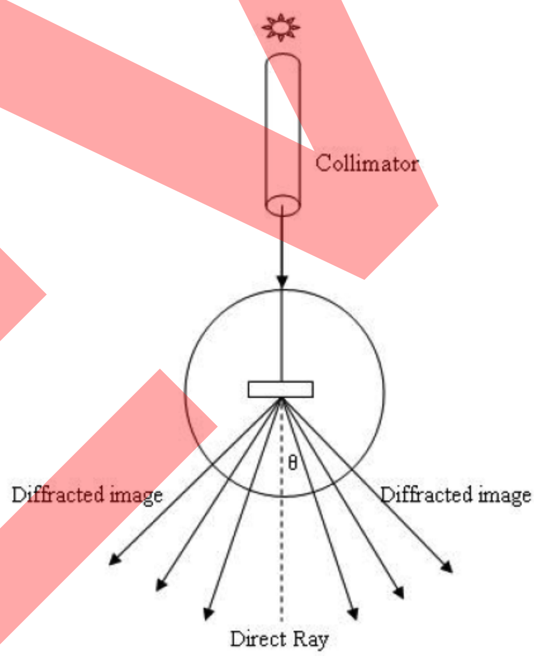


Figure: diffraction through grating

Observation:

1. Value of one division on main scale= $\frac{10^0}{20}=\left(\frac{1}{2}\right)^0=\left(\frac{1\times 60}{2}\right)'=30'=30\text{ minute }$ 1.
2. Number of division on Vernier=60
3. Least count of spectrometer= $\frac{\text{Value of one div on main scale}}{\text{Number of division on vernier scale}}$

$$=\frac{30'}{60}=\left(\frac{30\times 60}{60}\right)''=30''=30\text{ second}$$

4. Number of lines per inch=15,000
5. Grating element=2.54/15000= 1.69x10^{-4}cm
6. *Reading of Vernier for direct image: $23^0 30'$*
7. *Reading of Vernier after rotating telescope by 90^0= $113^0 30'$*

8. *Reading of Vernier when reflected image is obtained at cross wire= $113^0 30'$*
9. *Reading of Vernier after rotating prism table by 45^0= $158^0 30'$*
10. ***Table for angle of 1st order diffraction***

Sr. No.	Colour	Ver-nier	Telescope reading for reflection						2θ (=a~b)	Mean 2θ
			At minimum deviation			*Direct*				
			MSR	*VSR*	*Total (a)*	*MSR*	*VSR (div)*	*Total (b)*		
1.	Violet	V_1	37^0	1x30″	**$37^0 30''$**	$6^0 30'$	1x30″	**$6^0 30' 30''$**	$30^0 30'$	$30^0 0'$
		V_2	$215^0 30'$	1x30″	**$215^0 30' 30''$**	186^0	1x30″	**$186^0 30''$**	$29^0 30'$	
2.	Blue	V_1	$38^0 30'$	0x30″	**$38^0 30'$**	2^0	0x30″	**2^0**	$36^0 30'$	$36^0 30'$
		V_2	$218^0 30'$	0x30″	**$218^0 30'$**	182^0	0x30″	**182^0**	$36^0 30'$	
3.	Yellow	V_1	$42^0 30'$	1x30″	**$42^0 30' 30''$**	1^0	1x30″	**$1^0 30''$**	$41^0 30'$	$41^0 30'$
		V_2	$222^0 30'$	1x30″	**$222^0 30' 30''$**	181^0	1x30″	**$180^0 30''$**	$41^0 30'$	
4.	Red	V_1	44^0	1x30″	**$44^0 30''$**	$0^0 30'$	1x30″	**$0^0 30' 30''$**	$43^0 30'$	$43^0 30'$
		V_2	224^0	1x30″	**$224^0 30''$**	180^0	1x30″	**$180^0 30''$**	$43^0 30'$	

Calculation: ***For diffraction through grating,*** $(a+b)\sin\theta = n\lambda$

When n=1 then $\lambda = (a+b)\sin\theta$

3. For violet colour, $\theta_v = \frac{30^0 0'}{2} = 15^0$

$$\lambda_v = (a+b)\sin\theta_v = 1.69\times10^{-4}\times\sin15^0 = 1.69\times10^{-4}\times0.2588 = 0.4374\times10^{-4}$$
$$\lambda_v = 4374\times10^{-8}\,cm = 4374\,\text{Å}$$

4. For violet colour, $\theta_G = \frac{36^0 30'}{2} = 18^0 15'$

$$\lambda_G = (a+b)\sin\theta_G = 1.69\times10^{-4}\times\sin18^0 15' = 1.69\times10^{-4}\times0.3132 = 0.5293\times10^{-4}$$
$$\lambda_G = 5293\times10^{-8}\,cm = 5293\,\text{Å}$$

5. For violet colour, $\theta_Y = \frac{41^0 30'}{2} = 20^0 45'$

$$\lambda_Y = (a+b)\sin\theta_Y = 1.69\times10^{-4}\times\sin20^0 45' = 1.69\times10^{-4}\times0.3543 = 0.5988\times10^{-4}$$
$$\lambda_Y = 5988\times10^{-8}\,cm = 5988\,\text{Å}$$

6. For violet colour, $\theta_R = \frac{43^0 30'}{2} = 22^0 45'$

$$\lambda_R = (a+b)\sin\theta_R = 1.69\times10^{-4}\times\sin22^0 45' = 1.69\times10^{-4}\times0.3867 = 0.6535\times10^{-4}$$
$$\lambda_R = 6535\times10^{-8}\,cm = 6535\,\text{Å}$$

Result: The obtained wavelengths of different colours are as follows-

$\lambda_v = 4374\,\text{Å}$ $\lambda_G = 5293\,\text{Å}$ $\lambda_Y = 5988\,\text{Å}$ $\lambda_R = 6535\,\text{Å}$

Precaution:

(i) Before performing the experiment, the spectrometer should be adjusted.
(ii) Slit should be as narrow as possible.
(iii) Grating should be set normal to the incident light.
(iv) While taking observation, telescope and prism table should be kept fixed.
(v) Both verniers should be read.