SOPs: PHYSICS PRACTICAL EXERCISES OF UNDERGRADUATE STUDENTS

(DBT Life Sciences Star College Scheme, Ministry of Science & Technology, Govt. of India)

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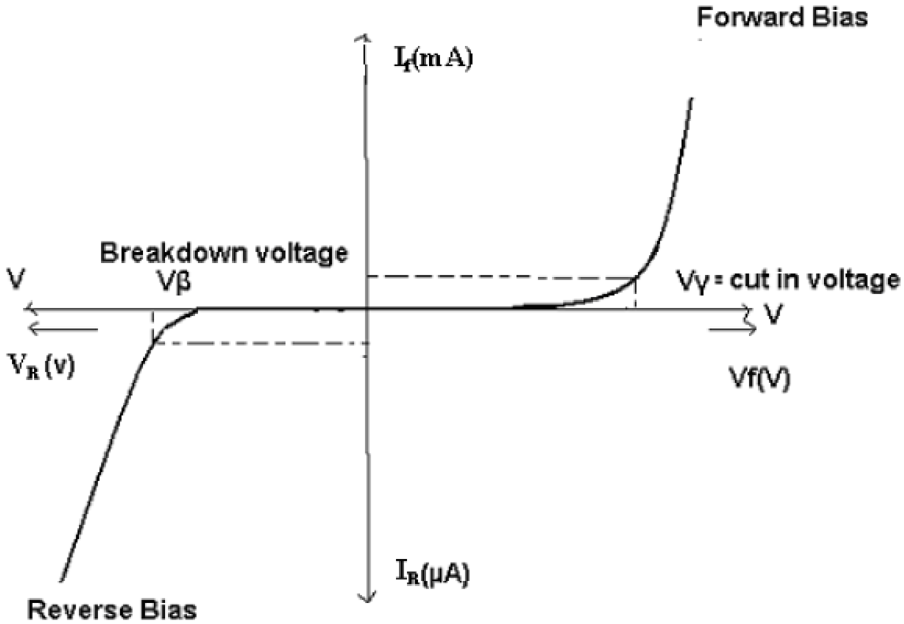
Experiment No. 1: To draw forward and reverse bas characteristics of a p-n junction diode.

Background: A P-N junction diode conducts only in one direction. The V-I characteristics of the diode are curve between voltage across the diode and current flowing through the diode. When external voltage is zero, circuit is open and the potential barrier does not allow the current to flow. Therefore, the circuit current is zero. When P type(Anode) is connected to +ve terminal and n- type (cathode) is connected to –ve terminal of the supply voltage is known as forward bias. The potential barrier is reduced when diode is in the forward biased condition. At some forward voltage, the potential barrier altogether eliminated and current starts flowing through the diode and also in the circuit. Then diode is said to be in ON state. The current increases with increasing forward voltage. When N-type (cathode) is connected to +ve terminal and P-type (Anode) is connected –ve terminal of the supply voltage is known as reverse bias and the potential barrier across the junction increases. Therefore, the junction resistance becomes very high and a very small current (reverse saturation current) flows in the circuit. Then diode is said to be in OFF state. The reverse bias current is due to minority charge carriers.



Material Requirements: P-N Diode, Regulated power supply, Resistor, Ammeter, Voltmeter, Connecting wires

Methodology:

A) FORWARD BIAS:

1. Connections are made as per the circuit diagram.
2. For forward bias, the +ve terminal of the battery is connected to the anode of the diode and while –ve is connected to the cathode of the diode
3. Switch on the power supply and increase the input voltage (supply voltage) in steps of 0.1V
4. Note down the corresponding current flowing through the diode and voltage across the diode for each and every step of the input voltage.
5. The reading of voltage and current are tabulated.
6. Graph is plotted between voltage (Vf) on X-axis and current (If) on Y-axis.

B) REVERSE BIAS:

1. Connections are made as per the circuit diagram
2. For reverse bias, the +ve terminal of the battery is connected to the cathode of the diode and while –ve is connected to the anode of the diode.

3. Switch on the power supply and increase the input voltage (supply voltage) in steps of 1V.

4. Note down the corresponding current flowing through the diode voltage across the diode for each and every step of the input voltage.

5. The readings of voltage and current are tabulated

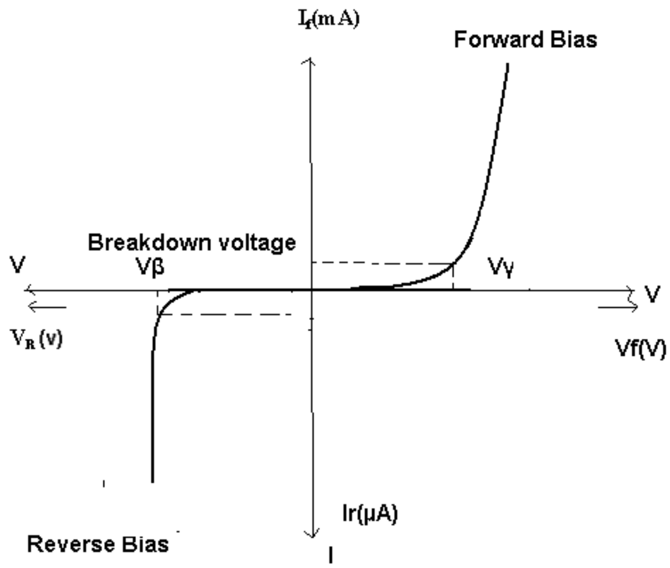
6. Graph is plotted between voltage(VR) on X-axis and current (IR) on Y-axis.

Precautions:

1. All the connections should be correct.
2. Parallax error should be avoided while taking the readings from the Analog meters.

Experiment No.2: To draw the characteristics of Zener diode.

Background: A zener diode is heavily doped p-n junction diode, specially made to operate in the break down region. A p-n junction diode normally does not conduct when reverse biased. But if the reverse bias is increased, at a particular voltage it starts conducting heavily. This voltage is called Break down Voltage. High current through the diode can permanently damage the device. To avoid high current, we connect a resistor in series with zener diode. Once the diode starts conducting it maintains almost constant voltage across the terminals what ever may be the current through it, i.e., it has very low dynamic resistance. It is used in voltage regulators.



Material Requirements: Zener Diode, Regulated power supply, Resistor, Ammeter, Voltmeter, Connecting wires

Methodology:

1. Connections are made as per the circuit diagram.
2. The Regulated power supply voltage is increased in steps.
3. The zener current (Iz), and the zener voltage (Vz.) are observed and then noted in the tabular form.
4. A graph is plotted between zener current (Iz) and zener voltage (Vz).

Precautions:

1. The terminals of the zener diode should be properly identified
2. While determined the load regulation, load should not be immediately shorted.
3. Should be ensured that the applied voltages & currents do not exceed the ratings of the diode.

Experiment No.3: To study efficiency and ripple factors for half wave rectifier circuit.

Background: 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. For practical circuits, transformer coupling is usually provided for two

1. The voltage can be stepped-up or stepped-down, as needed.
2. The ac source is electrically isolated from the rectifier. Thus preventing shock hazards in the secondary circuit.

Material Requirements: Experimental Board, Transformer, Diode, Capacitor, Resistor, Connecting wires

Methodology: 1. Connections are made as per the circuit diagram.

2. Connect the primary side of the transformer to ac mains and the secondary side to the rectifier input.
3. By the multimeter, measure the ac input voltage of the rectifier and, ac and dc voltage at the output of the rectifier.
4. Find the theoretical of dc voltage by using the formula,

$V_{dc}=V_m/\pi$

Where, $V_m=2V_{rms}$, (V_{rms}=output ac voltage.)

The Ripple factor is calculated by using the formula

r=ac output voltage/dc output voltage.

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.

Experiment No.4: To study the characteristics of common base transistor.

Background: A transistor is a three terminal active device. The terminals are emitter, base, collector. In CB configuration, the base is common to both input (emitter) and output (collector). For normal operation, the E-B junction is forward biased and C-B junction is reverse biased. In CB configuration, IE is +ve, IC is –ve and IB is –ve. So,

VEB = F1 (VCB, IE) and IC = F2 (VEB,IB)

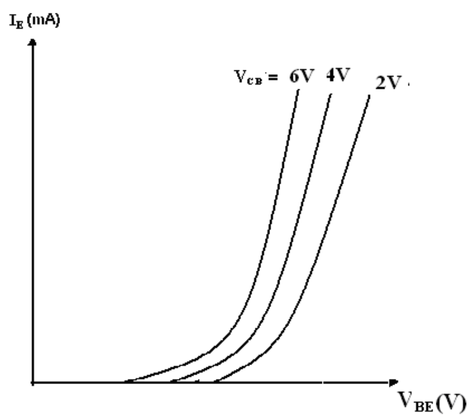
With an increasing the reverse collector voltage, the space-charge width at the output junction increases and the effective base width „W" decreases. This phenomenon is known as "Early effect". Then, there will be less chance for recombination within the base region. With increase of charge gradient within the base region, the current of minority carriers injected across the emitter junction increases.The current amplification factor of CB configuration is given by,

$$\alpha = \Delta I_C / \Delta I_E$$

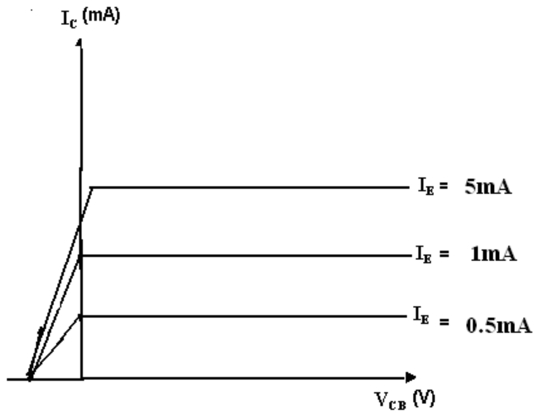
Input Resistance, ri = **ΔVBE /ΔIE** at Constant VCB

Output Résistance, ro = **ΔVCB /ΔIC** at Constant IE

Input characteristics:



Output characteristics:



Material Requirements: Common emitter transistor, Regulated power supply, Voltmeter, Ammeter, Resistor

Methodology:

A) INPUT CHARACTERISTICS:

1. Connections are made as per the circuit diagram.
2. For plotting the input characteristics, the output voltage VCE is kept constant at 0V and for different values of VEE ,note down the values of IE and VBE
3. Repeat the above step keeping VCB at 2V, 4V, and 6V and all the readings are tabulated.
4. A graph is drawn between VEB and IE for constant VCB.

B) OUTPUT CHARACTERISTICS:

1. Connections are made as per the circuit diagram.
2. For plotting the output characteristics, the input IE is kept constant at 0.5mA and for different values of VCC, note down the values of IC and VCB.
3. Repeat the above step for the values of IE at 1mA, 5mA and all the readings are tabulated.
4. A graph is drawn between VCB and Ic for constant IE

Precautions:

1. The supply voltages should not exceed the rating of the transistor.

2. Meters should be connected properly according to their polarities.

Experiment No.5: To study the characteristics of common emitter transistor.

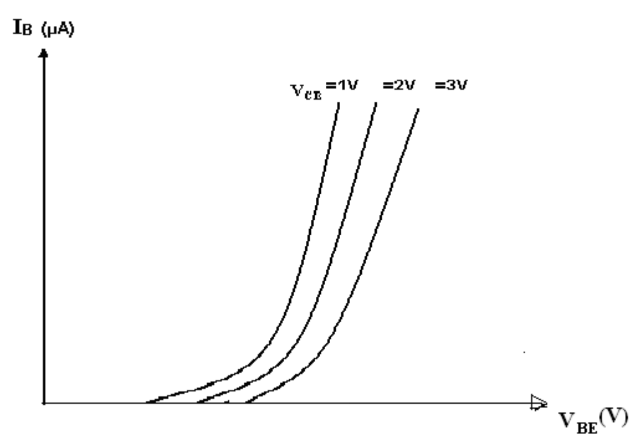
Background: In common emitter configuration, input voltage is applied between base and emitter terminals and out put is taken across the collector and emitter terminals. Therefore the emitter terminal is common to both input and output. The input characteristics resemble that of a forward biased diode curve. This is expected since the Base-Emitter junction of the transistor is forward biased. As compared to CB arrangement IB increases less rapidly with VBE. Therefore input resistance of CE circuit is higher than that of CB circuit. The output characteristics are drawn between Ic and VCE at constant IB. the collector current varies with VCE upto few volts only. After this the collector current becomes almost constant, and independent of VCE. The value of VCE up to which the collector current changes with V CE is known as Knee voltage. The transistor always operated in the region above Knee voltage, IC is always constant and is approximately equal to IB.The current amplification factor of CE configuration is given by

$$\beta = \Delta IC/\Delta IB$$

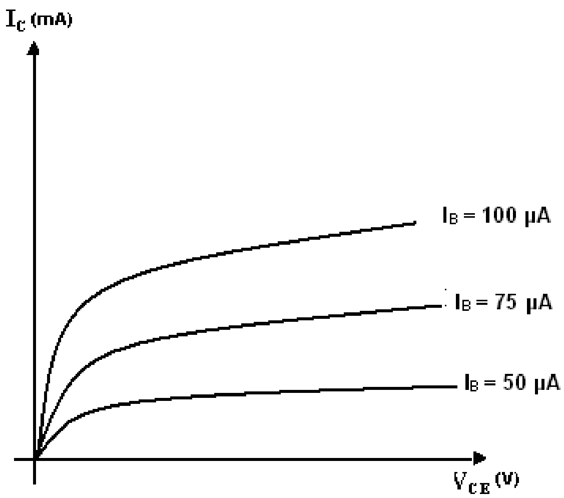
Input Resistance, ri = **ΔVBE /ΔIB (**μA) at Constant VCE

Output Résistance, ro = **ΔVCE /ΔIC** at Constant IB (μA)

Input Characteristics:



Output Characteristics:



Material Requirements: Common emitter transistor, Regulated power supply, Voltmeter, Ammeter, Resistor

Methodology:

A) INPUT CHARACTERISTICS

1. Connect the circuit as per the circuit diagram.
2. For plotting the input characteristics the output voltage VCE is kept constant at 1V and for different values of VBB , note down the values of IB and VBE
3. Repeat the above step by keeping VCE at 2V and 4V and tabulate all the readings.
4. plot the graph between VBE and IB for constant VCE

B) OUTPUT CHARACTERISTICS:

1. Connect the circuit as per the circuit diagram
2. for plotting the output characteristics the input current IB is kept constant at 50μA and for different values of VCC note down the values of IC and VCE
3. Repeat the above step by keeping IB at 75 μA and 100 μA and tabulate the all the readings
4. plot the graph between VCE and IC for constant IB

Precautions:

1. The supply voltage should not exceed the rating of the transistor

2. Meters should be connected properly according to their polarities

Experiment No.6: To investigate the resonance frequency and the quality factor, Q in the series LCR circuit.

Background: A series resonant circuit consists of a resistor, a capacitor, and an inductor in a simple loop. At some frequency the capacitive and inductive reactances will be of the same magnitude, and as they are 180 degrees in opposition, they effectively nullify each other. This leaves the circuit purely resistive, the source “seeing” only the resistive element. Consequently, the current will be at a maximum at the resonant frequency. At any higher or lower frequency, a net reactance (the difference between XL and XC) must be added to the resistor value, producing a higher impedance and thus, a lower current. As this is a simple series loop, the resistor’s voltage will be proportional to the current. Consequently, the resistor voltage should be a maximum at the resonant frequency and decrease as the frequency is either increased or decreased. At resonance, the resistor value sets the maximal current and consequently has a major effect on the voltages developed across the capacitor and inductor as well as the “tightness” of the voltage versus frequency curve: The smaller the resistance, the tighter the curve and the higher the voltage seen across the capacitor and inductor. The Q of the circuit can be defined as the ratio of the resonant reactance to the circuit resistance, Q=X/R, which also corresponds to the ratio of the resonant frequency to the circuit bandwidth, Q=F0/BW.

Material Requirements: AC function generator, Oscilloscope, Experimental Board

Methodology:

1. Using R=470 ohm, L= 10 mH, and C=10 nF, determine the theoretical resonance frequency and Q, and record the results. Based on these values determine the upper and lower frequencies defining the bandwidth, f1 and f2, and record them in tabular form.

2. Place a probe across the resistor. Set the output of the generator to a 1 V p-p sine wave. Set the frequency to the theoretical resonance frequency. Make sure that the *Bandwidth Limit* of the oscilloscope is engaged for both channels. This will reduce the signal noise and make for more accurate readings.

3. Adjust the frequency in small amounts, up and down, until the maximum voltage is found. This is the experimental resonance frequency. Record it in tabular form. Note the amplitude (it should be approximately equal to the source voltage of 1 V p-p). Sweep the frequency above and below the resonance frequency until the experimental f1 and f2 are found. These will occur at voltage amplitude of approximately .707 times the resonant voltage (i.e., the half-power points). Record these frequencies in tabular form. Also, determine and record the experimental Q based on the experimental f0, f1, and f2.

4. Transcribe the experimental frequencies of the mentioned table to the top three entries of the table. For all of the frequencies in the table, measure and record the voltage across the resistor. Also measure and record the inductor and capacitor voltages. Note that the inductor and capacitor will have to be swapped with the resistor position in order to maintain proper ground reference with the oscilloscope.

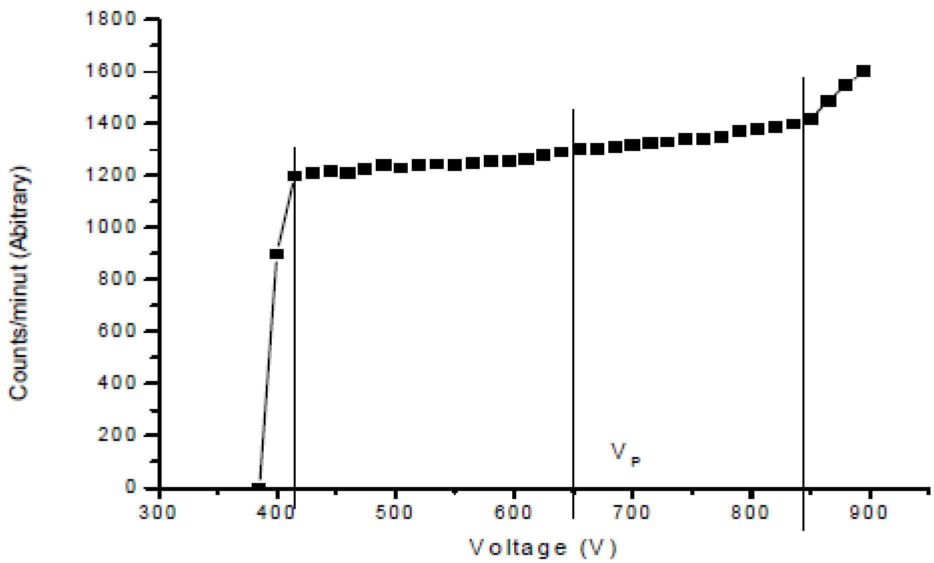
5. Based on the data from the table, plot VR, VC, and VL as a function of frequency.

Precautions:

1. Make the connections carefully.
2. Note down the readings after removing the parallax.

Experiment No.7: To determine the plateau and optimal operating voltage of a Geiger-Muller counter.

Background: Geiger-Müller (GM) counters were invented by H. Geiger and E.W. Müller in 1928, and are used to detect radioactive particles. A typical GM Counter consists of a GM tube having a thin end window (e.g. made of mica), a high voltage supply for the tube, a scalar to record the number of particles detected by the tube, and a timer which will stop the action of the scalar at the end of a preset interval. The sensitivity of the GM tube is such that any particle capable of ionizing a single atom of the filling gas of the tube will initiate an avalanche of electrons and ions in the tube. The collection of the charge thus produced results in the formation of a pulse of voltage at the output of the tube. The amplitude of this pulse, on the order of a volt or so, is sufficient to operate the scalar circuit with little or no further amplification. The pulse amplitude is largely independent of the properties of the particle detected, and gives therefore little information as to the nature of the particle. Even so, the GM Counter is a versatile device which may be used for counting alpha particles, beta particles, and gamma rays, albeit with varying degrees of efficiency.



Material Requirements: Geiger-Muller counter, radioactive source.

Methodology: 1. Connect the Power Card of GM counter to its AC adapter.

2. Connect a GM tube to the GM connector via a BNC cable.

3. Enter the HIGH VOLTAGE mode and set the high voltage to the recommended value for the GM tube.

4. Place the radioactive source close to the GM tube's window.

5. Using the Operating Mode information described above set the unit up to perform the desired function.

6. Press the COUNT Button to start data acquisition, the STOP button to halt data acquisition (providing Preset Time is not being used), and the RESET button to reset the time and data to zero.

Precautions:

1. Handle the apparatus very carefully as dangerous voltage can exist at the GM connectors.

2. Ensure that the high voltage is set to zero or that the instrument is off before connecting or disconnecting the detector.

Experiment No.8: To study gamma ray absorption using Scintillation counter.

Background: There are three main ways in which g-rays may interact with matter: photoelectric absorption, Compton scattering and pair production. Photoelectric absorption predominates for low energy g-rays (up to several hundred keV), pair production predominates for high energy g-rays (>5-10 MeV), and Compton scattering is the most probable process over the range of energies between these extremes. The pulse height spectra that you record will show evidence for these various interactions, and it should be possible to make a quantitative comparison between the measured positions of features within these spectra and the positions that are predicted by theory.

1. **Photoelectric absorption**

In photoelectric absorption the g-ray is completely annihilated, as it gives up all its energy in knocking a bound electron out of what is usually an inner atomic orbital. In its place, a photoelectron is produced from one of the electron shells of the absorber atom. Its kinetic energy is given by the incident photon energy Ef (hn) minus the binding energy of electron in its original shell (Eb). The vacancy in the electron shell is quickly filled by electron rearrangement and the binding energy liberated either in the form of an X-ray or an Auger electron. If nothing escapes from the detector, then the sum of the kinetic energies of the electrons that are created must equal the original energy of the g-ray. The single peak (b) in Figure 1 appears at a total electron energy corresponding to the largest flash generated in the crystal scintillator as a result of g-ray energy absorption Es. Photoelectric absorption is relatively more important at low g-ray energies, and becomes less likely as the energy of the g-ray increases.

2. Compton scattering

In Compton scattering a g-ray is involved in a “glancing collision” with a virtually free electron, and is scattered through an angle j. The result of this elastic collision is the creation of a recoil electron and scattered g-ray photon, with the division of energy between the two as a function of the scattering angle. By considering the conservation of energy and linear momentum, it can be shown that the energy transferred to the electron during this process is a function of the scattering angle. Thus Compton scattering can result in a continuum of energies, extending from 0, as the “Compton edge”, since the continuum distribution in the pulse height spectrum looks a like a broad plateau that drops rapidly to zero at the energy.

3. Pair Production

If the incident g-ray has energy greater than 1.022 MeV the formation of an electron-positron pair can occur. An energy of 0.511 MeV is required to create each of the positron and the electron, and the residual energy of Eg ~1:022 MeV is equally divided as kinetic energy between the two particles. Both the electron and positron are charged particles, so their range within the NaI Crystal is very short; they soon give up all their kinetic energy to the surrounding crystal, causing it to scintillate. In addition, within a very short time (less than 10□10 s) the positron will annihilate with another electron, producing two g-rays, each of energy 0.511 MeV.

Material Requirements: Scintillation counter, radioactive source.

Methodology:

1. Hold the radioactive sources in the clamp with the exit directed downward and line-up it so that the source is centred above the aperture of the scintillation at distance of about 1 cm.
2. Set the high-voltage power supply to zero, and switch it on.
3. Without high voltage, no pulses should be counted at the scintillation counter.
4. Gradually increase the voltage UPM of the high voltage power supply from 0 V until pulses are counted around the middle of the screen. This should be in steps started from about 0 to nearly about 690 V in 30 V for each step.
5. Once the set measuring time is over, the measurement is stopped.
6. When finishing the measurement, determine and record the following form parameters of the total absorption peak. Repeat these measurements for each voltage and put it in a tabular form.

Precautions:

1. Remove a source from storage only when you are ready to use it.

2. To ensure minimum exposure time, take the source isotopes out of the guard vessel only as long as is necessary in order to perform the experiment.
3. Always use the tweezers provided when you are handling the radioactive sources. Never touch them directly with your hands.

Experiment No. 9: To determine refractive index of glass and liquid using spectrometer.

Background: Spectrometer is an optical instrument having three parts (i) Collimator (ii) Telescope and (iii) Prism table. The following initial adjustments should be carried out before starting any experiment with a spectrometer.

a) The telescope is turned towards a white wall of background and the eyepiece is gently pushed in or pulled out so that a clear image of the cross wires is seen without parallax.

b) To adjust the telescope for parallel rays, the telescope is directed towards a distant object like distant tree or building and the distance between the objective lens and the eyepiece is altered till the clear image of the distant object is seen in the field of view of telescope.

c) To adjust the collimator for parallel rays, the slit of the collimator is illuminated with a monochromatic source of light (sodium vapour lamp). The telescope is brought in line with the collimator in order to catch the image of the slit in the telescope. The distance between the convex lens in the collimator and the slit is altered to get the clear image of the slit through the telescope, so that the width of the slit is minimized.

d) The prism table is made perfectly horizontal by adjusting the screws provided with the help of the spirit level.

Materials Requirements:

Spectrometer, given glass prism, Sodium vapour lamp, Reading lens, black cloth, etc.

Methodology:

Angle of the prism A:

After making initial adjustments, the least count of the spectrometer is determined (as in Vernier Calipers). Having a very fine slit, the telescope is adjusted for direct ray. A prism is placed on the prism table. The telescope is turned to catch the reflected image from one polished face AB of the prism. Fixing in that position, the tangential screw is adjusted till the vertical cross wire is made to coincide with the fixed edge of the image of the slit. The readings in the scales I and II are noted. The telescope is then turned to the other polished face AC of the prism. The readings in the scales I and II are noted when the vertical cross wire coincides with the fixed edge of the image of the slit. The difference between both the scale I readings is 2A. Similarly the difference between both the scale II readings is 2A. Then the average of the angle of the prism A is calculated.

Angle of minimum deviation D:

The prism is placed on the prism table. The ray of light from the collimator incident on one polished face of the prism gets refracted and emerges out of the other polished face. Viewing the image of the slit through the telescope, the prism table and telescope are rotated simultaneously through small angle such that the image of the slit moves towards the direct ray. At one stage, it is found that the image of the slit is stationary for a moment and on rotating the prism table further in the same direction the image begins to retrace its path. The telescope is fixed at that position, the cross wire is made to coincide with the fixed edge of the image of the slit. At this minimum deviation position, the readings of scales I and II are noted.

The prism is removed from the prism table. The telescope is brought in line with the collimator and the image of the slit is seen through the telescope. The vertical cross wire is made to coincide with the fixed edge of the image of the slit. The readings in the scales I and II are noted.

The difference between the two readings of scale I or scale II gives the angle of minimum deviation D. Hence the refractive index of the material of the prism is calculated using the formula.

Formula:

The refractive index of the material of the glass prism

Where A= angle of the prism

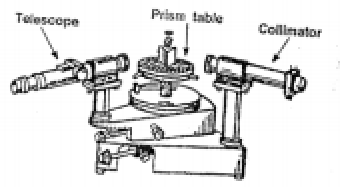
D = angle of minimum deviation

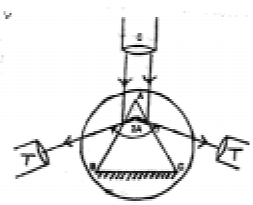
$$\mu = \frac{\sin\left[\frac{A+D}{2}\right]}{\sin\left[\frac{A}{2}\right]}$$

Description :

Result:

The refractive index of the material of the prism=





Observations:

Least count of Spectrometer:

Value 0f 20 MSD =

Value of 1 MSD =

No. divisions on the Vernier scale (n) =

=

Least Count (LC) $= \frac{1}{n}$ x value of 1MSD

=

Tabular column I:

To determine the angle of the prism A

LC =

Ray	Spectrometer readings in degree							
	Scale I				Scale II			
	MSR	VSC	VSR = VSC $\times$ LC	OR = MSR + VSR	MSR	VSC	VSR = VSC $\times$ LC	OR = MSR + VSR
Reading of the reflected ray (left)				x_1 =				x_3 =
Reading of the reflected ray(right)				x_2 =				x_4 =

$2A = (x_1 \sim x_2) =$

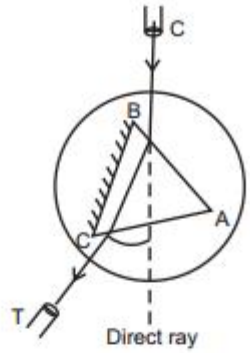
$A = \dfrac{\qquad}{2} =$

$2A = (x_3 \sim x_4) =$

$A = \dfrac{\qquad}{2} =$

The average angle of the prism A $= \dfrac{\quad + \quad}{2}$

$=$



Tabular column II:

To determine the angle of the minimum deviation D

LC =

Ray	Spectrometer readings in degree							
	Scale I				Scale II			
	MSR	VSC	VSR = VSC × LC	OR = MSR + VSR	MSR	VSC	VSR = VSC × LC	OR = MSR + VSR
Reading of minimum deviated ray				d_1 =				d_3 =
Reading of Direct ray				d_2 =				d_4 =

Precautions:

(i) The axis of telescope and collimator should be horizontal.

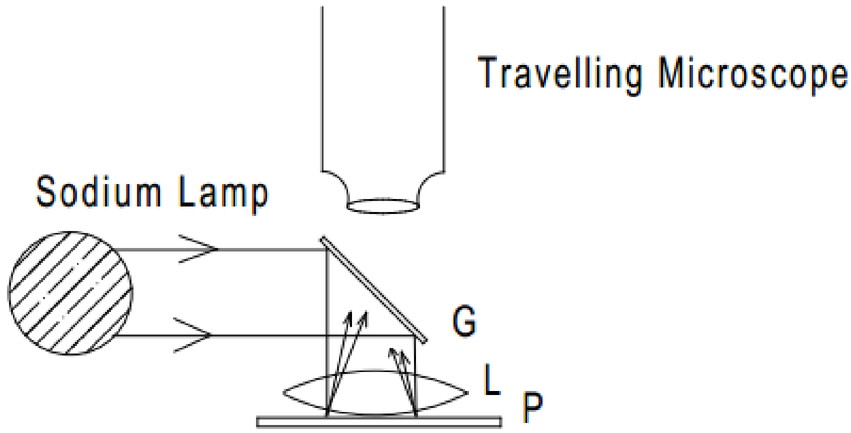
(iii) Backlash error in the micrometer screw should be avoided.

(v) The width a should be thin and fine.

Experiment No. 10: To Determine the Wavelength of Sodium Light using Newton's Rings

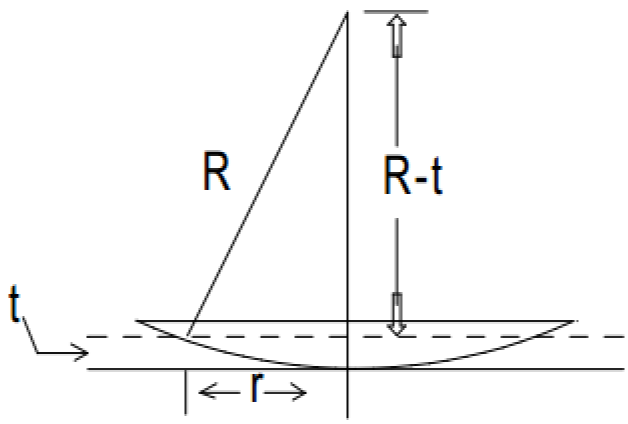
Background: Consider a ray of light incident on the air film at a point where its thickness is t. The optical path difference between the two reflected rays will be 2t. Taking into account the phase change of π for reflection at the rare to dense surface, the conditions for constructive and destructive intereference are

$$2t \;=\; \left(m + \frac{1}{2}\right)\lambda \qquad \text{(constructive interference or bright rings)}$$



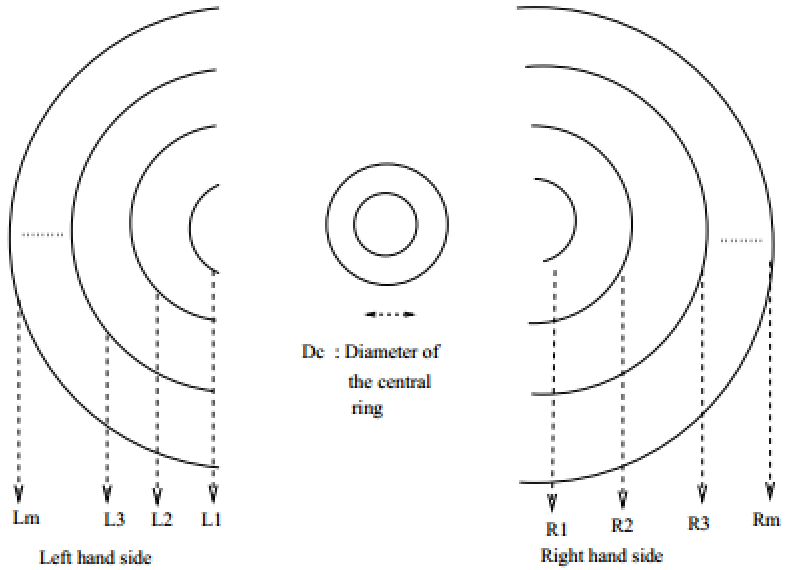
$$2t = m\lambda \qquad \text{(destructive interference or dark rings)}$$

where m is the order of the ring and can take the values m = 0, 1, 2, 3 . . ..



If R is the radius of curvature of the lens and r, the distance of the point under consideration to the point of contact of the lens and glass plate (see Fig. 8.2) then

$$R^2 = (R - t)^2 + r^2$$



$$
\begin{aligned}
&= R^2 - 2tR + t^2 + r^2 \\
2t &= \frac{r^2}{R} = \frac{D^2}{4R}
\end{aligned}
$$

Ring Number	L_m	$\lvert L_m - L_1 \rvert$	R_m	$\lvert R_m - R_1 \rvert$	D_m
24					
23					
22					
..					
1					

$$D_m^2 = 4Rm\lambda$$

Material Requirements: Travelling microscope, glass plate, spherometer, convex lens, sprit level, sodium light as sourse. 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

Methodology:

- Clean the lens and the glass slides with lens tissue and setup the apparatus.
- The light from the sodium lamp is partially reflected downwards by a glass slide A. The beams reflected from the lens, L, and the glass slide B go through the slide A to the microscope.
- Look for the interference rings with the naked eye – it is easiest to spot these from a height and changing your viewing angle. You may need to manoeuvre the reflecting slide until you can clearly view the rings.
- Focus the microscope on the fringes and align the cross-hair tangential to the central dark spot.
- Measure the diameters of at least six dark rings by setting the cross-hair on one side of a series of rings, reading the positions and then moving the microscope to the other side of the corresponding rings.
- You could start measuring the position of the 12th ring, proceeding to the 10th, 8th, etc. and then moving across to the other side of the central ring until you have measured the 12th ring again.
- Use the magnifying glass provided to read the Vernier scale precisely. To remind yourself how to use the Vernier scale refer back to the Air Wedge experiment.
- Hence calculate the value of λ, using the value of R stated and the gradient of the graph. Compare your result with the accepted value for sodium light of 589nm.

Precautions:

(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 diam eters.

(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.

Experiment No.: 11 To find the resolving power of a Telescope.

Background: The resolution of any viewing instrument (a telescope, our eyes) refers to the ability of being able to distinguish between two closely spaced objects. Common experience tells us that bringing an object closer to our eyes usually allows us to say if the object is singular or has multiple components (such as an intertwined string). By bringing the object closer to our eyes, we increase the angle subtended by the two separate components allowing us to "resolve" them.

A telescope is an instrument which aids in the viewing of remote objects. Telescopes are designed to give an image of a point source which is as small as possible. When parallel light passes through the aperture, it gives a diffraction pattern with a central maximum of fixed width. This diffraction pattern limits the resolving power of the telescope.

Formula Used: The theoretical and practical resolving powers are given by Theoretical resolving power = λ/a and Practical resolving power = d/D, Where λ = mean wavelength of light employed, a = width of the rectangular slit for just resolution of two objects, d = separation between two objects, D = distance of the objects from the objective of the telescope hence $\lambda/a = d/D$.

Material Requirement: Telescope with a rectangular adjustable slit, a black cardboard with narrow white strips on it, traveling microscope and meter scale.

Methodology:

(i) Mount the telescope on a stand such that its axis lies horizontal and the rectangular lines marked on cardboard or glass on another stand such that they are vertical. Place the two stands at a suitable distance.

(ii) Illuminate the object with source of light. Now open the slit with the help of micrometer screw and move the telescope in the horizontal direction such that the images of two vertical sources are in the field of view of the eyepiece.

(iii) Gradually reduce the width of the slit till the two images just cease to appear as two.

Note down the reading of the micrometer. Again close the slit completely and note down the micrometer reading. The difference of the two readings gives the width of the slit (a) just sufficient to resolve the two images.

OR

If the slit is not provided with micrometer arrangement, the slit is gradually reduced till the two images cease to appear two. Take the slit and measure its width with the help of traveling microscope.

(iv) Measure the width (d) of white or black rectangular strips with the help of traveling microscope.

(v) Measure the distance between the object and the slit which gives D.

(vi) The experiment is repeated for differently values of D.

Result: The theoretical and practical resolving powers of the telescope are shown in the following table.

Theoretical and Practical Resolving Powers:

Distance	Theoretical Resolving Power (λ/a)	Practical Resolving Power (d / D)
…	…	…
…	…	…
…	…	…

Precautions:

(i) The axis of telescope should be horizontal.

(ii) The plane of the slit should be parallel to the objects.

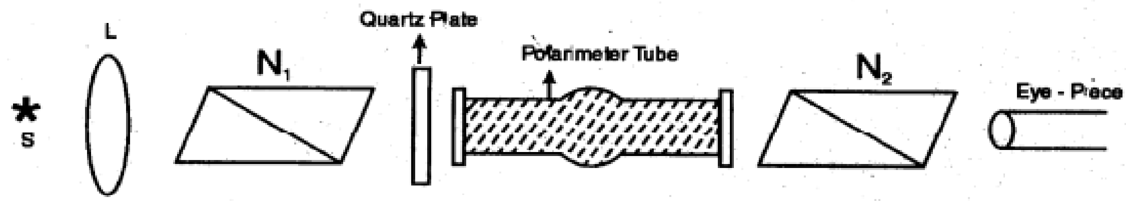
(iii) The width a should be measured carefully.

(iv) The minimum width of the slit for resolution should be adjusted very carefully.

(vii) The distance D should be measured from the slit of the telescope to the cardboard.

Experiment No. 12 To determine the specific rotation of sugar using Laurent'z half shade polarimeter.

Background: If θ is the optical rotation produced by 'l' decimetres of a solution and c is the concentration in gm/cc, then specific rotation S can be given as, $S = \theta / l c$



Procedure : Find out the least count of analyser scale using following formula L.C. of travelling microscope = Value of smallest division on main scale Total No. of division on vernier scale. Place the polarimeter tube so that the aperture of the tube is in the front of light. Look through the eye-piece so that the two halves of the half shade device are clearly visible . Fill the polarimeter tube with distilled water taking care of thateither there is no air bubble in the tube or if it is there, it remains at the centre part of the tube. Place the tube in the polarimeter and observe through the eyepiece-E . In general we find two semi circles of different colours. By rotating the analyser eyepiece system, the colour pair gets changed. Let us select a pair of different colour, say red and blue. By rotating the analyser scale, the colour pair can be interchange. By rotating the analyser scale, the two colours can be mixed so that circular field of view appears gray instead of two semicircle of red and blue. Record the reading of analyser scale at this position.

Prepare a sugar solution by dissolving 10 gm., 8gm, 6gm, and 4gm of sugar in 100ml of distilled water separately. Fill the polarimeter tube with 10gm concentration of sugar solution. Adjust the analyser scale until the field of view appears gray. Note down the analyser reading . Repeat the same procedure for other sugar concentrations i.e. 8gm,6gm,and 4gm. Adjust the analyser scale until the field of view appears gray everytime. Calculate the values of angle of rotation θ for different sugar concentrations with respect to distilled water. Plot the graph of angle of rotation θ against mass of sugar n. Graph is straight line, find out its slope.

Materials Requirements: Laurent'z half shade polarimeter, source of light , sugar, distilled water, measuring cylinder, beakers.

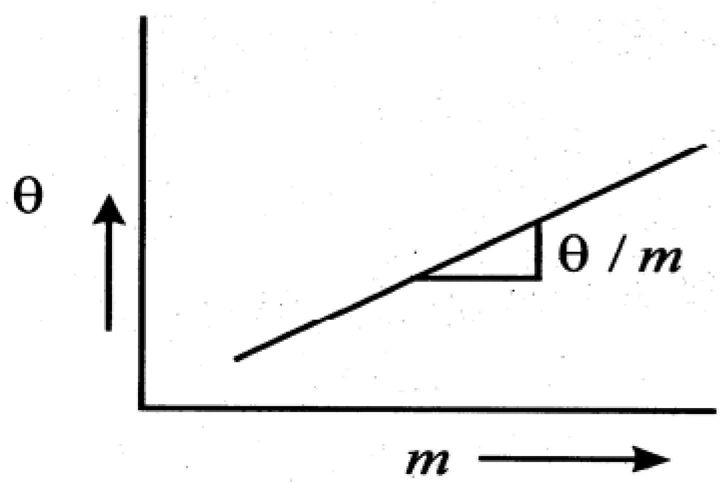
Calculations : $S = 1000\theta / Lm$ Where , L= length of polarimeter tube = 20cm, θ = Angle of rotation, m= mass of sugar

Obsrevations: Length of polarimeter tube = 20cm; Least count of analyser scale=_______

Table:

Sr.No.	Mass of sugar in water (m)	Analyser reading	Angle of rotation (θ)
1	Distilled water		
2	10gm sugar in 100ml water		
3	8gm sugar in 100ml water		
4	6gm sugar in 100ml water		
5	4gm sugar in 100ml water		

GRAPH :



Result : Specific rotation S = __________0/gm cc

Precautions:

(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.

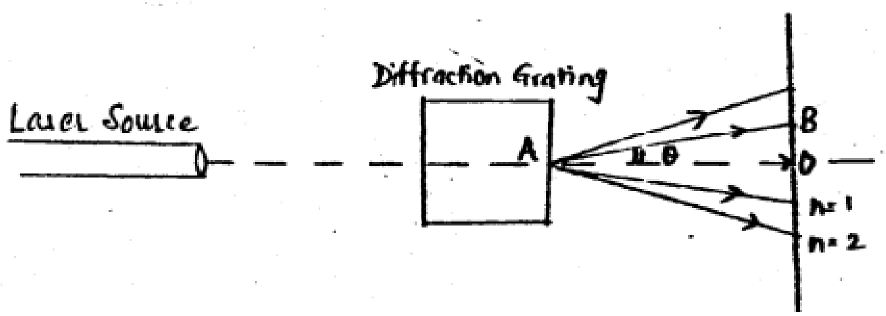
(v) The position of analyzer should be set accurately.

(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.

Experiment No. 13 AIM: To determine the wavelength of LASER source

Background: Keep the laser source and stand for grating as shown in the diagram. Focus the laser beam so as to get a fine spot on the screen.



Dist. AO = x

Dist. OB = y

Following characteristics are to be studied in case of laser source.

I) Intensity

II) Beam of divergence

III) Change in diffraction pattern obtained on the screen as a function of various gratings.

By measuring distance 'x' and 'y' (refer diagram), angle θ can be determined.

Using relation $(a+b)\sin\theta = n\lambda$, the wavelength of given laser source can be determined.

CALCULATIONS:

$(a+b)\sin\theta = n\lambda$ where, $(a+b)$= width of grating = 2.54/15000

θ = angle of diffraction; n = order of diffraction; λ = wavelength of given laser source

Number of line per inch =15000

Material Requirement: source (diode Laser, 5 mW power), diffraction grating of various orders, stand, etc.

Methodology:

1 Mount the double slits on the uprights and place near the laser.

2 Adjust the position of the screen and the double slit to get a clear parallel fringe pattern on the screen.

3 note the fringe pattern on the graph paper from the screen.

4 Find the distance between the slit and screen and also find the distance between the two slits.

5 Now change the distance between the source and the slits and record the pattern formed on the screen.

6 After recording the pattern find the distance between every two consecutive pattern and then find the mean fringe width.

7 After finding the value of mean fringe width we will calculate the value of wavelength of He-Ne laser source.

Precautions:

1 The slit must be narrow and close to each other as laser beam is very thin.

2 Keep the distance of the screen on the eyepiece from the slit sufficiently large to observe measurable fringe width.

3 slit should be adjusted for a vertical position and very near the beam coming from the laser source.

Experiment No. 14 To find the wavelength of white light with the help of a plane transmission diffraction grating.

Background: The spectrometer is set with its collimator towards the source of light. The telescope is brought in line with the collimator. The width of the slit is made sufficiently narrow. The spectrometer is levelled with with the help of spirit level such that the image of slit is at the centre of the field of view. The eyepiece of the telescope is adjusted so that cross wires are distinctly visible. The crosswire tube is rotated such that the vertical crosswire coincides with the image of the slit is obtained. Using a glass prism, the optical levelling of the prism table is done. The collimator and telescope are adjusted for parallel rays. The least count of the instrument is determined . It is taken care that adjustments of the spectrometer are not disturbed subsequently during the experiment.

Setting thegrating for normal incidence:-

As the formula is derived for the case where light is incident perpendicular to the face of the grating, it is essential that the grating is to be set on the prism table with its plane normal to the axis of the collimator. The setting is achieved through the following steps. The telescope is brought in line with the collimator to have image of the slit on the vertical cross wire. It is locked in that position. The lower screw of the spectrometer is unlocked and tha table is rorated till the reading on one vernier is exactly 360 degrees. The reading on the second vernier is therefore 180 degrees. The screw is locked. Now the telescope arm is unlocked and ratated through 90 degrees in clockwise or anticlockwise direction. It is locked in that position. The grating stand is mounted on the prism table and the grating is placed in it with its ruled surface towards the telescope. Care is taken that the grating stands at the centre of the prism table. Then the prism table is rotated slowly so that a reflected image is seen in the field of view of the telescope. Rotating the prism table very slowly the reflected image to coincide exactly with the vertical crosswire. In this position, the angle of incidence of light on the grating surface is 45 degrees. The reading of the position of the prism table is noted down. The prism table is rotated from the above position through 45 degrees more so that the grating plane becomes normal to the direction of light. The prism table is locked in this position. This is the normal incidence position.

No. of rulings per inch on the grating, N = ………

Least count of spectrometer = ………. second

Reading of telescope for direct image = ……….

Reading of telescope after rotating it through 90° = ………

Reading of circular scale when reflected image is obtained on the cross wire = ………

Reading after rotating the prism table through 45° or 135° = ……….

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

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

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

Materials Requirements:

Diffraction grating, spectrometer, mercury vapour lamp, reading lens and sprit level.

Methodology:

The following initial adjustments of the spectrometer and the grating are made first.

The spectrometer and the prism table are arranged in horizontal position by using the leveling screws.

• The telescope is turned towards a distant object to receive a clear and sharp image.

• The slit is illuminated by a mercury vapour lamp and the slit and the collimator are suitably adjusted to receive a narrow, vertical image of the slit.

• The telescope is turned to receive the direct ray, so that the vertical slit coincides with the vertical crosswire. The readings of one vernier are noted. The vernier table is firmly clamped.

•Now, the telescope is rotated through 90° and is fixed in this position. The grating is mounted vertically on the prism table with its ruled surface facing the collimator. The vernier table I released and is slowly rotated till the reflected image coincides with vertical crosswire.

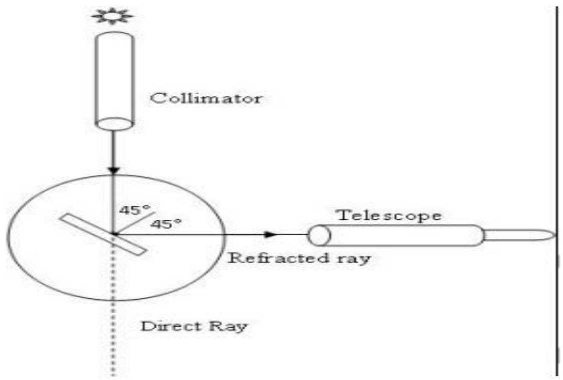
• The leveling screws are adjusted so that the image is at the centre of the field of view of the telescope. The prism table is fixed and after making fine adjustments with tangential crew, the reading of the vernier are noted. Now, the angle of incidence is 45 degree.

• The vernier table is then released and rotated exactly through 45° (or 135°) in the proper direction so that the surface of the grating becomes normal to the incident light. The vernier table is firmly clamped in this position. The telescope is then released and is brought to observe the direct image. (B) Measurement of angles of diffraction for different colours.

Rotate the telescope to the left side of direct image and adjust the different spectral lines (violet, yellow and red) turn by turn on the vertical cross wire for first order. Note down the reading of both the verniers in each setting. Rotate the telescope further to obtain the second order spectrum and again the spectral lines on the vertical cross wire and note the readings. • Now rotate the telescope to the right of the direct image and repeat the above procedure for first order as well as for second order.

Find out the difference of the same kind of verniers (V1 fromV1 and V2 fromV2) for the each spectral line in the first order and then in the second order. The angle is twice the angle of diffraction for that particular colour. Half of it will be angle of diffraction.

• Find out the angles of diffraction for other colours in first and second orders.



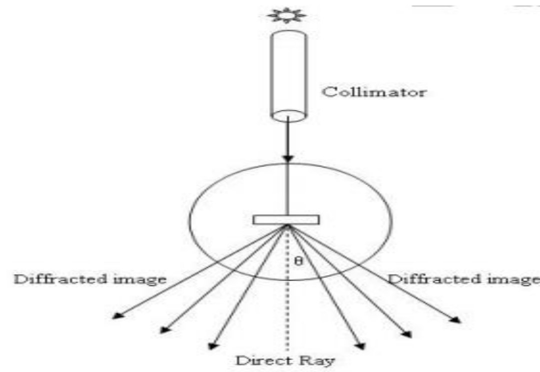


Table for determination of angles of diffraction:

Order of spectrum n	Colour	Vernier	Telescope reading of spectrum on						Angle of diffraction $\theta = (a - b)/2$	Mean θ
			Left side			Right side				
			MSR	VSR	TR (a)	MSR	VSR	TR (b)		
First	Violet	V_1								
		V_2								
	Yellow	V_1								
		V_2								
	Red	V_1								
		V_2								
Second	Violet	V_1								
		V_2								
	Yellow	V_1								
		V_2								
	Red	V_1								
		V_2								

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Colour of spectral line	Calculated wavelength	Standard wavelength	% Error
Violet		4358 Å	
Yellow		5770 Å, 5791 Å	
Red		6678 Å, 7065 Å	

Precautions:

(i) Before performing the experiment, the spectrometer should be adjusted.

(ii) Slit should be as narrow as possible and both verniers should be read.

(iii)Grating should be set normal to the incident light.

(iv)While taking observation, telescope and prism table should be kept fixed.

Experiment No. 15: To determine Planck's constant using light emitting diodes [LED's] by observing the 'reverse photo-electric effect'.

Background: If a bias voltage is passed across the LED, which is equal or greater than the difference in the energy of the bands, i.e. the barrier potential, then the bands will 'line up' and a current will flow. When current flows, electrons flow from the conduction band of the N type conductor and are forced up into the conduction band of the P type. Since the P type conductor's valance band is lacking in electrons and we are overpopulating its conduction band with the bias voltage the electrons readily fall into the 'holes' in the valance band of the P type conductor. When they fall, this energy is released in the form of a photon. Planck's Constant kit and LED's Theory: The energy of a photon is given by the equation:

E = hv ……..(1)

Where E is the energy of photon □ is its frequency, and h is a constant. In the case of the photoelectric effect, an electron is emitted from a metal if the energy of the photon is greater than the work function of the metal. If the energy of said photon is greater than the work function of a given material then the electron emitted possesses a voltage, which equals the difference in these energies. In the case of an LED's the opposite is true. If an electron of sufficient voltage is passed across a material then a photon is emitted whose energy is equivalent to the work function of that material. The voltage at which this effect observed is the 'turn on voltage'. This effect is not normally observed in metals and other typical substances because the photons emitted are usually outside the range of visible light, usually somewhere in the infrared. The energy of the photons emitted should then be the same as the energy of a given electron. Since:

P = IV ……. (2)

Where P is power, I is current and V is the voltage of a system. The energy of one electron is the charge of an electron (i.e. the current flow of one electron per second in amps) times the voltage. Using this knowledge we then from the equation: E= eV

Materials Requirements: Specially designed variable dc power supply (0 – 5 V) whose output can be varied in steps of 1 mV. Digital dc Micro ammeter (0-999 µA dc), Digital Voltmeter (0 – 9.99V dc)

Methodology:

1. Make the connection in the kit.

2. Take the current measurement of each LED by varying the voltage as given in the table.

3. Plot the curve on the graph paper between Voltage on X axis and current on Y axis.

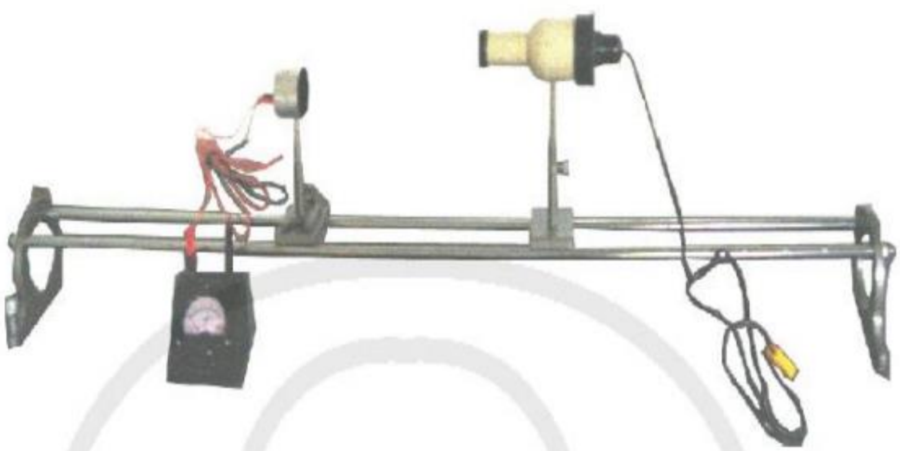
4. The linear portion of the I/V curve is extra plotted back to the X axis .

Experiment No. 16: To verify Inverse square law of light using a photo cell.

Background:- The photoelectric emission may be regarded as a phenomena of liberation of an electron at the surface of a metal when a photon of light having energy above threshold energy (metal work function) incident on a metallic surface and transfer the enough energy to the electron to escape through the potential barrier layer. The photo cell can be considered as the generation of a voltage across a circuit element under illumination. Let P be the illuminating Power of a source so the intensity of illumination I due to it at a distance r would be I= P/r2. Since the photo electric current (θp) produced is directly proportional to the intensity of illumination ie. I α θp; I=Kθp

Where K is constant, hence I= P/r2 = Kθp. Since P and K are constant hence the relationship between 1/r2 and θp is straight line which verifies the inverse square law of radiation.

Materials Requirements:- Optical bench, Photocell housed with Red and Black sockets, lamp house with lamps, DC Microammeter.



Methodology:-

1. Arrange the optical bench in such a way that both the lamp and the photo cell are at the same level.

2. Make the connection of photo cell to microammeter Red to (+)ve and black to (–)ve terminal of the microammeter.

3. Adjust the distance of the lamp such that we will get the microammeter reading.

4. Then decreases the distance in step of 5cm and each time note the reading in microammeter and note your observation in table-1.

5. Draw the curve between 1/r2 and d. 1/r2 on x axis and θp at y axis.

Observation table:-

S.N.	Distance of lamp from cell in cm 'r'	$1/r^2$	Reading in microammeter (θp) uA
1.			
2.			
3.			
4.			
5.			

Precautions:

1. Light should fall on normally on the photocell

2. The photocell should not be exposed to light for a long time continuously.

3. A Cover should be placed on the photocell to protect it.