Experiment-1

Aim:

Study of Newton's Rings

Apparatus:

Traveling microscope, sodium vapour lamp, Plano-convex lens, plane glass plate, magnifying lens.

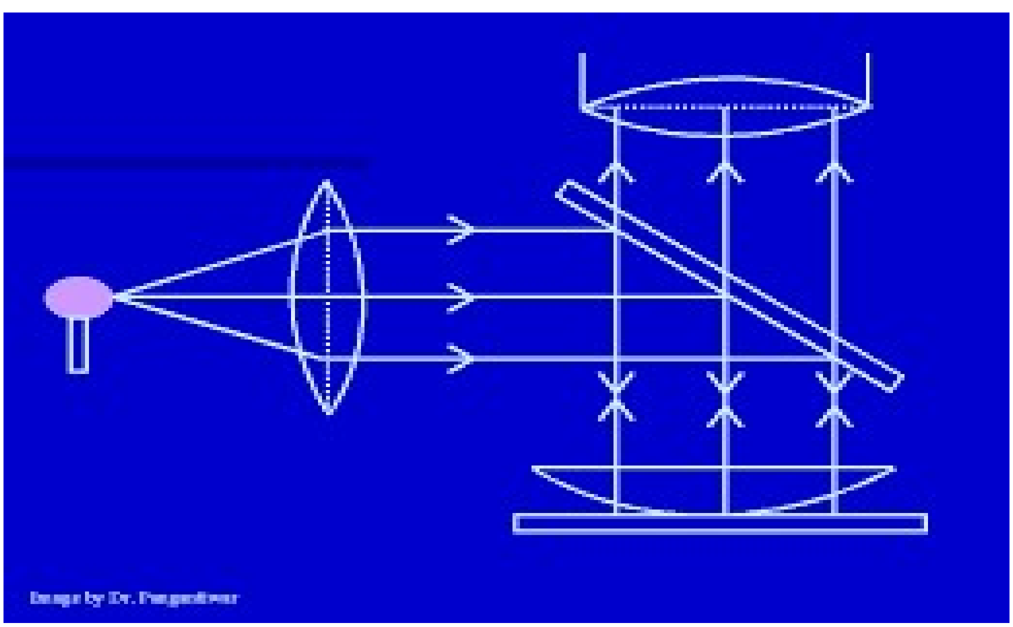
Formula used:

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

Where Dn = diameter of nth bright ring and Dn+m = diameter of In + m)th bright ring. Radius of curvature R of the convex surface of Plano convex lens is given as:

About experiment:

When a Plano-convex lens (L) of long focal length is placed on a plane glass plate(G), a thin film of air I enclosed between the lower surface of the lens and upper Surface of the glass plate. The thickness of the air film is very small at the Point of contact and gradually increases from the centre outwards. The fringes Produced are concentric circles. With monochromatic light, bright and dark circular Fringes are produced in the air film. When viewed with the white light, the fringes are coloured .A horizontal beam of light falls on the glass plate B at an angle of 450. The plate B So if we know the wavelength we can calculate R(radius of curvature of the lens).



Procedure:

1. Illuminate the system by sodium lamp. Place a convex lens Ll in between the lamp and inclined glass plate so as to allow a parallel beam of light to fall on the inclined glass plate.
2. Place the microscope vertically above the inclined glass plate so that its axis is just above the point of contact of Plano-convex lens and glass plate.
3. Focus the microscope, using rack and pinion arrangement, on the surface of the lens. When we see through the microscope large numbers of Newton's rings are observed. Make fine adjustment of microscope using slow motion screw so that rings are clearly visible and brilliant.
4. U sing slow motion screw move the microscope till the cross wire just falls on the middle of 20th (say) bright ring on the left hand side of central ring. Note the microscope reading. Slowly move the microscope till the crosswire is on 16th, 12th and 8th bright rings. Note the microscope reading each time.
5. Now go on moving the microscope in the same direction till the cross wire is on 8th bright ring on the right hand side of central ring and note the microscope reading. Now move the microscope in the same direction and note reading on 12th, 16th and 20th bright rings.
6. Remove the plan convex lens and fmd out the radius of curvature of its convex surface using a spherometer. For accurate measurement we use a spherometer of smaller value of least count (say 0.005 cm)
7. Now calculate the wavelength of sodium light by applying the formula.

Observations:

Vernier constant of microscope = ... cm

Table for diameter of rings.

Sr. No.	No. of ring	Microscope reading at the ring end (cm)		Diameter D=L-R (cm)	D2 (cm)2
		Left(L)	Right (R)		
1.	20				
2.	16				
3.	12				
4.					

For measurement of R –

Pitch of the spherometer = ... cm

Total no. of divisions on circular scale = ...

:. Least count of spherometer = ... cm

Sr. no.	Reading of circular scale on convex surface 'at	Reading on plane surface		Additional No. of divisions on circular scale (a- b) or (100 + a- b)	h = p x pitch + (a- b) x L.C. In cm
		No. of complete rotations 'pt	Circular scale reading 'b'		
1. 2. 3. 4.					

Mean value of h =.... cm

Calculations:

$$\text{Radius of curvature } R = \frac{l^2}{6h} + \frac{h}{2} = \ldots\text{cm}$$

(i) $$D_{20}^2 - D_{12}^2 = \ldots\ldots\ldots\ldots = \ldots\ldots\ldots\ldots = \ldots\ldots\ldots \text{ cm}^2$$

$$\therefore \quad \lambda = \frac{D_{20}^2 - D_{12}^2}{4(20\times 12)\times R} = \frac{D_{20}^2 - D_{12}^2}{32R} = \ldots - \ldots \text{ cm}$$

(ii) $$D_{20}^2 - D_{12}^2 = \ldots = \ldots \text{ cm}^2$$

$$\therefore \quad \lambda = \frac{D_{16}^2 - D_8^2}{32R} = \ldots = \ldots \text{ cm}$$

Precautions:

1. The Plano convex lens should be of large focal length.
2. The glass plate and the plan convex lens should be cleaned thoroughly.
3. To avoid the back lash error travelling microscope should be moved throughout the course of observations in one direction only.
4. While measuring radius of curvature the value of h should be measured very carefully as a small error in its measurement may causes a large percentage error in the final result.
5. The incident beam falling on inclined glass plate must be horizontal and parallel so that after reflection at the inclined plate the beam is incident normally on the lens surface and hence at the air film, But this condition is not fulfilled because the source of light is not of a point size but a broad source.
6. Do not measure diameter of first few rings as first few rings are too thick and the adjustment of crosswire become difficult.

7. The interference fringes formed in Newton's rings experiment are localized and are formed in between the Plano convex lens and plane glass plate. However, we observe them through the lens surface and hence the fringes are slightly modified. We should use a lens as thin as possible so that this modification is negligible.

Result:

Wavelength of sodium light as obtained using Newton's rings δ...., ...= ... cm
Standard value of wavelength of sodium light = 5.893 x 10^{-5} cm

Experiment-2

Aim:

- To find the resolving power of the prism.

Apparatus:

Spectrometer, prism, Clamp, mercury vapour lamp, lens.

Formula used:

$\frac{\lambda}{d\lambda}$= -t$\frac{d\mu}{d\lambda}$= t. $\frac{2B}{\lambda^3}$

Where meaningful length $\frac{\lambda_1+\lambda_2}{2}$

ii> Resolving power of the prism:

=($\frac{d}{d\lambda}$).$\frac{d}{a}$

Where d is the length of the base of given and a is the width of aperture for just resolution.

About experiment:

If a spectrograph can just resolve two lines near wavelength with a separation of , the resolving power is defined as

$$\frac{\lambda}{\Delta\lambda}$$

Prism Spectroscopy:

Newton demonstrated in the 1600's that white light passing though a prism could be separated into its different colors. While at that time he believed in the corpuscular theory of light, we know now that these individual colors represent different wavelengths or frequencies. From our introduction to refraction it is to be expected that light of different colors will bed through different angles.

Perhaps the simplest form of astronomical spectroscopy is the objective prism. Unsurprisingly, this is a very thin prism that sits in front of a telescope objective – often in front of the corrector plate of a Schmidt telescope (to get “wide field” results).

Procedure:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapor lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Least Count of Spectrometer

One main scale division (N) =...............minute
Number of divisions on vernier (v) =...............

$$L.C = \frac{N}{v} = \text{......................minute}$$

To determine the Angle of minimum deviation:

Direct method

1. Rotate the prism table so that the light from the collimator falling on one of the face of the prism and emerges through the other face.
2. The telescope is turned to view the refracted image of the slit on the other face.
3. The vernier table is slowly turned in such a direction that the image of slit is move directed towards the directed ray; ie., in the direction of decreasing angle of deviation.
4. It will be found that at a certain position, the image is stationary for some moment. Vernier table is fixed at the position where the image remains stationary.
5. Note the readings on main scale and vernier scale.
6. Carefully remove the prism from the prism table.
7. Turn the telescope parallel to collimator, and note the direct ray readings.
8. Find the difference between the direct ray readings and deviated readings. This angle is called angle of minimum deviation (D).

To determine the Resolving power of prism:

1. Rotate the vernier table so as to fall the light from the collimator to one face of the prism and emerged through another face. (Refer the given figure).

2. The emerged ray has different colours.
3. Turn the telescope to each colour, and note the readings for different colours.
4. Remove the prism, hence note direct ray reading.
5. Find the angle of minimum deviation for different colour.(Say ,violet, blue, green, yellow).
6. Find the refractive index for these colours. Using equation **(3).**
7. Resolving power for yellow and blue

$$\omega = \frac{n_b - n_y}{n-1}$$

,

$$n = \frac{n_b + n_y}{2}$$

Where n_b and n_y are the refractive index of blue and yellow, and

Observations:

Line	Vernier	Refracted ray readings	Direct readings	Difference (Minimum Deviation)	Mean D	n
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					
	V_1					
	V_2					

Calculations:

Refractive index for the line _________ n1 =
Refractive index for the line _________ n2 =

Average refractive index n = $\frac{n1+n2}{2}$

Resolving power for ______ and ______ line ω = $\frac{n2-n1}{n-1}$ =

Result:

Angle of the Prism =……………………………….Degrees
Angle of minimum deviation of the prism =……………………………….Degrees

Refractive index of the material of the prism =………………………………

Dispersive power of the prism =………………………………

Experiment-3(a)

Aim

To determine the refractive index and dispersive power of prism material by spectrometer.

Apparatus:

Spectrometer, prism, prism clamp, sodium vapour lamp, lens.

Formula used:

The refractive index of the material of the prism can be calculated by the equation.

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Where, D is the angle of minimum deviation, here D is different for different colour

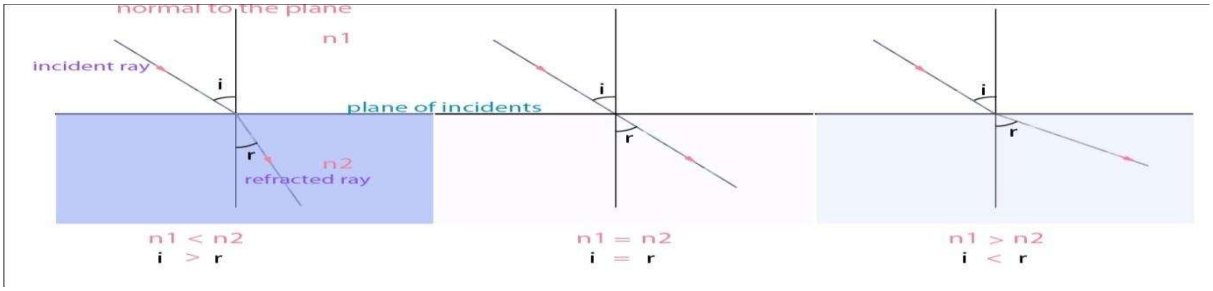
About experiment:

When a beam of light strikes on the surface of transparent material(Glass, water, quartz crystal, etc.), the portion of the light is transmitted and other portion is reflected. The transmitted light ray has small deviation of the path from the incident angle. This is called refraction. Refraction is due to the change in speed of light while passing through the medium. It is given by Snell's Law.

$$\frac{\sin(i)}{\sin(r)} = \frac{n_2}{n_1}$$

Where, D is the angle of minimum deviation, here D is different for different colour

Where i is the angle of incident and r is the angle of refraction. And n_1 is the refractive index of the first face and n_2 is the refractive index of the second face.



Procedure:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window; focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapor lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base leveling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Observations Table:

Reading of reflected ray from	Vernier 1			Vernier 2		
	MSR	VSR	Total	MSR	VSR	Total
face 1 (say a)						
face 2 (say b)						
Difference between a & b						

Precaution:

1. The telescope and collimator both should individually be set for parallel ray.
2. The slit should be perfectly vertical and horizontally.

Result:

Angle of the Prism	=……………………………….Degrees
Angle of minimum deviation of the prism	=……………………………….Degrees
Refractive index of the material of the prism	=……………………………….

Experiment-3(b)

Aim

To determine the dispersive power of prism.

Apparatus:

Spectrometer, prism, prism clamp, sodium vapour lamp, lens.

Formula used:

The refractive index of the material of the prism can be calculated by the equation.

$$n = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

There for dispersive power is.

Where, D is the angle of minimum deviation, here D is different for different colour

$$\omega = \frac{(n_V - n_G)}{n}$$

Where

$$n = \frac{(n_V + n_G)}{2}$$

About experiment:

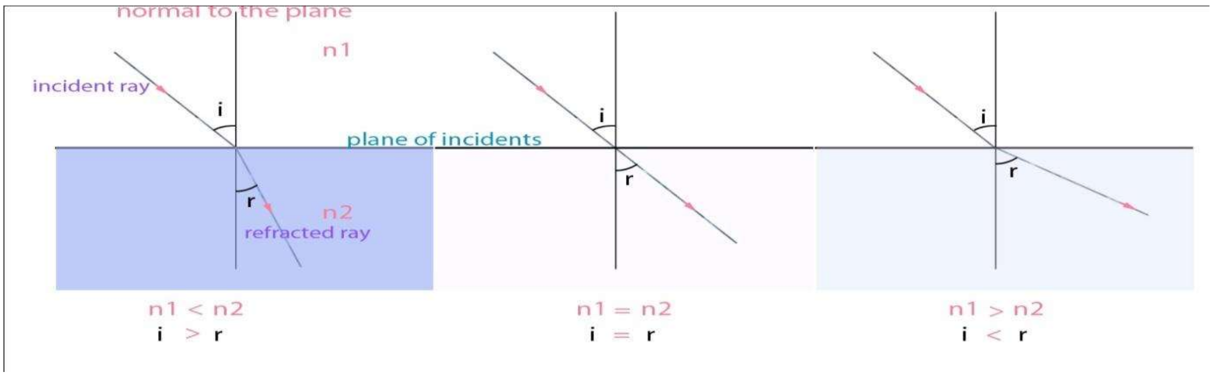
When a beam of light strikes on the surface of transparent material (Glass, water, quartz crystal, etc.), the portion of the light is transmitted and other portion is reflected. The transmitted light ray has small deviation of the path from the incident angle. This is called refraction.

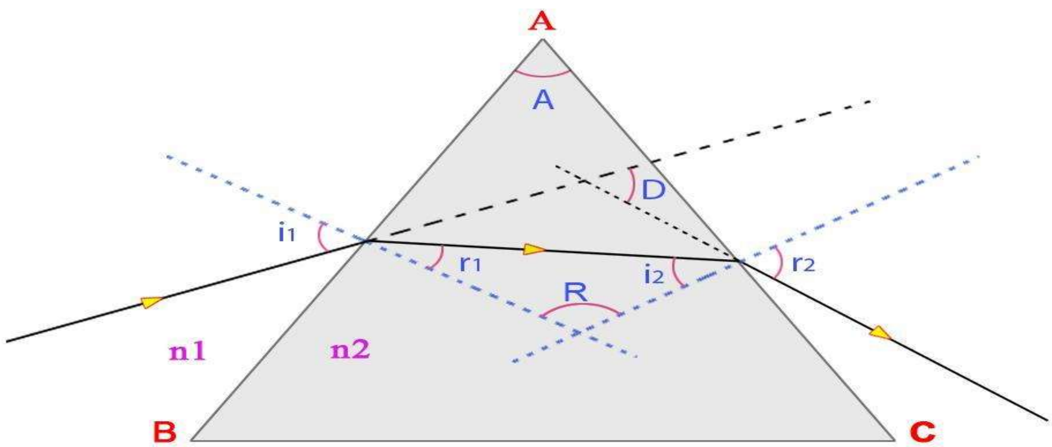
Refraction is due to the change in speed of light while passing through the medium. It is given by Snell's Law.

$$\frac{\sin(i)}{\sin(r)} = \frac{n_2}{n_1}$$

Where, D is the angle of minimum deviation, here D is different for different colour

Where i is the angle of incident and r is the angle of refraction. And n_1 is the refractive index of the first face and n_2 is the refractive index of the second face.





Procedure:

1. Turn the telescope towards the white wall or screen and looking through eye-piece, adjust its position till the cross wires are clearly seen.
2. Turn the telescope towards window, focus the telescope to a long distant object.
3. Place the telescope parallel to collimator.
4. Place the collimator directed towards sodium vapour lamb. Switch on the lamp.
5. Focus collimator slit using collimator focusing adjustment.
6. Adjust the collimator slit width.
7. Place prism table, note that the surface of the table is just below the level of telescope and collimator.
8. Place spirit level on prism table. Adjust the base levelling screw till the bubble come at the centre of spirit level.
9. Clamp the prism holder.
10. Clamp the prism in which the sharp edge is facing towards the collimator, and base of the prism is at the clamp.

Observations Table:

Reading of reflected ray from	Vernier 1			Vernier 2		
	MSR	VSR	Total	MSR	VSR	Total
face 1 (say a)						
face 2 (say b)						
Difference between a & b						

Precaution:

1. The telescope and collimator both should individually be set for parallel ray.
2. The slit should be perfectly vertical and horizontally.

Result:

Angle of the Prism	=……………………………….Degrees
Refractive index for blue line, n1	=……………………………….
Refractive index for yellow line, n2	=……………………………….
Dispersive power of the prism for blue and yellow line	=……………………………….

Experiment-4

Aim:

Determine the wavelength of sodium light and the no. Of line per centimetre using a diffraction grating.

Apparatus:

Spectrometer, diffraction grating element and sodium lamp.

Formula used:

Intensity is given by,

$$I = I_0 \frac{\sin^2\left(\frac{N\delta}{2}\right)}{\left(\frac{\delta}{2}\right)^2}$$

Where δ is the total phase angle, it can be related to the deviation angle

$$\delta = \frac{2\pi a * \sin(\theta)}{\lambda}$$

I_0 is the maximum intensity λ is the wavelength of the light and ***a*** is the slit width.

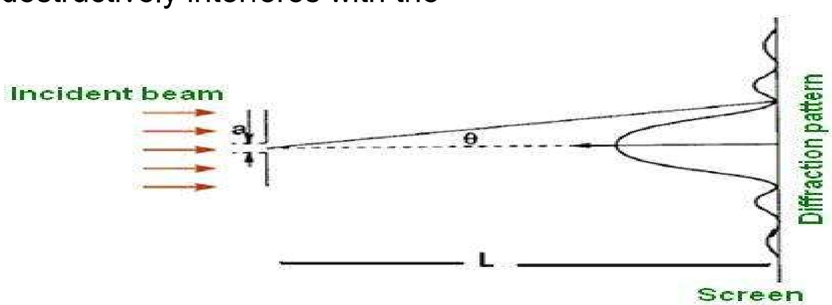
About experiment:

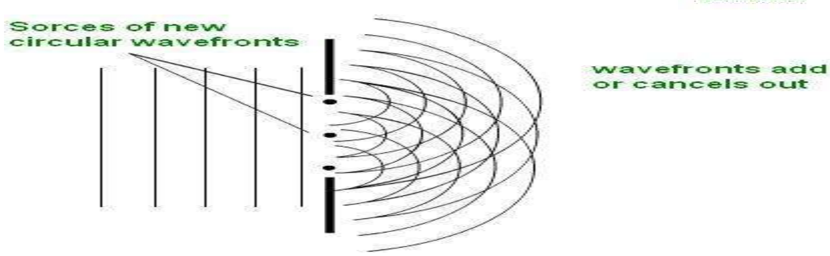
When a wave train strikes an obstacle, the light ray will bend at the corners and edges of it, which causes the spreading of light waves into the geometrical shadow of the obstacle. This phenomenon is termed as diffraction.

Single slit diffraction:

When waves pass through a gap, which is about as wide as the wavelength they spread out into the region beyond the gap. Huygens considered each point along a wave front to be the source of a secondary disturbance that forms a semi-circular wavelet.

Diffraction is due to the superposition of such secondary wavelets. The secondary wavelets spread out and overlap each other interfering with each other to form a pattern of maximum and minimum intensity. The pattern formed on a screen consists of a broad central band of light with dark bands on either side. The dark bands are caused when the light from the top half of the slit destructively interferes with the





Procedure:

1. Turn the telescope towards the white wall or screen and looking through eye-piece adjust

2. Its position till the cross wires are clearly seen.
3. Turn the telescope towards window; focus the telescope to a long distant object.
4. Place the telescope parallel to collimator.
5. Place the collimator directed towards sodium vapor lamb. Switch on the lamp.
6. Focus collimator slit using collimator focusing adjustment.
7. Adjust the collimator slit width.

Observations Table:

Green, λ (nm)	Left		Right		Difference reading (2θ)		Mean θ	N=sinθ/nλ
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		

For green light, λ = 546.1nm
Determination of wavelength for prominent lines

Color	Left		Right		Difference reading (2θ)		Mean θ	λ=sinθ/nN
	Ver I	Ver II	Ver I	Ver II	Ver I	Ver II		
Yellow I								
Yellow II								
Blue-Green								
Violet I								
Violet II								

Result:

The wavelength of Yellow I = ...nm
The wavelength of Yellow II = ...nm
The wavelength of Blue-green = ...nm
The wavelength of Violet I = ...nm
The wavelength of Violet II = ...nm

Experiment-5

Aim

. To obtains the load regulation and ripple factor of a half-wave rectifier by using
(a) Without Filter (b) With Filter

Apparatus Required:

S. No	Name of the Apparatus	Range	Quantity
1	Diodes IN 4007 (Si)		1
2	Decade Resistance Box	(1KΩ -10 KΩ)	1
3	Transformer	230 V AC	1
4	Capacitor	100μF	1
5	Bread Board		
6	Digital Voltmeter	(0-20)V (AC & DC)	2
7	Connecting Wires	As Required	

Formula used:

(a) WITH OUT FILTER

For a Half-Wave Rectifier,

Therefore, Ripple factor $\Gamma=\sqrt{(V_{rms}/ V_{dc})^2 -1}$ = **<u>1.21</u>**

% regulation = $[(V_{NL}-V_{FL})/V_{FL}]*100$

b) WITH FILTER

Ripple factor for a Half-Wave Rectifier is $\Gamma=1/(2\sqrt{3}\, fRC)$.

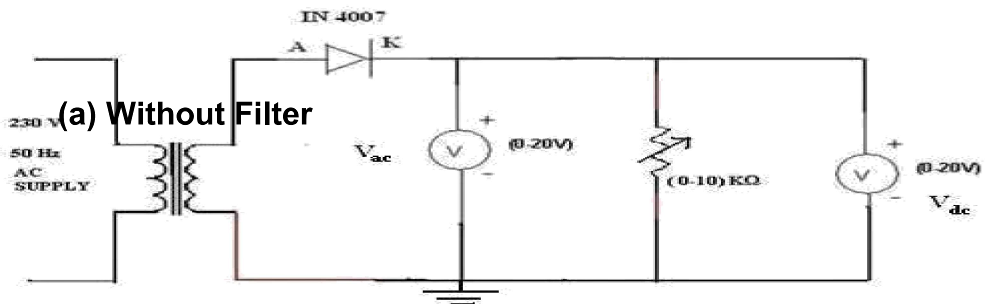
% regulation = $[(V_{NL}-V_{FL})/V_{FL}]*100$

About experiment:

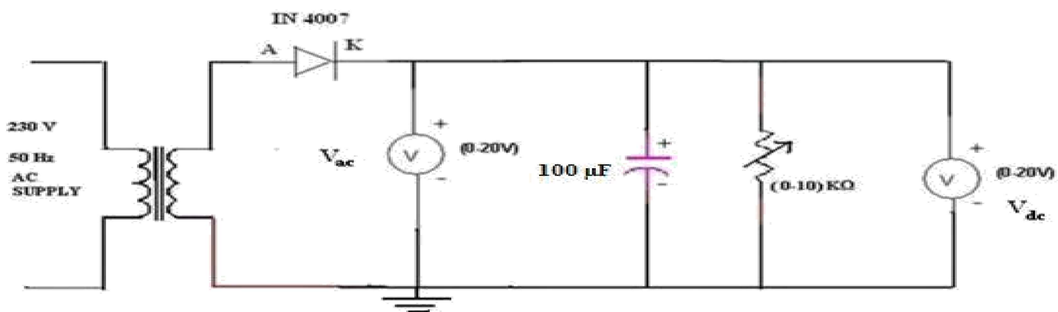
During positive half-cycle of the input voltage, the diode D1 is in forward bias and conducts through the load resistor R1. Hence the current produces an output voltage across the load resistor R1, which has the same shape as the +ve half cycle of the input voltage.

During the negative half-cycle of the input voltage, the diode is reverse biased and there is no current through the circuit. i.e., the voltage across R1 is zero. The net result is that only the +ve half cycle of the input voltage appears across the load. The average value of the half wave rectified o/p voltage is the value measured on dc voltmeter.

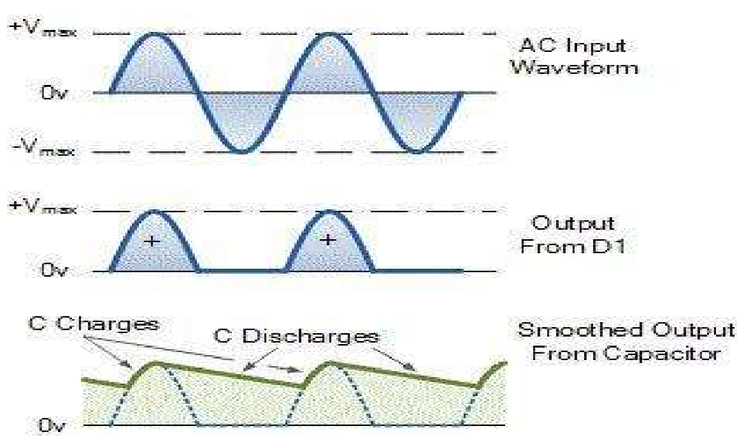
(a) Without Filter



(b) With Filter



Input and Output Waveforms



Procedure:

1. Connect the primary side of the transformer to ac mains and the secondary side to the rectifier input.
2. By using the multimeter, measure the ac input voltage of the rectifier and, ac and dc voltage at the output of the rectifier.
3. Find the theoretical value of dc voltage by using the formula, **$V_{dc}=V_m/\Pi$**
4. Where, $V_m=2V_{rms}$, (V_{rms}=output ac voltage.)
5. Now, the Ripple factor is calculated by using the formula
    a. **= ac output voltage (V_{ac})/dc output voltage (V_{dc})**
6. By increasing the value of the resistance from 1 KΩ to 10KΩ, the voltage across the load(V_L) and current (I_L) flowing through the load are measured.
    a. Draw a graph between load voltage (V_L) and load current (I_L) by taking V_L on X-axis and I_L on y-axis.
    b. From the value of no-load voltage (V_{NL}), the % regulation is to be calculated
    c. from the theoretical calculations given below.

Observations:

(a) With Out Filter

V_{NL} =______V

S.No	Load Resistance (KΩ)	V_{ac}(v)	V_{dc}(v)	$\Gamma= V_{ac}/ V_{dc}$	% Regulation

(b) With Filter

V_{NL} =______V

S.No	Load Resistance (KΩ)	V_{ac}(v)	V_{dc}(v)	$\Gamma= V_{ac}/ V_{dc}$	% Regulation

Precautions:

1. The primary and secondary sides of the transformer should be carefully identified.
2. The polarities of the diode should be carefully identified.
3. While determining the % regulation, first Full load should be applied and then it should be decremented in steps.

Result:

The Ripple factor and the % regulation for the Half-Wave Rectifier with and without filters are calculated

1. The Ripple factor of Half-Wave Rectifier without filter is ____________________
1. The Ripple factor of Half-Wave Rectifier with filter is _____________________
2. The % Regulation of Half-Wave Rectifier without filter is ___________________
3. The % Regulation of Half-Wave Rectifier with filter is _____________________

Experiment-6(a)

Aim:

To draw the characteristics of CE transistor.

Apparatus:

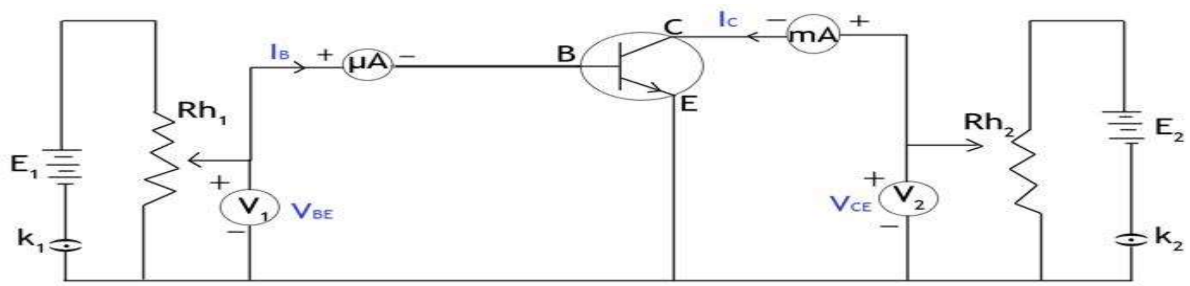
- Rheostat
- Voltmeter
- Ammeter
- Battery
- One way key
- Transistor
- Bread board

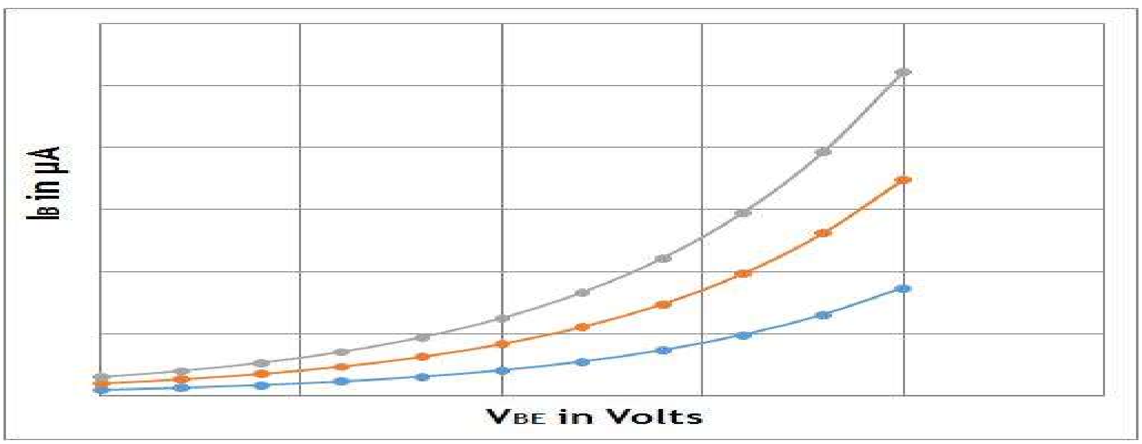
About experiment:

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal.

1) Input characteristics

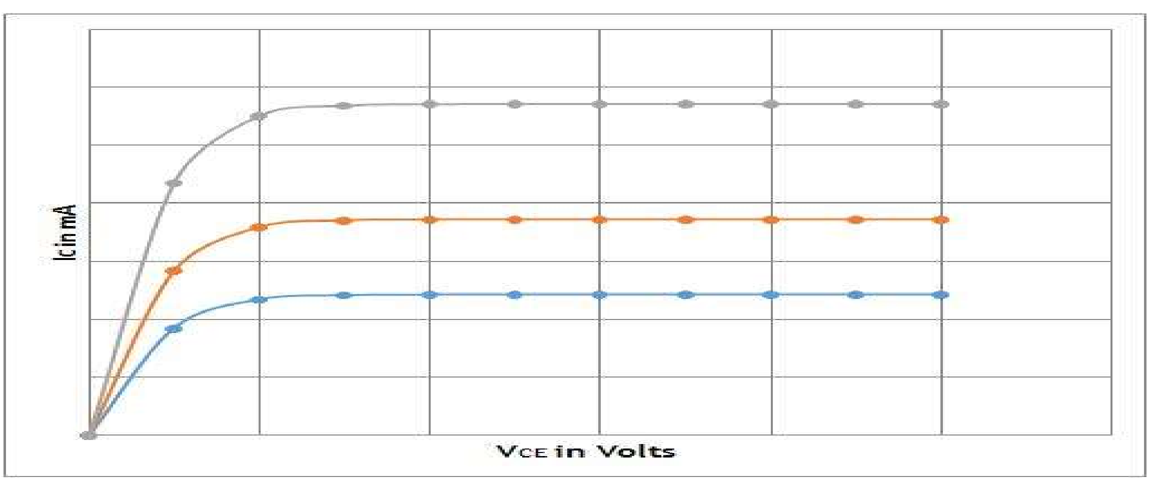
Keeping the collector- emitter (V_{CE}) voltage constant, the base- emitter (V_{BE}) voltage is increased from 0 and the corresponding base current (I_B) values are noted. This is repeated for increasing values of V_{CE}. The family of curve obtained by plotting I_B against V_{BE} for each V_{CE} value is called input characteristics





2) Output Characteristics

By keeping the base current (I_B) constant, collector- emitter (V_{CE}) voltage is varied and the corresponding I_C values are obtained. This is repeated for increasing values of I_B. The family of curves obtained by plotting I_C against V_{CE} for each value of I_B is called output characteristics.



Procedure:

1. The collector voltage V_{CE} is kept constant (eg. 1V) by adjusting the rheostat Rh_2.
2. The base voltage V_{BE} is varied from zero by adjusting the rheostat Rh_1.
3. The base current I_B is noted in each step.
4. A graph is drawn with V_{BE} along X-axis and I_B along Y-axis.
5. The experiment is repeated with V_{CE} kept constant say 2V, 3V, 4V etc. and corresponding graphs are plotted.
6. The base current I_B is kept constant (eg. 20μA) by adjusting the rheostat Rh_1.
7. Now the collector voltage is increased by adjusting the rheostat Rh_2.
8. The corresponding collector current I_C is noted.
9. A graph is drawn with V_{CE} along X-axis and I_C along Y-axis.
10. The experiment is repeated with keeping IB constant, say 40μA, 60μA, 80μA etc and similar graphs are plotted

Observations:

V_{CE} (1V)	V_{BE} (V)			
	I_B (μA)			
V_{CE} (2V)				
V_{CE} (3V)				
V_{CE} (4 V)				

Output characteristics

I_B (μA)	V_{CE} (V)			
	I_C (mA)			
I_B (μA)				
I_B (μA)				
I_B (μA)				

Precautions:

1. The primary and secondary sides of the transformer should be carefully identified.
2. The polarities of the diode should be carefully identified.
3. While determining the % regulation, first Full load should be applied and then it should be decremented in steps.

Result:

Experiment-6(b)

Aim:

To draw the characteristics of CE transistor.

Apparatus:

- Rheostat
- Voltmeter
- Ammeter
- Battery
- One way key
- Transistor
- Bread board

Formula:

$A_V = V_{out}/V_{in} = (I_C*R_L) / (I_E*R_{in})$

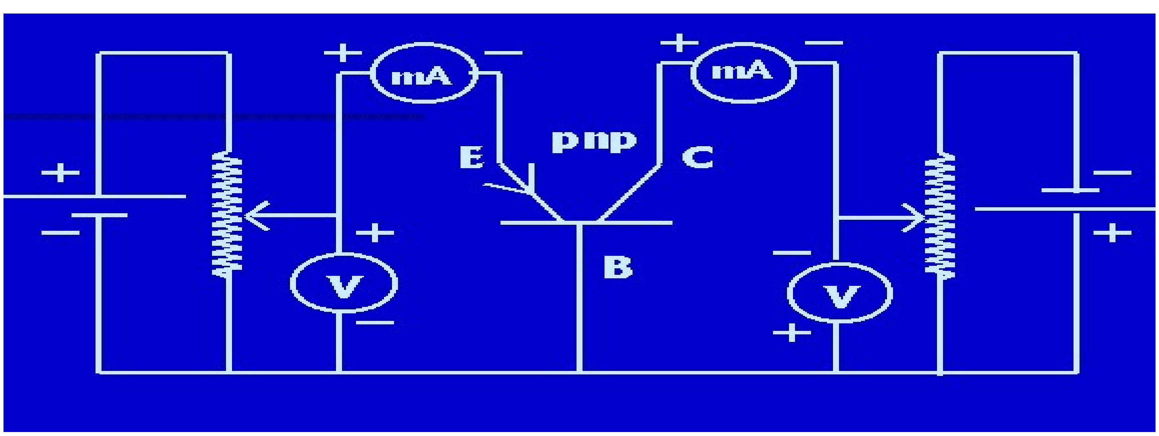
Current gain in common base configuration is given as

α = Output current/Input current

$\alpha = I_C/I_E$

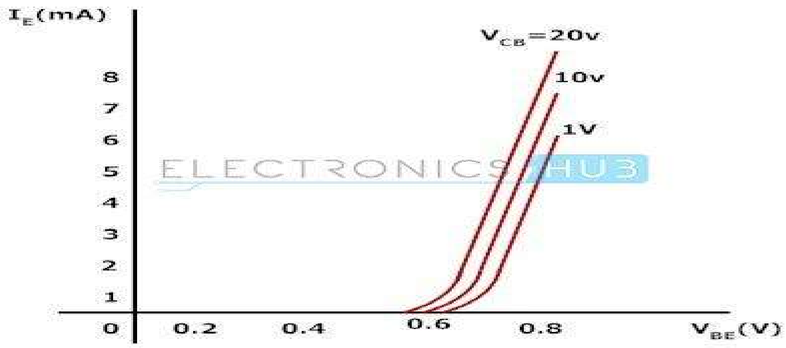
About experiment:

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Because the controlled (output) power can be higher than the controlling (input) power, a transistor can amplify a signal.



Input Characteristics

Input characteristics are obtained between input current and input voltage with constant output voltage. First keep the output voltage V_{CB} constant and vary the input voltage V_{EB} for different points then at each point record the input current I_E value. Repeat the same process at different output voltage levels. Now with these values we need to plot the graph between $I_E$and V_{EB} parameters.



Output Characteristics

The output characteristics of common base configuration are obtained between output current and output voltage with constant input current. First keep the emitter current constant and vary the V_{CB} value for different points, now record the I_C values at each point. Repeat the same process at different I_E values. Finally we need to draw the plot between V_{CB} and I_C at constant $I_{E.}$ The below figure show the output characteristics of common base configuration.

$R_{out} = V_{CB} / I_C$ (when I_E is constant)

Procedure:

11. The collector voltage V_{CE} is kept constant (eg. 1V) by adjusting the rheostat Rh_2.
12. The base voltage V_{BE} is varied from zero by adjusting the rheostat Rh_1.
13. The base current I_B is noted in each step.
14. A graph is drawn with V_{BE} along X-axis and I_B along Y-axis.
15. The experiment is repeated with V_{CE} kept constant say 2V, 3V, 4V etc. and corresponding graphs are plotted.
16. The base current I_B is kept constant (eg. 20μA) by adjusting the rheostat Rh_1.
17. Now the collector voltage is increased by adjusting the rheostat Rh_2.

18. The corresponding collector current I_C is noted.
19. A graph is drawn with V_{CE} along X-axis and I_C along Y-axis.
20. The experiment is repeated with keeping IB constant, say 40μA, 60μA, 80μA etc and similar graphs are plotted.

Observation table:

Vcb = o V		Vcb =4 V		Vcb =8 V	
V_{EB} V	I_E mA	V_{EB} V	I_E mA	V_{EB} V	I_E mA
0 0.1 0.2 0.3 0.4 0.5 0.55 0.6 0.65					

For output characteristics

I_E = 5 mA		I_E = 7.5 mA		I_E = 10 mA	
V_{CB} V	I_C mA	V_{EB} V	I_E mA	V_{EB} V	I_E mA
0 0.1 0.2 0.3 0.4 0.5 0.55 0.6 0.65					

Result:

Experiment-7

Aim:

To draw frequency response curve of a R-C coupled transistor amplifier.

Apparatus:

Two transistors, variable frequency oscillator, multimeters potentiometers, resistances, capacitances, 9-volt power apply and connecting wires etc.

About experiment:

When a.c. signal is applied to the base of the first transistor, it is amplified and appears across its collector load $R_{C.}$
Now the amplified signal developed across R_C is given to the base of the next transistor through a coupling capacitor C_C .
The second stage again amplifies this signal and the more amplified signal appears across the second stage collector resistance. In this way the cascaded stages amplify the signal and the overall gain is considerably increased. However, the total gain is less than the product of the gains of individual stages. It is because, when a second stage follows the first stage, the effective load resistance of first stage is reduced due to the shunting effect of the input resistance of second stage. This reduces the gain of the stage which is loaded by the next stage. To explain it better, let us take an example of 3-stage amplifier. The gain of first and second stage will be reduced due to loading effect of the next stage. But the gain of the third stage which has no loading effect due to subsequent stage, remains unchanged.

Procedure:

1. Complete the amplifier circuit as shown in circuit diagram. Join audio frequency signal generator across the input circuit of amplifier and an ac multimeter across the amplifier output .
2. Set load resistance and the coupling capacitor C to suitable values. Adjust the output of the AF. Signal generator (i.e. the input for amplifier) at some suitable value, say few mV and keep it constant throughout.
3. Change the frequency of AF. Sine wave from 10 Hz to 20 kHz in regular steps and note the output voltage each time.
4. Plot graph between logarithmic of frequency and the voltage gain.
5. Repeat the observations by changing the values of coupling capacitor and load resistance and plot graphs.

Observations:

Constant input voltage Vi =.... Volt
Load resistance R = ... ,Q ; Coupling capacitance, C = ... J...I.F

Sr. No.	Frequency in Hz	Output voltage Vo in volt	Voltage gain A = Vo/VI
1.			
2.			
3.			
4.			
5.			
6.			
7.			
B.			
.....			
.....			
.....			
.....	20×10^3		.

Make similar table for two different values of Rr, and C_c

Calculations:

Draw graphs between log of frequency and voltage gain for different values of load resistance and coupling capacitances, taking log frequency along x-axis and voltage gain along y-axis.

Precautions:

1. Value of circuit elements should be chosen carefully.
2. The output of AF. signal generator i.e. the input of the amplifier should throughout remain constant through the experiment for each set of Rr, and C_c.
3. Before using multimeter. **It** should be set for its proper range and then zero adjustment should be made.

Result:

The frequency response curves of R-C coupled amplifier are attached herewith. From these curves we conclude that voltage gain is constant for mid frequencies but falls for low and high frequencies.

Experiment-8

Aim:

To study the voltage doublers and tripler circuit.

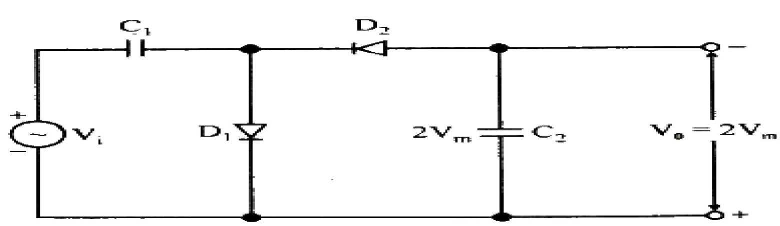
Apparatus:

Step down transformer with tappings in secondary coil so as to get rms output of 6, 9, 12 volt (150- 200 mA current ratings), four P-N junction diodes, four electrolyte capacitors of32!!F each, AC. voltmeter, D.C. voltmeter, D.C. milliammeter, few resistances of 500 ohm each joined in series and the connecting Wires.

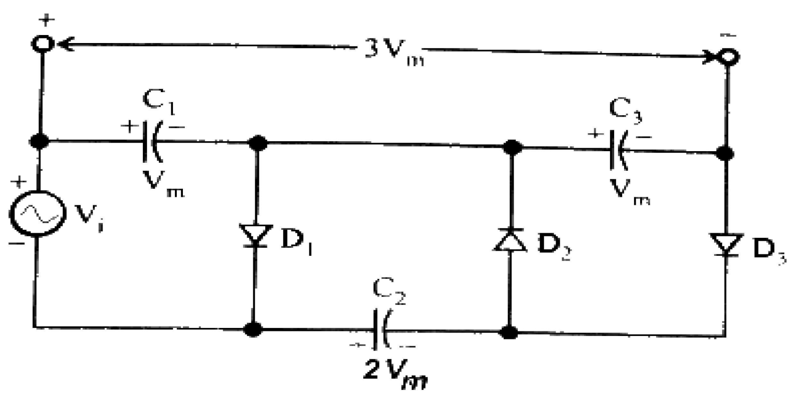
About experiment:

Although it is usual in electronic circuits to use a voltage transformer to increase a voltage, sometimes a suitable step-up transformer or a specially insulated transformer required for high voltage applications may not always be available. One alternative approach is to use a diode voltage multiplier circuit which increases or "steps-up" the voltage without the use of a transformer.

Voltage multipliers are similar in many ways to rectifiers in that they convert AC-to-DC voltages for use in many electrical and electronic circuit applications such as in microwave ovens, strong electric field coils for cathode-ray tubes, electrostatic and high voltage test equipment, etc, where it is necessary to have a very high DC voltage generated from a relatively low AC supply.



Half-wave voltage doubler.



Voltage Tripler

Procedure:

1. Complete the circuit connections as shown in the fig. This arrangement may act as voltmeter doublers, Tripler as well as quadrupler.
2. Initially use the tapping 1 of secondary of transformer. Switch on the AC. mains and measure the voltage across the secondary of the transformer by the use of an AC. voltmeter. Voltmeter Reading is the rms voltage. Obviously peak AC. voltage will be VO = 12. V rms

For Voltage doublers arrangement:

3. Between the points C and D, join a D.C. voltmeter in parallel and a milliammeter mA and resistance R in series.
4. Insert a suitable resistance of the order of 500 - 1000 ohm from resistance arrangement Rand note the readings of voltmeter V and milliammeter mA. Reading of voltmeter should be equal to $2V_o$. gradually increase the value of resistance R and every time note the reading of voltmeter and milliammeter. Voltmeter reading remains almost constant but milliammeter reading gradually decreases on increasing R.
5. Repeat the same procedure using tapping for 9 to 12 volts of the secondary coil of transformer.

   For voltage tripler arrangement.
6. For voltage tripler, join the output resistance, milliammeter and voltmeter circuit between the points ,C and T and repeat the steps 3, 4 and 5

Observations:

Sr. No.	Voltmeter reading Vo in volt	Resistance R in ohm	Current in mA
1.			
2.			
3.			
4.			
5.			
6.			

Make a table for voltage tripler arrangement is same as for voltage doubles arrangement.

Calculations:

1. Capacitors Cl' C_2 and C_3 should have at least 50 volt rating. Rating of capacitor C_4 should be of still higher.
2. Always connect a current limiting-resistor in the output circuit to protect the circuit from possible damage.
3. To measure the output voltage make use of a multimeter.

Precautions:

1. Capacitors Cl' C_2 and C_3 should have at least 50 volt rating. Rating of capacitor C_4 should be of still higher.

2. Always connect a current limiting-resistor in the output circuit to protect the circuit from possible damage.
3. To measure the output voltage make use of a multimeter.

Result:

1. In voltage doubler circuit arrangement the output D.C. voltage is almost double of the peak value of A.C. input voltage. The output voltage is almost steady and does not show much variation with load.
2. In voltage tripler arrangement the output voltage is almost triple of the peak value of A.C. Input.

Experiment-9

Aim:

To measure the area *of* a given window using a sextant and verify the result.

Apparatus:

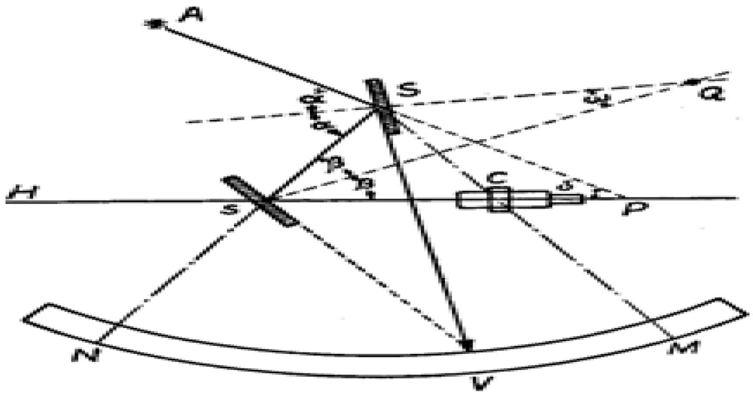
A sextant, a rigid clamp stand for sextant, a piece of chalk, measuring tape, plumb line and spirit level.

Formula used.

The length (or breadth) of the window is given by the formula h = d tan 8.
Where d = normal distance of the index mirror of sextant from the wall in which window is situated and 8 is the angle subtended at the index mirror of the sextant by the two ends of the window.
Area of the window = length *(l)* x breadth *(b)*

About experiment:

Broadly speaking a sextant is an instrument that measures the angle between two objects that are visible. Primarily, it is used to measure the angle between a celestial body and the horizon, a process normally known as sighting the object or taking a sight. The angle measured and the time at which it was measured is then used to identify the location of the user on the grid map of the world. Thus sextants are basically navigational tools and have been successfully used by seaman and even other travelers over the years. The most common process of this is to sight the sun at noon to find the latitude of one's location.



Procedure:

1. Place a rigid clamp. stand at a distance of about 7-8 meters from the window. Clamp the s-extant in this stand with its scale downwards and the telescope objective pointing horizontally towards the lower end of the window.

2. Adjust the sextant.
3. Using of spirit level check that the axis of telescope is horizontal. With the help of plumb line check that the plane of circular arc is vertical. Adjust the height of sextant so that telescope is at the same level as the lower end of the window. Now on viewing through the telescope we will see the image of lower edge of window in the centre of the field of view. This is direct image.
4. Find the least count of the sextant. Usually -the main scale is graduated in degrees. Some circular scale provided in sextant has 60 marks on its circumference. One mark on circular **1** Scale equals to 60 degree = 1 minute. Also on linear scale usually there are 5 divisions which **1** coincide with 4 divisions of the circular scale. Hence least count of sextant is 5 minute or 12 Second.
5. Rotate the index arm of sextant gently so that the reflected image of the lower edge of window is also visible in the telescope. Now adjust by rotating the circular micrometer head till the two images (direct image and reflected image)
6. ow move the index arm and see through the telescope. One half of the field of view appears to slide past the other half. Continue to move index arm till the reflected image of the upper edge of the window just coincide with the direct image of the lower edge of window. For this purpose use the circular micrometer head. Note this reading on the scale.

7. Measure the distance between the window and the index mirror of sextant using measuring tape. Repeat the observation for at least three different distances.
8. Now adjust the sextant in a horizontal position such that the circular arc scale is horizontal and the axis of the telescope is pointing normally

towards the left edge ofthe window. Observe the direct image of the left edge of the window through the telescope. Now rotate the index arm gently and its position till the reflected image of the left edge of window coincides with the direct images. Note the reading of the scale.

9. Now move the index arm so that one half of the field of view appears to slide past and other. Continue to move the index arm till the reflected image of the right side edge of the window just coincides with the direct image of left side edge of window. Note this reading of the scale.
10. Measure the distance between the window and the index mirror of sextant using a measuring tape.
11. Repeat the observation for at least three different distances.
12. using the tape directly measure the length (i.e., height) as well as breadth of the given window.

Sr. No.	Distance d(cm)	Initial Reading of scaleθ_1(°)	Final Reading of scaleθ_2(°)	Difference in degreesθ° = (θ_1-θ_2)	l=d tanθ (cm)
1. 2. 3.					l_1 = l_2 = l_3 =

Table for breadth of the window:

Sr. No	Distance d(cm)	Initial reading of scale θ_1' = O	Final reading scale θ_2' =(°)	Difference in degrees .θ°=(θ_1'-θ_2}	b = d (cm)
					b_1 = b_2 = b_3 =

Observation:

Area of given window A =l× b……………….cm^2
Actual length of the window = ...cm
Actual breadth of the window=……………….cm
Actual area of the given window A' = = cm^2

Calculation:

1. Find the values of cot 9_1 and cot 9_2 and calculate value of h.
2. Total height of given building H = h + h' = ... m

Precautions:

1. The plane of the index mirror as well as the horizontal mirror should be perpendicular to the plane of the graduated arc.
2. The axis of the telescope should be parallel to the plane of the graduated arc and the axis of rotation of the index mirror must coincide with the centre of the graduated arc.
3. The axis of rotation of the index mirror should coincide with the centre of the graduated arc.
4. When sextant is used for measuring vertical length of the window, the plane of the graduated arc should be vertical and the telescope axis should be horizontal while using the sextant for measuring the horizontal breadth of the window, the plane of the graduated arc should be horizontal.
5. Readings should be taken when the two images (i.e. the direct image and the reflected image) just coincide and have the same intensity. Initial reading should be taken separately for each distance.

Result:

Experimentally observed value of area of given window A = ...cm^2
Actual value of area of window A' = ...cm^2
Percentage error = *A'* x 100% = ...%

Experiment-10

Aim:

To determine the height of an inaccessible object.

Apparatus:

A sextant, a rigid clamp stand for sextant, a piece of chalk, measuring tape, plumb line and a spirit level.

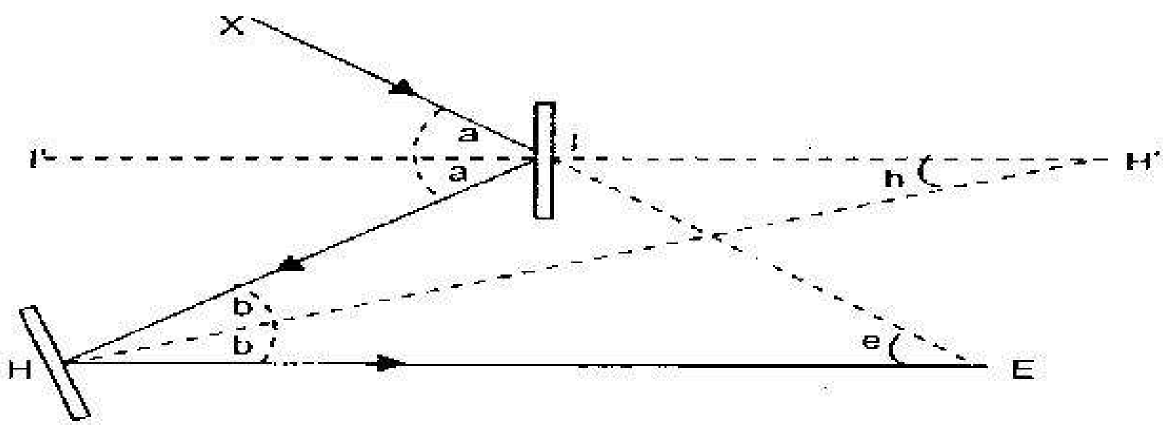
Formula used:

$$h = \frac{d}{\cot\theta_2 - \cot\theta_1}$$

Here, h = height of given accessible object, θ_1 = the angular elevation of the object at a position of sextant of sextant and θ_2 = the angular elevation of given object on moving the sextant away from the object through a distance d.

About experiment

Broadly speaking a sextant is an instrument that measures the angle between two objects that are visible. Primarily, it is used to measure the angle between a celestial body and the horizon, a process normally known as sighting the object or taking a sight. The angle measured and the time at which it was measured is then used to identify the location of the user on the grid map of the world. Thus sextants are basically navigational tools and have been successfully used by seaman and even other travelers over the years. The most common process of this is to sight the sun at noon to find the latitude of one's location.
The instrument is called a sextant because of the scale of the angles on it which runs up to 60°. The principle of the instrument was invented by Sir Isaac Newton during his life time but the actual tool was developed later on by two individuals separately.



Principle of Sextant

Procedure:

1. Fix the sextant an rigit clamp stand in such a way that its scale is downwards and the telescope objective pointing horizontally towards the building whose height is to be measured.
2. Check the adjustment of the sextant.
3. Find the vernier constant (least count) of the sextant.
4. Find the vernier constant (least count) of the sextant. using a coloured chalk.
5. Plane of circular arc scale should be vertical. Using spirit level check that the telescope axis is horizontal. Adjust the height of sextant so that the telescope is at the same level as the chalk mark on the wall.

6. Focus the telescope on the horizontal arrow and adjust the sextant so that direct image of the horizontal line is clearly visible in the centre of one half of the field of view of the telescope.
7. Move the index arm, so that the image of horizontal line as formed by reflection from two mirrors is also visible in the telescope. Adjust vernier screw till the two images of horizontal line (direct and reflected) just overlap. Note this reading on sextant scale.
8. Keeping your eye in the same position move the index arm. On moving the index arm, one half of the field of view will appear to slide past the other half. Continue to move the index arm till the image of the top of the given object just coincides with the direct image of horizontal line. For finer adjustment make use of vernier circular scale. Note this reading too on the sextant scale. Difference between the final and initial readings is equal to the angular elevation 9_1 of the building at that position of sextant.

9. Move the sextant away from the building through a known distance, d (about 5-6 metre).
10. Move the sextant away from the building through a known distance, d (about 5-6 metre).
11. Measure the height of horizontal line drawn from the ground level and add it into mean value obtained in step no. 10. The sum is equal to the total height of the building.

Observations:

Least count of vernier scale of sextant = ...
Height of horizontal line above the ground h = ... m

Sr. No.	Reading in 1st position of sextant			Distance in metre (d)	Reading of 2nd position of sextant			$\frac{d}{\cot\theta_2 - \cot\theta_1}$ in metre
	Initial reading In degree	**Final reading** in degree	θ_1 **in degree**		**Initial reading** in degree	**Final reading in degree**	θ_2 **in degree**	
1.								
2.								
3.								

Calculation:

1. Find the values of cot θ_1 and cot θ_2 and calculate value of h.
2. Total height of given building H = h + h' =..... m

Precautions:

1. Collimator both should individually be set for parallel rays. The slit should be perfectly.
2. Vertical and as narrow as possible.
3. The prism table should be leveled.
4. While taking observations the prism table as well as the telescope should be invariably clamped with the help of clamping screws provided.
5. For each observation both the verniers should be read carefully using magnifying glass.

Result:

The height of given building H =..... m

Experiment-11

Aim:

To plot graphs (i) between wavelength (λ).) and minimum deviation angle,

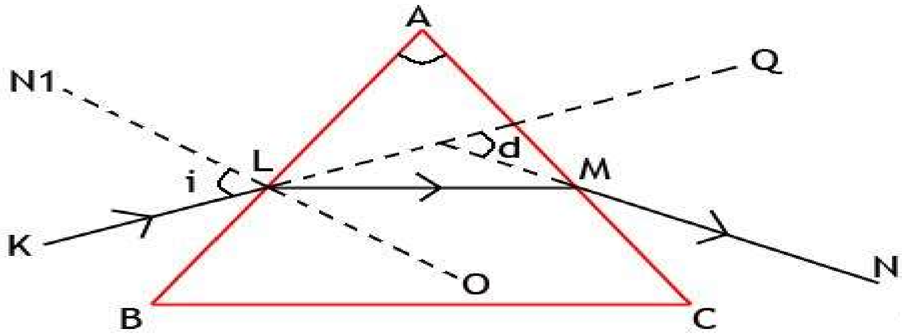
ii) Between $\frac{1}{2}$ and minimum deviation angle for prism for various lines from the spectrum of mercury discharge source.

Apparatus:

A spectrometer, glass prism, spirit level, reading lens, mercury lamp etc.

About experiment:

A prism is an optical element. It has polished flat surfaces that refract light. The traditional geometric shape of a prism has a triangular base and two rectangular sides. It is called triangular prism. prism can be made from materials like glass, plastic and fluorite. It can be used to split light into its components. When light travels from one medium to another medium, it is refracted and enters the new medium at a different angle. The degree of bending of the light's path depends on the angle that the incident beam of light makes with the surface of the prism.



Procedure:

1. Fix the sextant an rigit clamp stand in such a way that its scale is downwards and the telescope objective pointing horizontally towards the building whose height is to be measured.
2. Check the adjustment of the sextant.
3. Find the vernier constant (least count) of the sextant.
4. Mark a horizontally line, nearly 1- cm long, on the wall of given building at a height of about 1 metre using a coloured chalk.
5. Plane of circular arc scale should be vertical. Using spirit level check that the telescope axis is horizontal.
6. Adjust the height of sextant so that the telescope is at the same level as the chalk mark on the wall.
7. Focus the telescope on the horizontal arrow and adjust the sextant so that direct image of the horizontal line is clearly visible in the centre of one half of the field of view of the telescope.
8. Move the index arm, so that the image of horizontal line as formed by reflection from two mirrors is also visible in the telescope. Adjust vernier screw till the two images of horizontal line (direct and reflected) just overlap. Note this reading on sextant scale.
9. Keeping your eye in the same position move the index arm. On moving the index arm, one half of the field of view will appear to slide past the other half. Continue to move the index arm till the image of the top of the given object just coincides with the direct image of horizontal line. For finer adjustment make use of vernier circular scale. Note this reading too on the sextant scale. Difference between the final and initial readings is equal to the angular elevation θ_1 of the building at that position of sextant.
10. Move the sextant away from the building through a known distance, d (about 5-6 metre).
11. Again repeat the step no. 7 and 8 given above and obtain the angle of elevation 9

12. Measure the height of horizontal line drawn from the ground level and add it into mean value obtained in step no. 10. The sum is equal to the total height of the building.

Observations:

Vernier constant of verniers = ………………. .

Table for angular deviations:

Sr. No.	Colour of the line	Wavelength δ.(A) ,	$\frac{1}{\delta^2}(A°)^{-2}$	Telescope readings				Minimum deviations		
				Vernier VI		Vernier V_2		VI	V_2	Mean
				Minimum deviation position	Direct reading	Minimum deviation position	Direct reading	(δ_1^0)	$\delta_2^0)$	$\delta=\frac{\delta_1+\delta_2}{2}$
1.										
2.										
3.										
4.										
5 .										
...										
. ...										

Calculations:

1. Taking wavelength of light (A) along X-axis and the corresponding angle of minimum deviation 8 along Y-axis and plot a graph.).
2. By taking along X-axis and angle of minimum deviation 8 along Y-axis and plot a graph.

Precautions:

1. The telescope and collimator both should individually be set for parallel rays.
2. The slit should be perfectly vertical and as narrow as possible.
3. The prism table should be leveled.
4. While taking observations the prism table as well as the telescope should be invariably clamped with the help of clamping screws provided.
5. For each observation both the verniers should be read carefully using magnifying glass.

6. For finding the angle of the prism, prism should be placed with its refracting edge at the centre of prism table of prism.
7. The minimum deviation position should be noted when the slit image formed to refraction through the prism remains stationary even when the tangent screw of the prism table is slightly turned either way.

Result:

Experiment-12

Aim:

To determine the wavelength of sodium light using a plane diffraction grating.

Apparatus:

Sodium lamp, plane diffraction grating with clamp, spectrometer, magnifying glass, spirit level and a lamp.

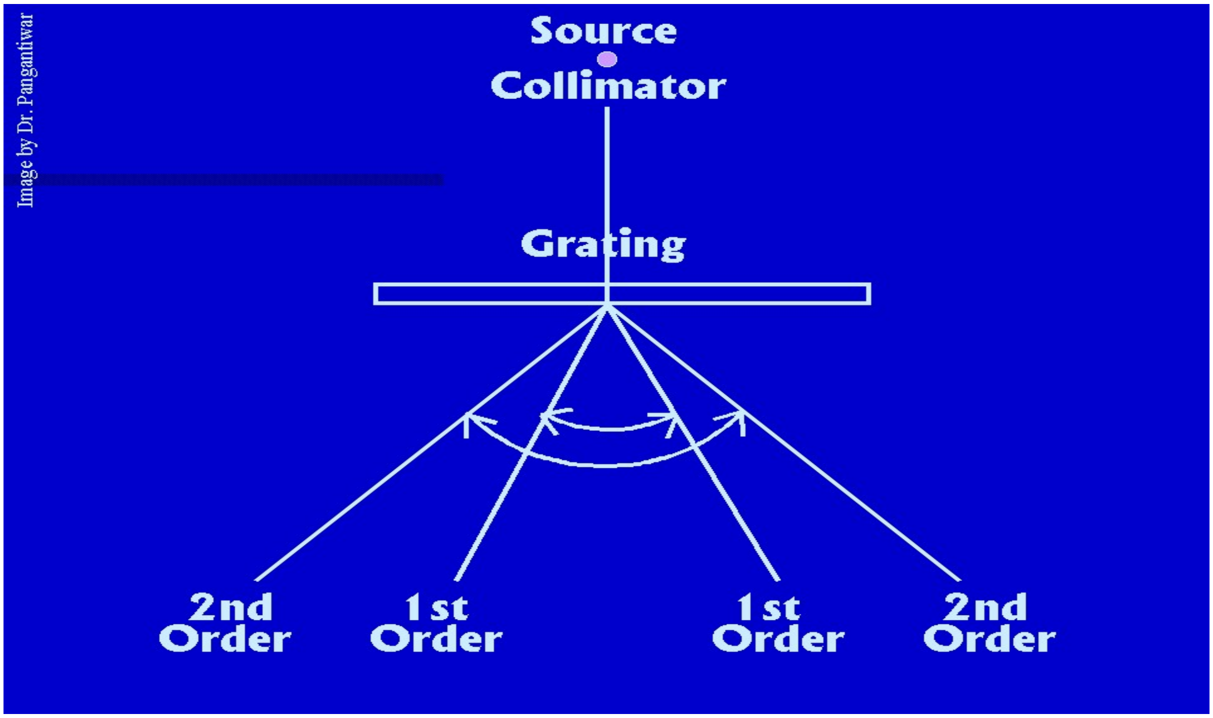
Formula used:

$$\text{Wavelength of light, } \lambda = \frac{(a+b)\sin\theta}{n}$$

Here (a + b) is the grating element and e is the angle of diffraction corresponding to the nth principal maxima on either side of the central slit image.

About experiment:

We know that the diffraction grating has ability to produce spectrum i.e., to separate the lines of nearly equal wavelengths and therefore it has resolving capability. The resolving power of a grating may be defined as its ability to form separate diffraction maxima of two wavelengths which are very close to each other.



Procedure:

(A) For adjustment of spectrometer

1. Keep the telescope of spectrometer towards a bright object (e.g. say a white wall) and adjust the position of the eye piece by drawing it in or out of the telescope tube till you get a clear distinct image of the cross wire through the eye piece. Adjust the cross wires in vertical-horizontal position by rotating the tube containing cross wire.
2. Direct the telescope, through an open window, towards a distant object rack and by using pinion arrangement get a distinct image of the distant object. Make fine adjustment and remove the parallax between the image of distant object and the cross wires. In this way telescope is set for a parallel beam of light.
3. Bring the spectrometer inside the dark room and place it on a table with the slit of collimator facing the sodium lamp. Bring the telescope in line with the collimater and see the slit image. Without altering the setting of eye piece, now adjust the rack and pinion arrangement provided with collimator and see a distinct image of slit through the telescope. Make fine adjustment by removing the parallax between slit image and cross wire. Now collimator emits parallel beam of light.
4. Now adjust the slit width so that its image is narrow and bright sharp line.
5. Level the prism table by adjusting the leveling screws provided in the prism table. This may be checked using a spirit level in two mutually perpendicular directions.

(B) For adjustment of grating:

6. Handle the grating properly and mount it in the grating stand on the prism table of spectrometer so that the plane of the grating is vertical and passes through the centre of prism table. the telescope so that vertical cross wire falls on the direct image of slit. Note the reading on circular scale of spectrometer using anyone vernier. Suppose this reading is a. Now rotate the telescope till the reading of the vernier becomes (a +

90°) and clamp it. In such a position the axes of the telescope and collimator are mutually at right angles to each other.

7. Now slowly rotate the turn table containing the grating till the reflected image of the slit is clearly obtained on the cross wires of telescope. Obviously in this condition, the grating is inclined at an angle 45° to the incident light beam as shown in Fig. 2. Note the reading on circular scale and then turn the table from this position through 45° in the proper direction so that grating is normal to the axis of collimator and its ruled surface is towards telescope. Clamp the turn table in this position.
8. Now rotate the telescope and see first order as well as second order spectrum formed on either side of the direct slit image.

(C) For Observations:

9. Move the telescope to get first order image on the left hand side. Using tangent screw provided with telescope move it till vertical cross wire just falls on first order image. Note the readings of both the vernier. Then, set the telescope for first order image on the right hand side and again note the readings of both the vernier. Difference between corresponding readings on left and right sides will be 29 and half of it will be equal to 9.
10. Repeat step 10 by setting the crosswire on second order image, first on left and then on the right side and find angle of diffraction for second order image.

Observation:

Vernier constant of spectrometer verniers = ...

Number of lines per centimeter length of grating n' =

For setting of grating for normal incidence -

Reading on the scale when collimator and telescope are in line

V1. = ... V_2 = ...

Reading on the scale when telescope has been rotated through 90°

VI = ... V_2 = ...

Reading on scale when slit image coincides with a cross wire on rotating the grating

VI = ... V_2 = ...

Reading on scale when grating has been rotated through 45°

VI = ... V_2 = ...

:. Mean value of wavelength δ=.......cm

Table for determination of the angle of diffraction:

Order of Spect-rum	Sr. No.	Reading of Vernier VI			Reading of Vernier V 2			Mean Value of θ^0	
		Right side image (θ_R)	Left side ima (θ_L)	$\theta = \frac{\theta_L - \theta_R}{2}$	Right side image (θ_R)	Left side image (θ_L)	$\theta = \frac{\theta_L - \theta_R}{2}$		
1st	(i) (ii) (iii) (iv)								θ_1 =

Order of spect-rum	S." No.	Reading of Venner V_1			Reading of Venner V_2			Mean Value of θ°	
		Ri sid im (θ_R)	Lef sid im (θ_L)	$\theta = \frac{\theta_L - \theta_R}{2}$	Rig sid im (θ_R)	Le si i (θ	$\theta = (\frac{\theta_L - \theta_R}{2})$		
2nd	(i) (i (i (i v (v								θ

Precautions:

1. All the adjustments of the spectrometer should be done carefully.
2. Never touch the ruled surface of grating. Always hold the grating gently between the thumb and fingers from edges.
3. After setting the grating normal to the collimator axis, clamp the turn table.
4. The grating should be so mounted that its ruled surface faces the telescope.

Result:

Mean observed value of wavelength of sodium light δ = ...cm
Standard value of wavelength = 5.893 x 10^{-5} crn

Percentage error = ... %

.

Experiment-13

Aim:

To determine the number of ruled lines percentimetre length of the given plane diffraction grating. Given wavelength of sodium light A. = 5893 A.

Apparatus:

Sodium lamp, plane diffraction grating with clamp, spectrometer, magnifying glass, spirit level and a lamp.

Formula used:

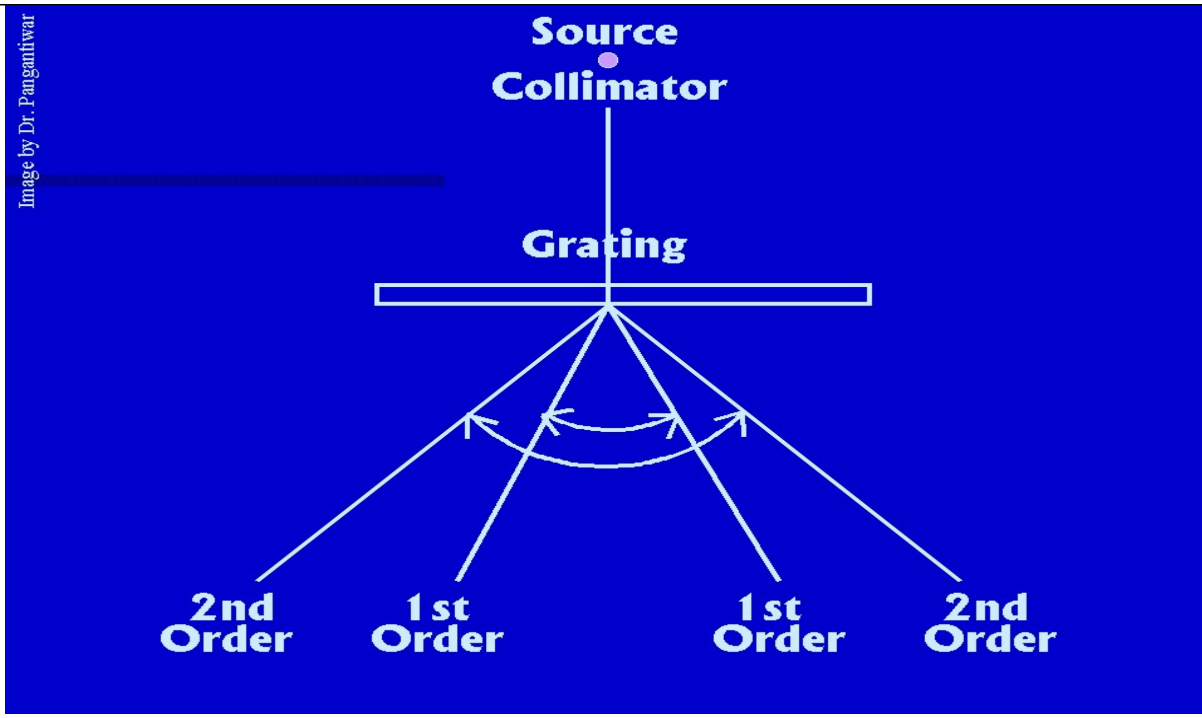
Number of lines per centimeter length of a grating

$$n' = \frac{1}{(a+b)} = \frac{\sin\theta}{n\lambda}$$

Where (a + b) is the grating element,,θ is the angle of diffraction for nth order principal maxima and A is the wavelength of light used (for sodium light A = 5893. A = 5.893 x 10-^{5} cm.

About experiment:

We know that the diffraction grating has ability to produce spectrum i.e., to separate the lines of nearly equal wavelengths and therefore it has resolving capability. The resolving power of a grating may be defined as its ability to form separate diffraction maxima of two wavelengths which are very close to each other.



Procedure:

(A) For adjustment of spectrometer

7. Keep the telescope of spectrometer towards a bright object (e.g. say a white wall) and adjust the position of the eye piece by drawing it in or out of the telescope tube till you get a clear distinct image of the cross wire through the eye piece. Adjust the cross wires in vertical-horizontal position by rotating the tube containing cross wire.
8. Direct the telescope, through an open window, towards a distant object rack and by using pinion arrangement get a distinct image of the distant object. Make fine adjustment and remove the parallax between the image of distant object and the cross wires. In this way telescope is set for a parallel beam of light.
9. Bring the spectrometer inside the dark room and place it on a table with the slit of collimator facing the sodium lamp. Bring the telescope in line with the collimater and see the slit image. Without altering the setting of eye piece, now adjust the rack and pinion arrangement provided with collimator and see a distinct image of slit through the telescope. Make fine adjustment by removing the parallax between slit image and cross wire. Now collimator emits parallel beam of light.
10. Now adjust the slit width so that its image is narrow and bright sharp line.
11. Level the prism table by adjusting the leveling screws provided in the prism table. This may be checked using a spirit level in two mutually perpendicular directions.

(B) For adjustment of grating:

12. Handle the grating properly and mount it in the grating stand on the prism table of spectrometer so that the plane of the grating is vertical and passes through the centre of prism table. the telescope so that vertical cross wire falls on the direct image of slit. Note the reading on circular scale of spectrometer using anyone vernier. Suppose this reading is a. Now rotate the telescope till the reading of the vernier becomes (a + 90°) and clamp it. In such a position the axes of the telescope and collimator are mutually at right angles to each other.
9. Now slowly rotate the turn table containing the grating till the reflected image of the slit is clearly obtained on the cross wires of telescope. Obviously in this condition, the grating is inclined at an angle 45° to the incident light beam as shown in Fig. 2. Note the reading on circular scale and

then turn the table from this position through 45° in the proper direction so that grating is normal to the axis of collimator and its ruled surface is towards telescope. Clamp the turn table in this position.

10. Now rotate the telescope and see first order as well as second order spectrum formed on either side of the direct slit image.

(C) For Observations:

9. Move the telescope to get first order image on the left hand side. Using tangent screw provided with telescope move it till vertical cross wire just falls on first order image. Note the readings of both the vernier. Then, set the telescope for first order image on the right hand side and again note the readings of both the vernier. Difference between corresponding readings on left and right sides will be 29 and half of it will be equal to 9.

10. Repeat step 10 by setting the crosswire on second order image, first on left and then on the right side and find angle of diffraction for second order image.

Observation:

Vernier constant of spectrometer verniers = ...

Number of lines per centimeter length of grating n' = ...

For setting of grating for normal incidence -

Reading on the scale when collimator and telescope are in line

V1. = ...V_2 = ...

Reading on the scale when telescope has been rotated through 90°

VI = ...V_2 = ...

Reading on scale when slit image coincides with a cross wire on rotating the grating

VI = ... V_2 = ...

Reading on scale when grating has been rotated through 45°

VI = ...V_2 = ...

:. Mean value of wavelength δ =.......cm

Table for determination of the angle of diffraction:

Order of Spect - rum	Sr. No.	Reading of Vernier VI			Reading of Vernier V 2			Mean Valu of θ^0	
		Right side image (θ_R)	Left side image (θ_L)	$\theta = \frac{\theta_L - \theta_R}{2}$	Right side image (θ_R)	Left side image (θ_L)	$(\theta = \frac{\theta_L - \theta_R}{2})^\circ$		
1 st	(i) (ii) (iii) (iv)								θ_1 = ...

Order of spect-rum	Sr No.	Reading of Vernier V_1			Reading of Vernier V_2			Mean Value of θ°	
		Right side image (θ_R)	Left side image (θ_L)	$\theta = \frac{\theta_L-\theta_R}{2}$	Right side image (θ_R)	Left side image (θ_L)	$\theta = (\frac{\theta_L-\theta_R}{2})$		
2nd	(i) (ii) (iii) (iv) (v)								θ_2

:. Mean value of wavelength δ =…….cm

Calculations:

(i) For first order spectrum, n = 1

$$n' = \frac{\sin\theta}{n\lambda} = \frac{\sin\theta_1}{5.893\times10^{-5}} = \ldots\ldots\ldots$$

(ii) For second order spectrum n = 2

$$\therefore n' = \frac{\sin\theta}{n\lambda} = \frac{\sin\theta_2}{2\times5.893\times10^{-5}} = \ldots\ldots$$

Precautions:

1. All the adjustments of the spectrometer should be done carefully.
2. Never touch the ruled surface of grating. Always hold the grating gently between the thumb and fingers from edges.
3. After setting the grating normal to the collimator axis, clamp the turn table.
4. The grating should be so mounted that its ruled surface faces the telescope .
5. . Read both the verniers.It eliminates the error due to the axis of rotation.

Result:

The experimentally observed value of the number of lines per centimeter of given grafting n'= ....
Standard value of the number of lines per centimeter of given grating = ...
.'. Percentage error = ...%

Experiment-14

Aim:

To determine the resolving power of a telescope.

Apparatus:

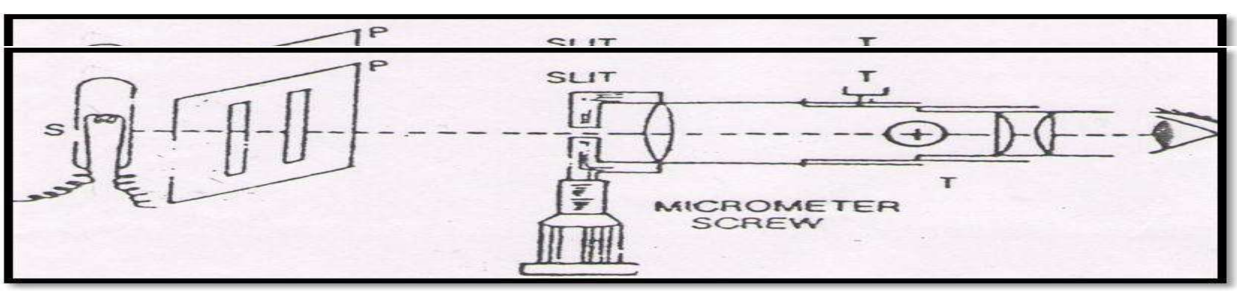
Telescope with clamp stand, Adjustable micrometer slit, sodium lamp, glass plate having a pair of slits, travelling microscope, metre rod or measuring tape and a magnifying glass.

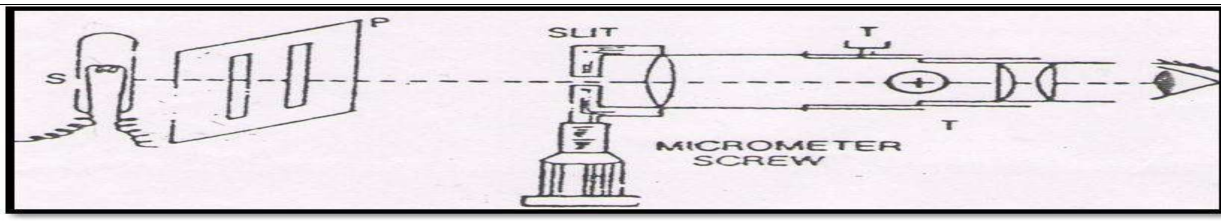
Formula used:

rectangular aperture, we have A.
Limit of resolution (Theoretical) = λ/a

Where λ = mean wavelength of the light employed and a is width of rectangular slit for just resolution of two objects.

About experiment:





Procedure:

1. Take a glass plate with tin foil having two narrow slits. If such a plate is not available then take a glass sheet and cover it with a thick black paper. Using a blade draw two narrow and straight slits at a distance of about 2-3 mm from each other.
2. Place this sheet in front of a sodium lamp. If sodium lamp is not available, use a white bulb (mean wavelength of white light as 6000 A). The plane of these slit sources must be vertical.
3. At a suitable distance (at least 2 metre) from the glass sheet adjust the telescope in a stand so that its plane is horizontal. Adjust the eye piece of telescope so that the cross-wires are clearly visible. Now using the rack and pinion arrangement provided with the telescope focus the telescope on the glass plate so that the two bright line images of the illuminated slits are clearly seen within the field of view.
4. Mount the given rectangular slit of adjustable width provided with a micrometer in front of the objective of the telescope.
5. Initially keep the width of adjustable rectangular slit wide enough so that we can see well resolved images of illuminated slits in the field of view of telescope. Gradually reduce the width of the adjustable slit with the help of micrometer and continue to see through the telescope.
6. When the width of slit is reduced, a stage comes when the two line images of the illuminated slits are just resolved i.e. by reducing the aperture just a little, the two images blend together to form a single image. Stop at the stage of just resolution and note the micrometer reading. Let it be *'x'.*
7. Further reduce the width of slit till the field of view of telescope is completely dark i.e., slit is closed. Note the new reading of micrometer. Suppose it is 'y'. Then width of rectangular aperture for just resolution of two illuminated slits is $= x - y = d$.
8. Using a measuring tape, measure the normal distance D between the illuminated slits and adjustable slit.
9. Repeat the procedure for different values of D.
10. Determine the least count of travelling microscope and use it to find the separation d between two illuminated slits.

Observations:

Table for distance between the illuminated slits (d) :

Sr. No.	Microscope reading at		$d = y_1 - X_1$ (cm)
	One end x_1 (cm)	Other end Y_1 (cm)	
I. 2.			

Mean value of d = cm

Table for width of rectangular aperature and resolving power:

Sr No	Micrometer reading when		Slit width a=x-y In cm	Distance D In cm	Limit of resolution	
	Images are just 'x' in cm	Slit is closed 'y' In cm			Theoretical	Practical
1.						
2.						
3						

Calculations:

Mean wavelength of light used 'A = ...A = ... cm

Least count of travelling microscope = ...cm

Precautions:

1. The axis of the telescope should be set horizontal.
2. The two illuminated slits should remain perfectly vertical and their separation should be small.
3. The telescope should be properly focussed.
4. The rectangular aperture mounted on telescope objective should be parallel to the illuminated slit objects i.e., the aperture should be vertical.
5. The minimum width of rectangular aperture (silt) needed for just resolution should be adjusted most carefully.
6. Backlash error in the micrometer screw should be avoided by rotating the screw in one direction only.
7. The distance D should be measured from the illuminated slits to the telescope slit.

Result:

The theoretical and practical values of limit of resolution of given telescope are as given in the following table:

Distance D (cm)	Theoretical limit of resolution	Practical limit of resolution	Difference (if any).
....	....	....	....
....	....	....	....
....	....	....	....

Experiment-15

Aim:

To determine the specific rotation of cane sugar solution using a biquartz polarimeter**.**

Apparatus:

Biquartz polarimeter, white light lamp, beaker, graduated cylinder, funnel, analytical balance, magnifying glass, watch glass, weight box, sugar and filter paper.

Formula used:

The specific rotation, S $=\frac{10\theta}{c.l}$

Here, θ is the optical rotation in degrees, c is the concentration of sugar solution in gram/cm and *l* is the length of the tube containing sugar solution in centimeter.

About experiment:

The study of optical activity of liquids began in the early 19th century with Biot and other scientists. They found that solutions of sugar and certain other naturally occurring chemicals would rotate a beam of polarized light passing through the solution. They called such substances optically active, a term which is still used. The instrument used to demonstrate or to measure this rotation was given the name polarimeter.

Clockwise rotation is given a positive (+) sign; counter clockwise rotation is given a negative (-) sign. Certain substances rotate light to a much greater extent than others. Both the direction of rotation and the amount of rotation per gram of solute in a given volume of solution are characteristic properties and can be used to help identify an unknown substance. When the identity of the solute is known, the polarimeter can be used to determine the concentration of the solution.

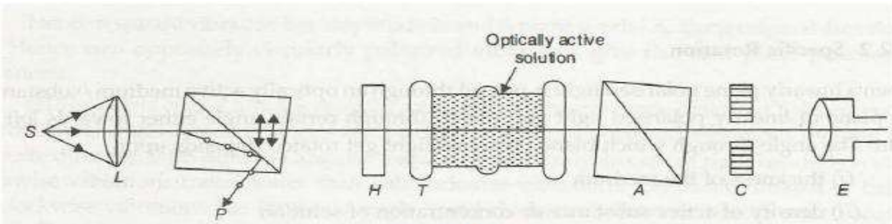


FIGURE 6.22

Procedure:

(A) **Preparation of sugar solution.**

1. Take a clean and dry watch glass and weigh it. Put about 20 gram sugar in it and weigh it again. The difference of two weights gives the mass of sugar. Suppose it is m gram.
2. Pour a little distilled water in the measuring cylinder gently (25-30 cm") and gently pour the sugar weighted into it. Shake the cylinder gently till whole sugar is dissolved into water. If needed add little more water for dissolving the sugar.
3. Now add more water in the measuring cylinder, preferably using pipette till the total volume of the solution is 100 crrr'. Filter this solution so as to remove dirt etc. if any.

(B) **Setting of polarimeter.**

4. Illuminate your biquartz polarimeter with a white (sodium) lamp. Look through the telescope and adjust the position of eye piece so that the field of view is clearly visible. Note the vernier constant of the circular scale fitted along with the analyser.

(C) **Reading without sugar solution.**

5. Take the polarimeter tube and clean its both the sides so that these are free from dust etc. Now fill the tube with pure water and see that it contains no air bubble. If it is there then it should be in the central bulged portion.
6. Place the polarimeter tube in its proper position inside the polarimeter and cover it. Look through the eye piece. Usually two halves are of different colours.
7. Gently rotate the analyser till you get "tint of passage" i.e. colour in both havles in exactly same and grayish violet. Note the reading on the scale.
8. Rotate the analyser through an angle slightly less than 180° and then gently set its position to obtain the same colour position. Note this reading also.

(D) Reading with sugar solution

9. Take the polarimeter out and remove water present in it. Put a few cm" of sugar solution in the tube and wash it carefully. Remove that solution from the polarimeter tube and then fill the tube completely with the given sugar solution and place the tube in its position.
10. Looking through the eye piece you will find that the previous adjustment of tint of passage has been disturbed. Obtain the same position (as with water). Note this reading.
11. Again rotate the analyser through an angle slightly less than 180° and then set its position to obtain tint of passage and note the reading.
12. Determine the difference between the corresponding readings with solution and without solution.

    It gives the angle of rotation. Find the mean value of rotation.

13. Repeat the above procedure with solutions of different concentration. For this take known volume of solution and mix it with known volume of distilled water. As an example take 20 cm^3 of the originally prepared sugar solution in a measuring cylinder and add 10 cm^3 water more so that the total volume becomes 30 cm".
14. Measure the length of the polarimeter tube in which sugar solution was filled. Also note the room temperature.

Observations:

Mass of the watch glass m_l = g
Mass of watch glass and sugar m_2 = g
Mass of sugar m - m_2 - m_l = g
Length of the polarimeter tube *l* = cm
Room temperature = ℃
Vernier constnat of scale =

Sr. No.	Reading on analyser for tint of passage					Optical rotation			$\frac{\theta}{c}$ (° — cm^3)
	with distilled water		With sugar solution			θ_1 =a'-a	'=b'-b	Ty mean $\theta = \frac{\theta_1}{2}$	
	First position (a)	Position after 180^0 rotation (b)	Conentration of sugar solution c in g/cm^3	First position (a)	Position after 180^0 rotation (b)				
(i) L (									
(i) 2. (									
(i) 3. (									

Calculations:

Specific rotation $S=\frac{10}{l}.\frac{\theta}{c}$=...................=...........................

Precautions:

1. While preparing the sugar solution in the beginning total volume of the solution (Sugar + Water) should be 100 cm.
2. The polarimeter tube and its side plates should be cleaned thoroughly.
3. There should be no air bubble present inside the solution in the passage path of poarised light.
4. The caps of glass tube should be screwed so that there is no leakage of water or solution. But these should not be made tight beyond a limit otherwise it might strain the glass. As strained glass may produce elliptically polarised light which might interfere with the experiment.
5. The adjustment for tint of passage position should be done accruately. If exact reading is not possible for a certain range then mean reading of that range should be recorded.
6. As specific rotation changes with temperature, hence the temperature of the solution should be recorded.
7. Whenever a solution is changed in the polarimeter tube, rinse the tube with new solution under examination and then fill it with the new solution.

Result:

The specific roation of cane sugar in water solution for yellow light (= 5893 A) at.. ... °C= ..... °

Standard value of specific rotation of cane-sugar solution is temperature t = ... °C is
(S) t = 66.5^0 .... 0.184 (t - 20) = ... = ...

Experiment-16

Aim:

To compare the illuminating powers (luminous intensities) of two given sources of light using Lummer-Brodhum.

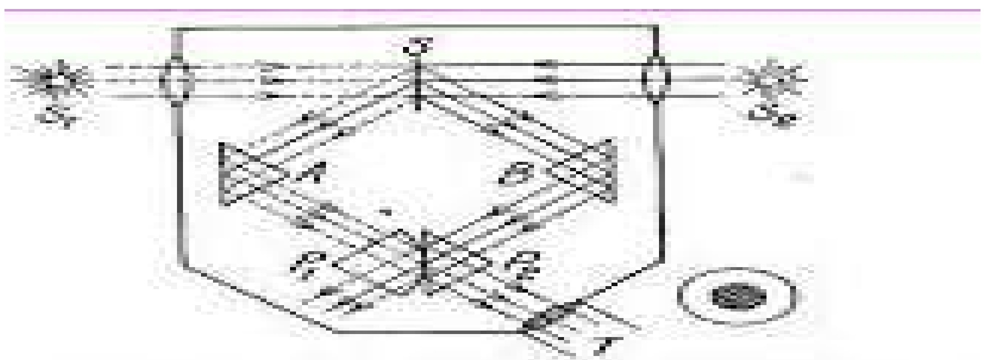
Apparatus:

$$\frac{L_1}{L_2} = \frac{r_1^2}{r_2^2}$$

Here L1 and L2 are the illuminating powers (luminous intensities) of two sources of light and r 1 and r_2 are their respective distances from photometer screen when there is uniform illuminating in the field of view of telescope.

About experiment:

This item is a Lummer-Brodhun Photometer. This Photometer consists of a metal box with two entrances and an eyepiece as well as a slot which allows a white magnesium carbonate disk to be mounted between the two entrances. Similar to the Weber Photometer this item was designed to compare the brightness of an unknown light source to the brightness of a standard light source. Light from each of the two sources enters through its respective entrance and illuminates one side of the white disk. The light that is reflected off each side of the disk is directed through a right angled prism and towards a Lummer-Brodhun cube. This cube directs the light rays coming from both sides of the disk into the eyepiece so that the user can observe the light from both sources simultaneously



Procedure:

1. Mount the Lumner-Brodhum photometer arrangement on an upright and fix it in the middle of the optical bench. Set the photometer head in such a way that diffusing screen S lies perpendicular in the length of bed of optical bench.
2. Mount the two sources of light S_1 and S_2 on the uprights in proper casings and set them at the same height as that of diffusing screen of photometer. Two light sources should be situated on opposite sides of the photometer and the line joining them should be parallel to the length of the bed of optical bench.
3. Focus the telescope on the contact surface of LumnerBrodhum cube P_3P_4.
4. Switch on the light sources. The lamps begin to glow and light beam from them falls normally on the opposite sides of diffusing screen.
5. Fix the source S, at a suitable distance r_1 from LummerBrodhum photometer. Place the source S2 very near the photometer. Look through the telescope. The brightness of central portion of the field of view will be found to be different from that of outer portion.
6. Take the sources S2 quite away. Gradually bring it closer to the photometer and look through the telescope. When whole field of view appears to be uniformly illuminated, fix S2' Note its position and record it under the heading "distance

decreasing".

7. Rotate the photometer by 180^0 and repeat the step no. 5 and 6 for same distance r 1 between the photometer and source S2' Mean of the four readings of S2 is the correct position of sources S2'
8. Repeat the experiment for different values of r I'

Observations

Sr. No.	Position Of source s_1	Position of Photometer Head(b) In cm	Position of source s_2 In m		Position of source s_2 on rotating photometer through 180" (in cm)		Mean Position Of s_2 (c) In cm	$r_1=b-a$ In cm	r_2=c-b in cm	$\frac{L_1}{L_2}$ $\frac{r_1^2}{r_2^2}$
			distance increasing	distance decreasing	distance increasing	distance decreasin				
1										
2.										
3.										
4.										

Precautions:

1. The heights of the two sources of light should be adjusted properly so that the light from them falls normally on the diffusing screen.
2. The photometer head should be adjusted in such a way that the diffusing screen lies normal to the length of the optical bench.
3. The sources should be placed at large distances (r 1 should be at least 40 cm) from the photometer.
4. Readings should be taken after rotating the photometer head through 180^0 so as to interchange the surface exposed to two light sources.

Result:

The ratio of the illuminating power of the given sources of light =..........

Experiment: 17

Aim:

To determine the frequency of an electricity maintained tuning fork by Melde's experiment.

Apparatus:

An electricity maintained tuning fork, low tension power supply (battery), rheostat, key, 2-3 metre long and light thread, pulley having adjustable height, pan, weight box, balance, metre scale etc.

Formula used:

(i) In transverse arrangement
Frequency of turing fork n is given

$$\frac{p}{2l}\sqrt{\frac{T}{m}}$$

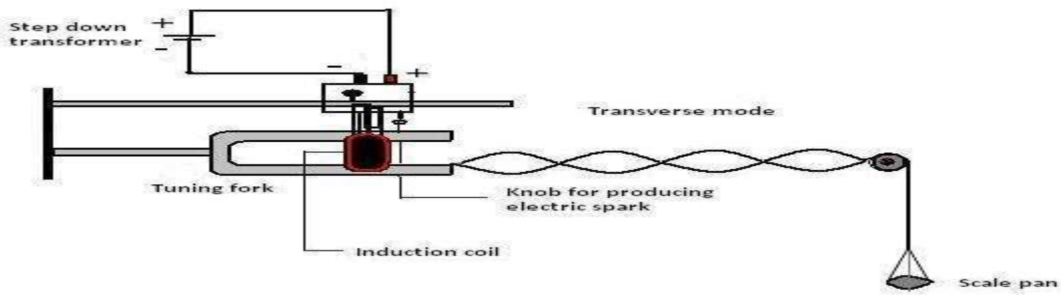
ii) In longitudinal arrangement
Frequency of turing fork n is,

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}}$$

Where l is length of the cord for p loops, T is tension applied and m is the mass per unit length of the cord.

About experiment:

A string undergoing transverse vibration illustrates many features common to all vibrating acoustic systems, whether these are the vibrations of a guitar string or the standing wave nodes in a studio monitoring room. In this experiment the change in frequency produced when the tension is increased in the string – similar to the change in pitch when a guitar string is tuned – will be measured. From this the mass per unit length of the string / wire can be derived. Finding the mass per unit length of a piece of string is also possible by using a simpler method – a ruler and some scales – and this will be used to check the results and offer a comparison. Finding the mass per unit length of a piece of string is also possible by using a simpler method – a ruler and some scales – and this will be used to check the results and offer a comparison.



Procedure:

(A) **For transverse arrangement**

1. Connect battery, a rheostat and a plug key across the given electrically maintained tuning fork as shown in the fig. (a).
2. Take a long and light thread of length 2 m or more and fix one of its ends to a prong of tuning fork with the help of binding screw providing on the prong. Pass the thread over a frictionless pulley and suspend a pan from its other end. Set the tuning fork as shown in fig. (a) and adjust the height of pulley in such a way that the cord between turning fork and pulley is perfectly horizontal.
3. Apply the plug in key K and move the adjustable screw so that it just touches the tip of the metal strip joined to prong of tuning fork and current begins to flow through the solenoid coil and the tuning fork begins to vibrate. Make the adjustment so that the tuning fork vibrates with a large and constant amplitude with minimum possible noise.
4. Put suitable weights in the pan the cord splits up into several loops. Gradually using weightsf smaller values and then the fractional weights, adjust the tension in such a manner that the loops become clear and well defined.
5. When the adjustment described in step no. 4 is perfect, gently mark the positions of extreme nodes, leaving out the two extreme loops (i.e., the loop formed near the tuning fork and the Loop near the pulley). Count the number of loops formed between these marks. Switch off the battery and carefully measure the total length between the marks by using a metre scale. Note the mass placed in the pan.
6. Repeat the above procedure for different lengths of cord and for different weights in the pan. Determine the mass of the pan using balance.
7. Repeat the above procedure for different lengths of cord and for different weights in the pan. Determine the mass of the pan using balance.
8. Take a certain length (2m) of the gives thread. Determine its mass by a sensitive balance and then calculate its mass per unit lengths. Applying the formula and calculate the frequency of tuning fork.
9. Complete the electrical circuit as in step no. 1 and then set the tuning fork as shown in fig. (b) so that the thread is perpendicular to the length of the prong.

10. Make the adjustment as discussed in steps no. 3 and 4. Remember the fact that for same length and same weights placed in the pan the number of loops is now reduced to half as compared to that in transverse arrangement.

11. Count the number of loops leaving the xtreme loops and measure the length of cord as in step no. 5.

12. Take a number of sets by changing length of cord and the tension.

13. Calculate the frequency of tuning fork.

Observation and Calculations:

Mass of the pan m_1 = ... g

Total length of cord weighed L = cm

Total mass of the cord M = ...gm

Mass per unit length of cord m *M*

Table for transverse arrangement

Sr. No	Mass place in pan In gm	Total mass m_l $+m_2$ In gm	Tension $T=(ml+m_2)$ in dyne	No. of loops	Length of the cord For p loops In			Frequency $n=\frac{1}{2l}\sqrt{\frac{T}{m}}$ (Hz)
					(i)	(ii)	Mean	
1.								
2.								
3.								

1. Mean frequency of tuning fork as measured in transverse arrangement = ... Hz Table

Table for longitudinal arrangement

Sr. No.	Mass placed in In gm	Total mass ml+ m_2 In gm	Tension T=(ml+ m_2) in dyne	No. of loops n	Length of the cord for p loops In c			Frequency $n=\frac{1}{2l}\sqrt{\frac{T}{m}}$ (Hz))
					(i)	(ii)	Mean	
1.								
2.								
3.								

Precautions:

1. The pulley should be friction less. If need oil the pulley.
2. The thread used in the experiment must be inextensible, light and of uniform thickness. A fishing cord fulfills all the conditions.
3. For transverse mode of vibrations, the thread is to be stretched so that the vibrations of the prong are at right angle to the length of the thread. For longitudinal mode of vibration, the tip of the prong must vibrate in line with the thread.
4. Adjust the height of the pulley so that the thread in perfectly horizontal.
5. Length between the loops should be measured only when these are clear and well defined i.e., the nodes are sharp points.
6. Mass of the thread should be noted carefully as its value is very small.
7. To avoid sparking between the metal strip and adjustable screw of the electrically maintained tuning fork arrangement, a capacitor of suitable capacity may be connected in parallel to the stip and screw.

Result:

Frequency of the given turning fork as determined for transverse arrangement = ... Hz Frequency of the given turning fork as determined for longitudinal arrangement = ... Hz

Experiment: 18

Program 1

```
C     PROGRAM TO PRINT ALL EVEN/ODD NUMBERS
C     BETWEEN GIVEN LIMITS
      WRITE (*, *) 'ENTER LOWER AND UPPER LIMIT”
      READ (*,*) L, M
      IF (MOD (L, 2). NE.O) THEN
          N=L+ 1
      ELSE
          N=L
      ENDIF
      WRITE (*, *) 'LIST OF EVEN NUMBERS’
      DO 10 I = N, M, 2
          WRITE (*, *) I

10    CONTINUE
      WRITE (*, *) 'LIST OF ODD NUMBER
      IF (MOD (L, 2). EQ.O) THAN
          L = L + 1
```

```
    ENDIF
    DO 15 I = L, M, 2
    WRITE (*, *) I
15  CONTINUE
    STOP
    END
```

Experiment: 19

```
C       PROGRAM TO FIND OUT MAXIMUM, MINIMUM AND RANGE
C       OF A GIVEN SET OF NUMBERS
         WRITE (*,*) 'HOW MANY NUMBERS ARE THERE?'
         READ (*,*) N
         WRITE (*, *) 'ENTER FIRST NUMBER'
         READ (*,*) L
         MAX=L
         MIN=L
         WRITE (*,*) 'ENTER REMAINING NUMBERS'
         DO 10 I = 2, N
                 READ (*,*)'I
           IF (L.GT.MAX.  MAX = L)              MAX = L
           IF (L.LT.MIN., MIN = L)              MIN = L
     10 CONTINUE
        IRANGE = MAX-MIN
        WRITE (*,*) 'MAXIMUM =', MAX
        WRITE (*,*) 'MINIMUM=', MIN
        WRITE (*,*) 'RANGE =', IRANGE
         STOP
         END
```

Experiment: 20

Program:

```
C          FIND THE ROOTS OF QUADRATIC EQUATION
           WRITE (*, *) 'ENTER A, B, C
           READ (*, *) 'ENTER, A, B, C
           DISC=B*B-4 * A *C
       IF (DISC.GT.O) THEN
           WRITE (*,*) 'ROOTS ARE REAL AND DISTINCT'
           ROOT1 = (-B+SQRT(DISC))/(2*A)
           ROOT2 = (-B-SQRT(DISC))/(2*A)
           WRITE (*,5) ROOT1.ROOT2
        ENDIF
    IF (DISC. EQ. 0) THEN
    WRITE (*, *) 'ROOTS ARE REAL AND EQUAL'
    ROOT1=-B/ (2* A)
   ROOT2=-ROOT1
```

```
 WRITE (*,10) ROOT1.ROOT2
 ENDIF

 IF (DISC.LT.O) THEN
 WRITE (*,*) 'ROOTS ARE IMAGINARY'
 PR=-B/(2*A)
PI=SQRT (-DISC)/(2*A)
WRITE(*,*) ROOT1=, PR,'+I '. PI
WRITE(*,*) ROOT2=, PR,'+I '. PI
ENDIF
STOP
END
```