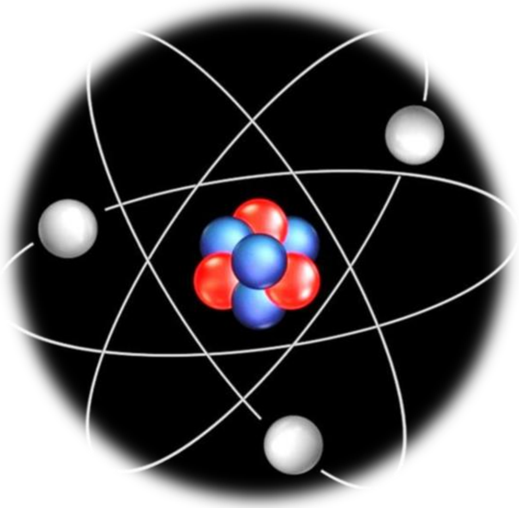
Department of Science and Humanities
Engineering Physics Laboratory



Laboratory Manual

(As per Revised Curriculum SVU R-2023)

FY B Tech AY 2023-24

SEMESTER II

List of Experiments:

Title of the Experiment	Mode of Conduction
Grating Constant	Hands-on
Wedge-Shaped Film	Hands-on
Newton’s Rings	Hands-on
Hg-Spectrum	Hands-on
Hall Effect	Hands-on
Energy Band Gap	Hands-on
e/m ratio	Demo +programming assignment
Photoelectric Effect	Demo +programming assignment
Planck’s Constant	Virtual Lab
Resistivity by 4-Probe	Hands-on + Virtual Lab
Laser Beam Divergence	Hands-on + Virtual Lab
Numerical Aperture	Hands-on + Virtual Lab

Note:

In order to successfully complete the Lab CA in Physics Lab Course (Course code: 216U06L102), students need to perform and prepare a written record of 6-8 hands on experiments and 2-4 demo + virtual lab experiments.

Instructions:

1. **Take printouts of only the template (page no 27, 28) for each experiment. DO NOT print the entire lab manual**. The template for preparing written record of experiments is given at the end of this manual. You can keep soft copy of the lab manual for reference during the lab sessions in your laptop/mobile phone.
2. <u>Diagrams, observation tables, graphs, calculations etc. should be handwritten</u>. Neatly written and well-organized journal will fetch better grades.
3. Results and/or conclusions should be written for every experiment.
4. Attach graph paper separately. Axes should be labelled. Indicate scale used and units.
5. Attach separate sheet for assignment work.
6. Each experiment should be completed and submitted on time as instructed by the Faculty I/c. Grades will be deducted for late submissions.
7. **Lab attendance should be 100%. Grade penalties will be applied for absenteeism.**
8. Journal carries 30 marks out of 50* marks of Lab CA. Distribution of marks for each experiment will be as follows:

Component	Max marks	Remarks
Performance and written record of experiment	15	Draw graph on a graph paper and attach with written record of the experiment
Assignment	05	Write assignment Q&A on separate assignment sheet
Attendance	05	0 for absent, 03 if performed in repetition turn
Viva	05	based on experiment performed
Total	30	Average of all experiments will be considered for grading the journal

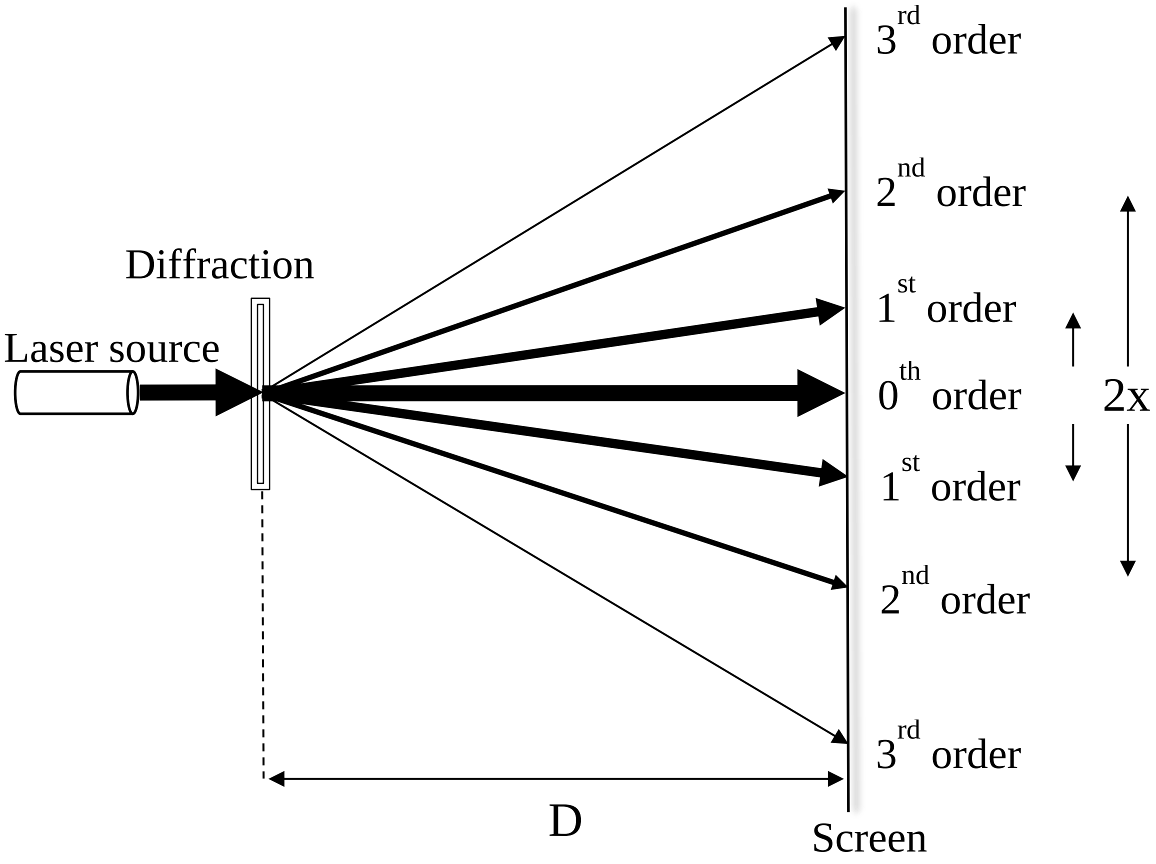
*remaining 20 marks are allotted to Lab quizzes based on experiments performed

Title of the experiment: Grating Constant

Aim: To determine the line density of a plane transmission diffraction grating

Apparatus: Plane transmission diffraction gratings, laser source, screen, and metre scale

Diagram:



Procedure:

1) Switch on the laser source so that a single bright spot (red) appears on the screen. Introduce given diffraction grating between the laser source and screen to obtain a diffraction pattern consisting of different intensity spots corresponding to different diffraction orders. Keep screen at around 25-50 cm from grating.
2) Measure distance (2*x*) between two first order spots (n = 1) on either sides of the central maximum. Hence, calculate average distance of the first order from the central maximum i.e. *x*. Repeat the same for higher orders (n = 2, 3 etc.).
3) Measure distance (D) between the grating and the central spot on the screen.
4) Calculate angle of diffraction (θ) for each order of grating. Repeat steps 2 and 3 for some other distance D.

Observations:

<table>
<tr><td colspan="5">Screen distance D = _________ cm
grating number: ______</td></tr>
<tr><td rowspan="2">Order of maxima m</td><td colspan="2">Separation of diffraction maxima from central maximum</td><td rowspan="2">Angle of diffraction θ</td><td rowspan="2">Sin θ</td></tr>
<tr><td>2x (cm)</td><td>x (cm)</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>--</td><td></td><td></td><td></td><td></td></tr>
<tr><td>--</td><td></td><td></td><td></td><td></td></tr>
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<tr><td>7</td><td></td><td></td><td></td><td></td></tr>
</table>

Formula: Line density of diffraction grating $\mathrm{N} = \frac{\mathrm{slope}}{\lambda}$
slope: slope of line sin θ v/s m
θ: angle of diffraction maxima $\theta = \tan^{-1}\frac{\mathrm{x}}{\mathrm{D}}$
m: order of diffraction maxima
λ: wavelength of laser light. λ = 640 nm

Graph: Plot sin θ as a function of order of diffraction maxima (m). From the points plotted, draw best fit line. Determine slope of this line.

Calculation: Determine line density of the diffraction grating used in the experiment using the formula given.

Result/s and Conclusion:
Line density (grating constant) of the given diffraction grating N = ___________/cm

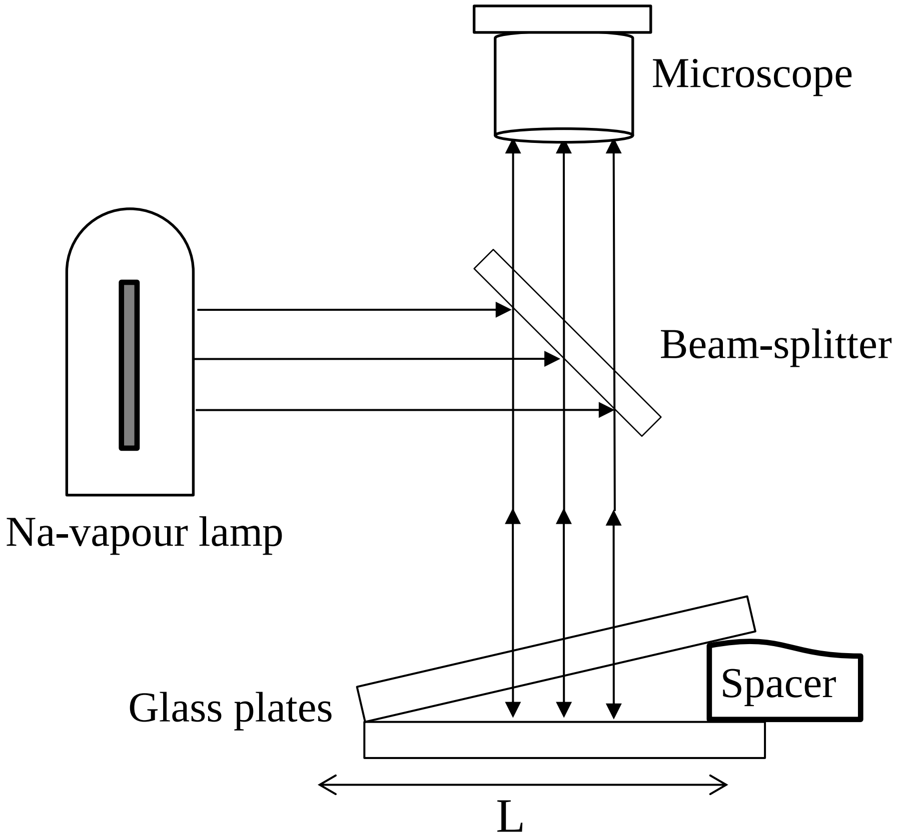
Assignment:
Re-calculate the separations x’ for all orders for green laser (wavelength = 532 nm) using $\sin\theta = \mathrm{mN}\lambda$. Use the same screen distance (D) used in the experiment for calculations. Tabulate your answers. Show calculation for any one order in detail.

Title of the experiment: Wedge-Shaped Film

Aim: To determine spacer thickness in a wedge shaped film interference pattern

Apparatus: Wedge-shaped film set-up (two optically flat glass plates separated by a spacer at one end, beam-splitter with black box), monochromatic source (Na-vapour lamp), and travelling microscope.

Diagram:



Procedure:

1) Arrange apparatus as shown schematically in the diagram. Focus the microscope to get Interference fringes. The field of view can be adjusted anywhere on the fringe pattern. Adjust the vertical cross wire such that it is parallel to the fringes.
2) Set the vertical cross wire on a particular dark fringe so that they coincide. Note the reading at this position. Number this dark fringe as 0.
3) Move the cross wire through dark fringes either towards left or towards right and note the reading on the 5th dark fringe from the 0th dark fringe selected.
4) Move further in the same direction and through same number of fringes and repeat step number 3 to note down readings at dark fringes such as 10th, 15th, 20th etc.

Observations:

Sr. No	Dark fringe no (n)	Main Scale Reading M (cm)	Vernier Reading V = CD x LC* (cm)	Total Reading T_n = M + V (cm)
1				
--				
--				
--				
8				

*CD: Coinciding Division, LC: Least Count

Formula: Spacer thickness $d = \frac{\lambda L}{2\beta}$.
λ: wavelength of light from Na-vapour lamp = 589 nm
L: length of glass plates = 4 cm
β: Fringewidth (from graph)

Graph: Plot a graph of total reading as a function of fringe number. Take T_n along the Y-axis and n along the X-axis. For the points plotted, draw best-fit line. Determine slope of this line.

Calculation: The slope equals the fringewidth of interference pattern. Calculate spacer thickness using the formula given.

Result/s and Conclusion:
Thickness of spacer d = ___________ cm

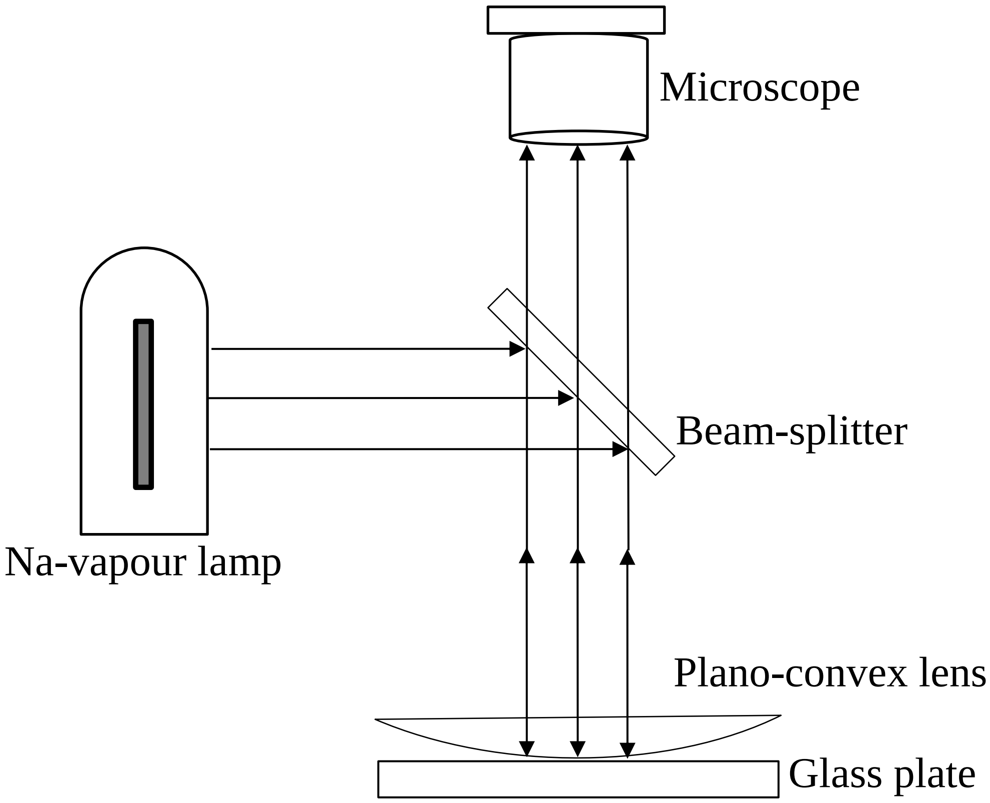
Assignment:
Determine the wedge angle $\theta \approx \frac{\lambda}{2\beta}$. Calculate total number of fringes $N = \frac{L}{\beta}$. Now if the wavelength is changed to 540 nm, calculate the wedge angle and number of fringes. (Note: when wavelength changes, fringewidth will also change)

Title of the experiment: Newton's Rings

Aim: To determine radius of curvature of plano-convex lens by measuring diameters of interference rings

Apparatus: Newton's rings set-up (pair of plane glass plate and plano-convex lens, beam-splitter with black box), monochromatic source (Na-vapour lamp), and travelling microscope.

Diagram:



Procedure:

1) Arrange apparatus as shown in the diagram. Wait until the Na-vapour lamp turns bright yellow. Observe through the microscope and adjust focus to get a clear Newton's rings interference pattern (alternate dark/bright rings).
2) First, adjust crosswire on the centre of the pattern. The central spot is taken as n = 0 and for the innermost dark ring, n = 1. Shift crosswire towards left side of the pattern and count the number of dark rings. Get the crosswire at the 10th dark ring so that the vertical crosswire is tangential to it. Note down the travelling microscope reading at this position.
3) Now shift the crosswire towards centre of the pattern and adjust it at the 8th dark ring. Follow step 2. Continue this procedure for inner dark rings by skipping one dark ring in-between until you complete reading for 2nd dark ring on the left side of central spot.
4) After this, continue shifting the crosswire in same direction (from left to right) so that it moves on the right side of central spot. Adjust the crosswire tangential to 2nd dark ring on right side of pattern and note down the reading. Continue readings in this manner for outer dark rings by skipping one dark ring in-between until you complete reading for 10th dark ring on the right side of central spot.
5) Difference between two readings (i.e. on left and right) for the same ring number will be the diameter (D_n) of that ring. Find diameters of all rings.

Observations:

Sr. No	Ring no (n)	Travelling Microscope Reading (cm)						Diameter D_n (cm) = L-R	D_n^2 (cm^2) (take 10^{-2} factor common)
		*On Left L = M + V (cm)			*On Right R = M + V (cm)				
		M	V	L	M	V	R		
1	12								
--	10								
--	--								
--	--								
6	2								

*M: Main scale reading, V: Vernier reading = coinciding division x least count, L: Total reading on left side and R: Total reading on right side of the centre of the ring pattern

Formula: Radius of curvature of lens $R = \frac{\text{slope}}{4\lambda}$
Slope: slope of line D_n^2 v/s n
λ: wavelength of light from Na-vapour lamp = 589 nm

Graph: Plot a graph of squares of diameters of dark rings as a function of dark ring number. Take D_n^2 along the Y-axis and n along the X-axis. From the points plotted, draw best-fit line that passes through the origin also. Determine slope of this line.

Calculation: Determine radius of curvature of the lens using the formula given.

Result/s and Conclusion:
Radius of curvature of plano-convex lens R = ________ cm.

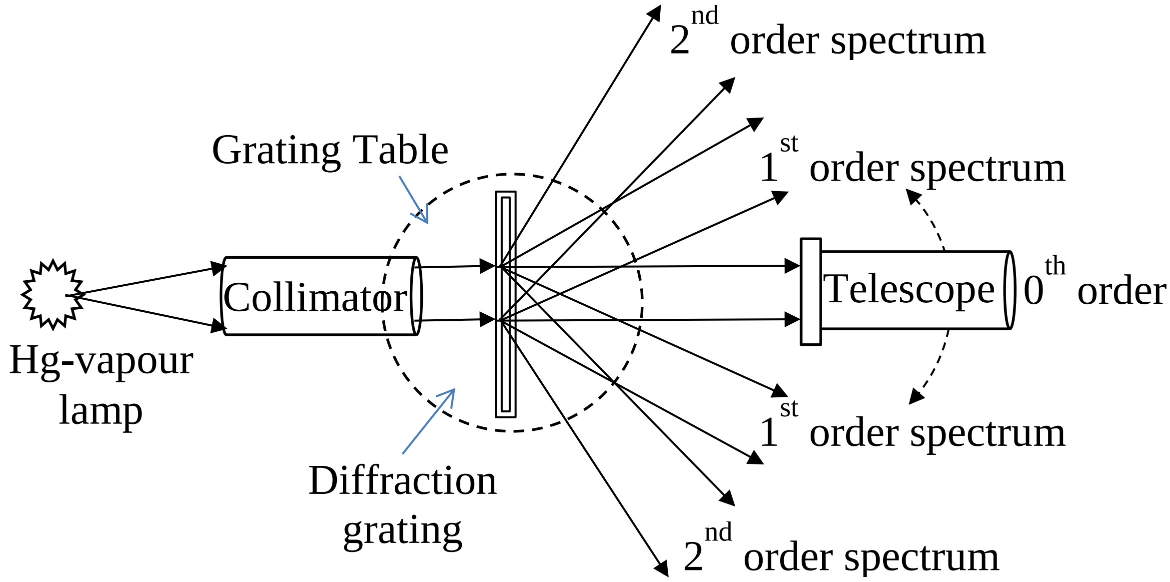
Assignment:
If the entire set-up is immersed in water, diameters of the rings will change. Re-calculate these diameters using the equation: $D_n'^2 = \frac{4n\lambda R}{\mu}$ where, μ is refractive index of water and $D_n'^2$ are diameters of dark rings in water. Tabulate your answers. Plot a graph of $(D_n')^2$ v/s n in the same graph paper.

Title of the experiment: Hg-Spectrum

Aim: To determine wavelengths of different spectral lines (colours) emitted from a mercury vapour lamp (Hg-source)

Apparatus: Spectrometer, Hg-vapour lamp, and diffraction grating

Diagram:



Procedure:

1) Level the spectrometer, prism table, collimator and telescope. Illuminate collimator-slit with Mercury source. Bring telescope in line with collimator and focus it on the illuminated slit. The slit must be sufficiently narrow.
2) Adjust the eyepiece of the telescope so that the crosswire is distinctly visible and vertical crosswire is coinciding with the sharp image of the slit. Mount diffraction grating on prism table, perpendicular to incident light (i.e. to the collimator). Lock prism table.
3) Move telescope to one side of the incident direction (say, to the left) until you see the first order spectrum. Spectral lines will be visible in the order from violet to red from the incident direction i.e. white line. Focus on the bright-coloured violet/blue spectral line. Adjust the vertical crosswire so that it coincides with the violet/blue line. If required, fix telescope & use its fine motion for this adjustment. Note down readings in both the windows.
4) After violet/blue, release the telescope and move it further to get green line. Follow the same procedure as in step 3. Repeat the same for one of the yellow lines and brightest red line from the spectrum.
5) Now take the telescope to the right side of the incident direction and follow the procedure of steps 3 and 4.
6) The angle 2θ for a particular spectral line is the difference between its readings on the LHS and RHS of incident direction from the same window.

Observations:

Sr. No	Spectral Line	Spectrometer Reading (degrees and minutes)						Diffraction angle# $\theta = \frac{L \sim R}{2}$ (deg-min)
		*On Left L = M + V			*On Right R = M + V			
		M	V	L	M	V	R	
1	Blue/Violet							
2	Green							
3	Yellow							
4	Red							

*M: Main scale reading, V: Vernier reading = coinciding division x least count, L: Total reading on left of the incident direction, R: Total reading on right of the incident direction
#The sign ~ means find difference L-R or R-L whichever is positive

Formula: Wavelength of spectral line $\lambda = \frac{\sin\theta}{mN}$
θ: angle of diffraction maxima
m: order of diffraction maxima. Take m = 1
N: Line density of diffraction grating. N = 5905/cm

Graph: --

Calculation: Calculate wavelengths of spectral lines using the formula given.

Result/s and Conclusion:
Wavelengths of main spectral lines:

Sr. No	Colour	wavelength (nm)
1	Blue/Violet	
2	Green	
3	Yellow	
4	Red	

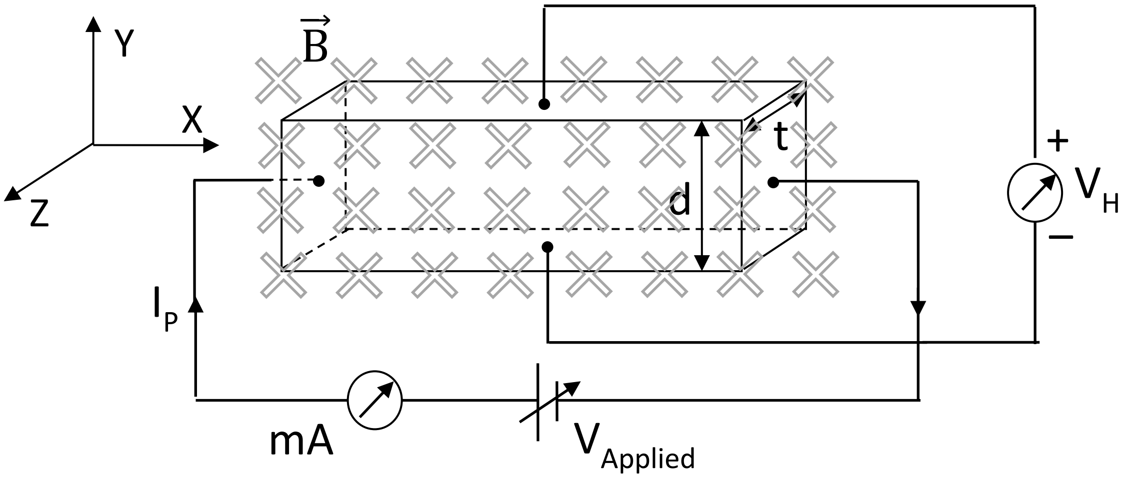
Assignment:
Determine highest order of diffraction maxima possible for all the above spectral lines using $m_{max} = \frac{1}{N\lambda}$. (Note: m_{max} is an integer value. This will be the integer part of the answer and not the rounded-off value). Next, re-calculate the angles of diffraction (θ') for second order (m = 2) using the formula $\theta' = \sin^{-1}(mN\lambda)$ for all the spectral lines. Tabulate your answers.

Title of the experiment: Hall Effect

Aim: To determine carrier concentration of a semiconductor sample using Hall Effect

Apparatus: Electromagnet, power supply, current source, voltmeter, ammeter, Hall probe

Diagram:



Procedure:

1) Connect electromagnet to its power supply. Connect hall probe into probe socket. Keep magnet and probe current knobs nearly in midway position.
2) Switch on power supply. Adjust magnet current and probe current to zero. Adjust probe setting to read zero on voltmeter display.
3) Set 1 cm gap between pole pieces. Insert hall probe between the pole pieces and adjust its position so that the poles are perpendicular to the flat side of probe. Assure that the probe does not touch the pole pieces.
4) Slowly increase magnet current (I_M) and set it to +200 mA. Vary probe current (I_P) from 0 to 100 mA in equal steps and note down corresponding Hall voltage (V_H) each time. Repeat procedure by varying I_P in reverse order (100 mA to 0). Find average value of V_H.

Observations:

Electromagnet current =
Intensity of magnetic field =
Error voltage V_R =

Sr. No	I_P (mA)	V_M (mV)	Corrected V_H = $V_M \pm V_R$ (mV)
1	-100		
2	-80		
--	--		
--	0		
--	--		
--	+80		
11	+100		

Formula: $n = \frac{B}{q \times t \times slope}$
n: charge carrier concentration in m^{-3}
B: intensity of magnetic field in tesla
q: elementary charge = 1.6×10^{-19} C
t: sample thickness = 450 micron
Slope: slope of line V_H v/s I_P

Graph: Plot Hall voltage as a function of probe current. Take V_H along Y-axis and I_P along X-axis. From the points plotted, draw best-fit line passing through the origin. Determine slope of this line.

Calculation: Calculate charge carrier concentration using the formula given

Result/s and Conclusion:
Carrier concentration in given semiconductor sample n = __________/m^3.

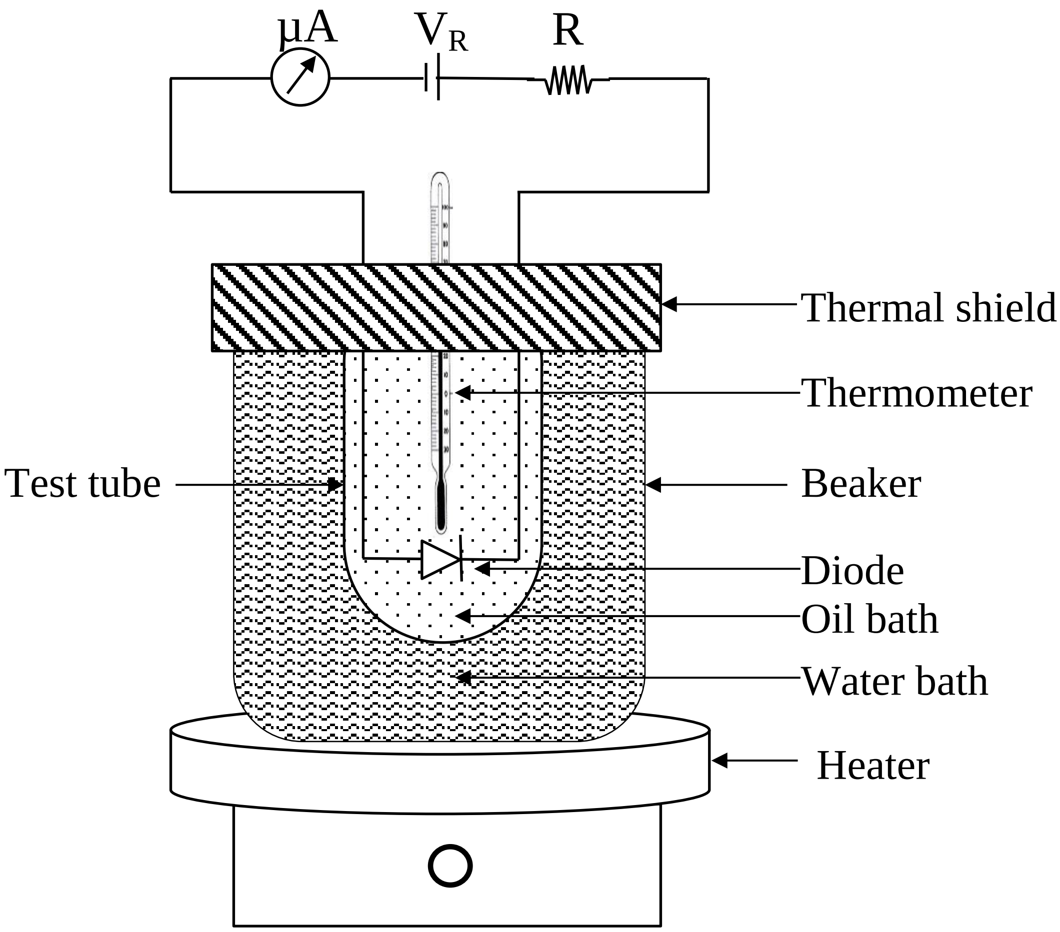
Assignment:
Calculate conductivity of charge carriers using the formula $\sigma = qn\mu$, where "μ" is mobility of charge carriers. Take μ = 2 m^2/V-s. Mobility gives how fluently a charge carrier can move through the material. Measure the room temperature (T_A). The conductivity calculated above is σ (T_A). The temperature dependence of conductivity is given by $\sigma(T) = Ae^{-\left(\frac{B}{KT}\right)}$, where A and B are constants. Calculate conductivity at 100°C using the given equation.

Title of the experiment: Energy Band Gap

Aim: To determine energy band gap of the material of semiconductor p-n junction diode using temperature dependence of reverse saturation current

Apparatus: DC power supply, voltmeter, micro-ammeter, semiconductor diode, heating bath, thermometer, and connecting wires

Diagram:



Procedure:

1) Connect the circuit as shown in experimental set-up. Adjust 2 V on the dc power supply and note the reverse saturation current (I_S) at room temperature (RT).
2) Insert the diode in heating bath assuring that it is in contact with the bulb of thermometer. Start heating the diode.
3) Record I_S for every 5°C rise in temperature (T) up to a maximum of 70°C. Switch off heater when temperature rises above 65°C.

Observations:

Sr. No	Temperature (T) °C	kelvin	Reverse current I_S (amp)	1/T (K^{-1})	$\ln\left(\frac{I_S}{T^2}\right)$
1					
2	40				
--	--				
--	--				
--	--				
8	70				

Formula: Energy Band Gap $E_g = \kappa \times |\text{slope}|$
|slope|: absolute value of slope of line $\ln\frac{I_S}{T^2}$ v/s $\frac{1}{T}$
κ: Boltzmann constant. κ = 1.38 x 10-23 J/K
I_S: reverse saturation current
T: absolute temperature

Graph: Plot $\ln\frac{I_S}{T^2}$ as a function of $\frac{1}{T}$. The graph will be in 4^{th} quadrant. From the points plotted, draw best fit line. Determine slope of this line. Use absolute value of the slope for calculations.

Calculation: Determine energy band gap of the material of given p-n junction diode using the formula given.

Result/s and Conclusion:
Energy band gap of Ge (E_g) = _________ eV.

Assignment:
Calculate energy band gap of the semiconductor material at absolute zero using the formula $E_g(0) = E_g(T) + \frac{\alpha T^2}{T+\beta}$ where, α, β are material parameters. For the given material, take α = 3.16 x 10^{-4} eV/K and β = 93 K. Next, Determine the temperature at which, this semiconductor material will start behaving like metal (means its energy band gap becomes zero).

Title of the experiment: e/m ratio of electrons

Aim: To determine the specific charge (e/m ratio) of electrons using Thomson's method

Apparatus: CRT with power supply and controls, bar magnets, and magnetometer

Diagram: --

Procedure:

1) Keep the CRT along N-S direction. Keep magnetometer in the central slot of wooden bench. Set pointer of the magnetometer to read 0-0 along the E-W direction (the needle will be resting in N-S direction).
2) Keep a bar magnet at a suitable distance (say 10-15 cm) from the needle in one of the arms of the magnetometer. Note down deflections θ-θ of magnetometer.
3) Take readings by reversing the polarity of magnet and placing the magnet in other arm of the magnetometer.
4) Find average deflection θ. Find tan θ. Calculate magnetic field (B).
5) Replace magnetometer with CRT. Keep magnet at the same distance as in earlier case. First, keep applied voltage to be zero. Note down deflection of the spot on the screen (y).
6) Next, increase the deflection control knob so that the spot come to un-deflected position. Read this value of applied voltage (V).
7) Repeat the procedure with other positions of the bar magnet as before.
8) Find average deflection y and average applied voltage V. Calculate electric field (E).

Observations:

Data given:

Horizontal component of Earth's magnetic field $B_H = 4.2 \times 10^{-5}$ Wb/m^2

Separation between deflection plates d =

Screen distance D =

Length of deflection plates l =

<table>
<tr><td colspan="8">Part I: Measurement of magnetic field (B):
Distance of magnet from CRT =</td></tr>
<tr><td colspan="4">Magnet in Left arm</td><td colspan="4">Magnet in Right arm</td></tr>
<tr><td colspan="2">N facing CRT</td><td colspan="2">S facing CRT</td><td colspan="2">N facing CRT</td><td colspan="2">S facing CRT</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Mean θ =</td><td colspan="4">tan θ =</td></tr>
<tr><td colspan="8">Magnetic field $\mathbf{B = B_H \tan\theta}$ =</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td colspan="8">Part II: Measurement of electric field (E):
(distance of magnet should be same as in part I)</td></tr>
<tr><td colspan="4">Magnet in Left arm</td><td colspan="4">Magnet in Right arm</td></tr>
<tr><td colspan="2">N facing CRT</td><td colspan="2">S facing CRT</td><td colspan="2">N facing CRT</td><td colspan="2">S facing CRT</td></tr>
<tr><td>Y (cm)</td><td>V (volt)</td><td>Y (cm)</td><td>V (volt)</td><td>Y (cm)</td><td>V (volt)</td><td>Y (cm)</td><td>V (volt)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Mean y =</td><td colspan="4">Mean V =</td></tr>
<tr><td colspan="8">Electric field $\mathbf{E = \frac{V}{d}}$ =</td></tr>
</table>

Formula: e/m ratio of electrons $\frac{e}{m} = \frac{y \times E}{D \times l \times B^2}$
y: mean deflection of the spot on screen
E: electric field
D: screen distance
l: Length of deflection plates
B: magnetic field

Graph: --

Calculation: Determine e/m ratio of electrons using the formula given.

Result/s and Conclusion:
e/m ratio (specific charge) of electrons = ____________ C/kg.

Assignment:
Write a code in C-language to estimate the following:

- Problem statement: If the bar magnet is rotated w.r.t. the electron beam direction, re-calculate the corresponding deflections (y) and voltages (V).
- Guidelines: Let φ be the angle between magnetic field due to bar magnet and direction of velocity of electron beam. Magnetic field varies as B sin(φ). (Force will be maximum for φ = 90° and zero for φ = 0°). At maximum force, B = B_{max}. Take B_{max} to be the value of magnetic field determined in the experiment. Deflection of magnetometer is given by $\theta = \tan^{-1}\left[\frac{B\sin(\varphi)}{B_H}\right]$. Assume y and V vary linearly with θ. Calculate y and V by cross-multiplications.
- Input-Output:
  The input should prompt for an array (φ) of length 10.
  The output should print two arrays for y and V both of length 10.

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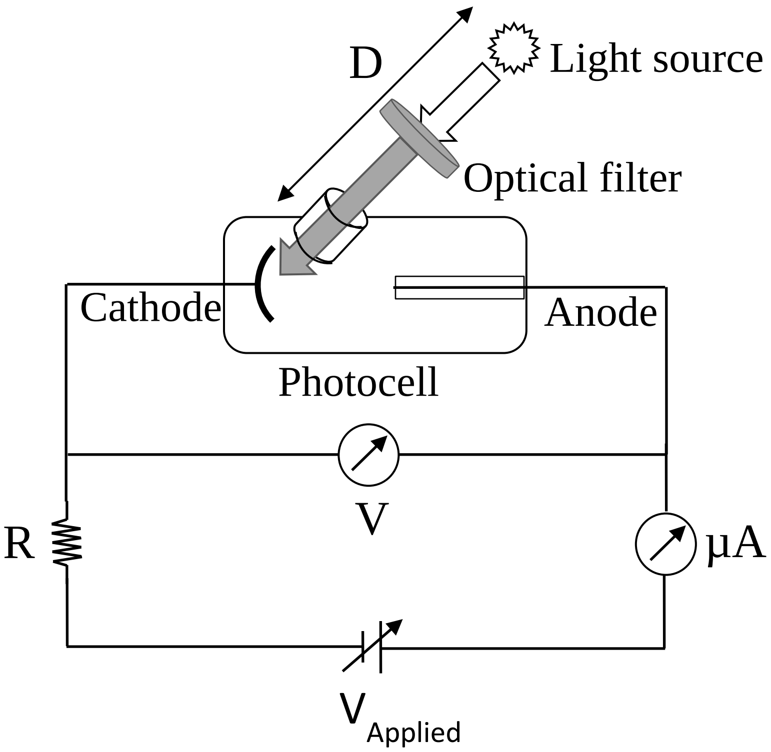
Title of the experiment: Photoelectric Effect

Aim: To analyse dependence of stopping potential on intensity and frequency of incident radiation and hence to determine the Planck's constant, threshold frequency and work function of the material of photocell

Apparatus: Vacuum photocell, voltmeter, ammeter, optical filters, polychromatic light source, scale etc.

Diagram:



Procedure:

1) Keep the lamp host at 4-6 cm from the photocell. Insert filter 1 in the filter slot on IPU. Switch on power supply to photocell and set applied voltage V = 0.
2) Switch on the lamp. Current meter will show some reading. This is photocurrent (i_{ph}) at zero bias due to light of specific frequency (f) transmitted through the optical filter. Adjust filter alignment and lateral position of lamp host to get maximum current reading. Let it stabilize.
3) Now, slowly reduce V to negative bias (retarding potential) and note down the voltage when i_{ph} becomes zero. This voltage is the stopping potential (V_S) for the selected frequency. Set V = 0 after this step.
4) Repeat step 2 and 3 for other filters. While replacing filters, either cover the photocell or switch off the light.
5) For any one filter, repeat steps 2 and 3 for different distance of the lamp from the photocell to check effect of intensity

Observations:

- Constant Intensity (same distance):

Distance kept D =			
Sr. No	Filter No/colour	Frequency f (x 10^{14} Hz) = $\frac{c}{\lambda}$	Stopping Potential V_S (volt)
1			
2			
3			
4			

- Constant frequency (same filter):

Filter selected: Frequency of radiation f =		
Sr. No	Distance D (cm)	Stopping Potential V_S (volt)
1		
2		
3		
4		

Formula: --

Graph: --

Calculation:
Determine X-intercept from the graph as instructed the assignment (below). Multiply X-intercept with slope. This gives work function of the material of photoelectric cell used in the experiment.

Result/s and Conclusion:
Value of Planck's constant (h) = _______________ J-s
Work function (W) = ___________ eV.

Assignment:
Write a code in C-language to plot the following:

- Problem statement: Plot stopping potential v/s frequency and determine Planck's constant.
- Guidelines: Store values of frequency without the power of 10 (e.g. if f = 5.5 x 10^{14} Hz, store only the number 5.5). Select lowest and highest values of both, f and V. Store them as f_1, f_2 and V_1, V_2. Calculate Planck's constant using $h = 16\left(\frac{V_2 - V_1}{f_2 - f_1}\right)$. Print only the numeric value of Planck's constant without the power of 10 (which is around 6.63).
- Input-Output:
  The input should prompt for two variables: f and V. Store the inputs as arrays of length 4 each. The output should plot V as a function of f and print the value of Planck's constant (without factor of 10)

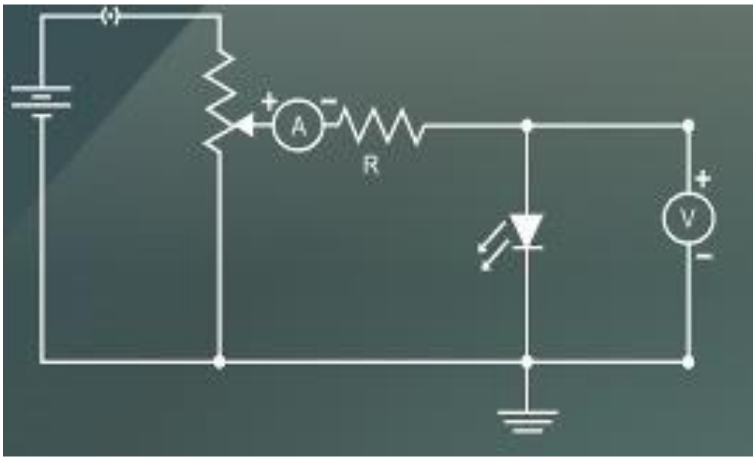
Title of the experiment: Planck's constant

Aim: To determine value of Planck's constant using LEDs of different colours

Apparatus: Power supply, rheostat, milliammeter, voltmeter, 1 K resistor, various LEDs.

url: https://vlab.amrita.edu/?sub=1&brch=195&sim=547&cnt=1

Diagram:



Procedure:

1) Connect the circuit as shown in the diagram. After the connections are completed, click on 'Insert Key' button.
2) Click on the combo box under 'Select LED' button.
3) Click on the 'Rheostat Value' to adjust the value of rheostat.
4) Corresponding voltage across the LED is measured using a voltmeter, which is the knee voltage.
5) Repeat, by changing the LED and note down the corresponding knee voltage.

Observations:

Sr. No.	LED	Wavelength λ (nm)	1/λ (nm^{-1})	V_{th} (volt)
1.	RED			
2.	YELLOW			
3.	GREEN			

Formula: $\mathrm{h} = \mathrm{slope} \times \frac{\mathrm{e}}{\mathrm{c}}$

Slope: slope of line v_{th} v/s 1/ λ

λ: wavelength of light for a particular LED

$e = 1.6 \times 10^{-19}$ C

$c = 3 \times 10^{8}$ m/s

Graph: Plot a graph of threshold voltage (v_{th}) as a function reciprocal of wavelength (1/ λ). Take v_{th} along the Y-axis and 1/ λ along the X-axis. From the points plotted, draw best-fit line. Determine slope of this line. Also mark points corresponding to threshold voltage for IR and Blue LEDs.

Calculation: Determine Planck's constant using the formula given. Find wavelengths of IT and blue LEDs from the marked points.

Result:
Value of Planck's constant (h) = ______________ J-s

Assignment:
Measure threshold voltage for IR and Blue LEDs. Mark points corresponding to threshold voltage on the graph plotted. Find wavelengths of IR and blue LEDs from the marked points.
Wavelength of IR LED = __________ nm
Wavelength of Blue LED = __________ nm

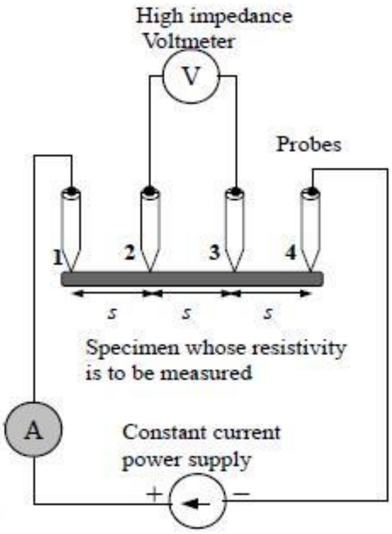
Title of the experiment: Resistivity by 4-Probe Method

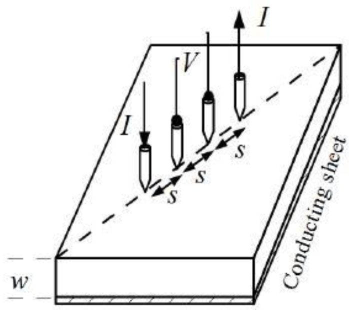
Aim: To analyse temperature dependence of resistivity of a semiconductors by four probe method

Apparatus: Probe arrangement, sample, oven 0-200°C, constant current generator, oven power supply and digital panel meter (measuring voltage and current)

url: https://vlab.amrita.edu/?sub=1&brch=282&sim=1512&cnt=4

Diagram:





Procedure:

1) Select the semiconductor material from the combo box.
2) Select the source current from the slider. Restrict the slider based on the range of current.
3) Select the Range of oven from the combo box. Set the temperature from the slider.
4) Click on the Run Button to start heating the oven in a particular interval, from the default 25°C to the temperature that we set already Click on the Wait button to stop heating.
5) Click on the Set button to display the temperature that we set in the oven.
6) Click on the Measure button to display the present temperature in the oven.
7) Select the range of voltmeter from the combo box. Measure the Voltage using Voltmeter.

Observations:

Material: Germanium

Constant current I = _________ mA

Temperature (T) °C	Temperature (T) K	Voltage (V) mV	Resistivity (ρ) (Ω-m)	In(ρ)	$\frac{1}{T}$ (K^{-1})
25	25+273 = 298				
30					
--					
--					
--					
70					

Formula: $\rho = 2.13 \times 10^{-3} \frac{V}{I}$
ρ: Resistivity (with geometrical factor)
V: Voltage across the sample
I: Current through the sample

Graph: Plot a graph of resistivity (ρ) as a function of temperature (T). Take ρ along the Y-axis and T along the X-axis.

Result: Resistivity of semiconductor at room temperature (ρ) = ________ Ω-m. Resistivity of semiconductor changes ______________ with temperature.

Assignment:
Calculate log of resistivity [ln(ρ)] and inverse temperature (1/T) using values of resistivity calculated at different temperatures
.

Temperature (T) °C	Temperature (T) K	Resistivity (ρ) (Ω-m)	ln(ρ)	$\frac{1}{T}$ (K^{-1})
25	25+273 = 298			
30				
--				
--				
--				
70				

Plot a graph of log of resistivity [ln(ρ)] as a function of inverse temperature (1/T). Take ln(ρ) along the Y-axis and 1/T along the X-axis. For the points plotted, draw best-fit line. Determine slope of this line. Calculate energy band gap of semiconductor using the formula given. Express it in units of eV.

Energy Band Gap $E_g = \kappa \times |\text{slope}|$
|slope|: absolute value of slope of line $\ln \rho$ v/s $\frac{1}{T}$
κ: Boltzmann constant. κ = 1.38 x 10-23 J/K
T: absolute temperature

Energy band gap of semiconductor (E_g) = ________ eV.

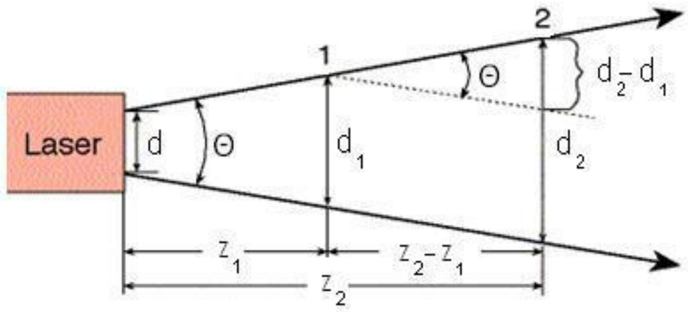
Title of the experiment: Laser Beam Divergence

Aim: To determine divergence of laser beam using photodetector

Apparatus: Laser source, photodetector, micrometer

url: https://vlab.amrita.edu/index.php?sub=1&brch=189&sim=342&cnt=4

Diagram:



Procedure:
1) The **start** button enables the user to start the experiment.
2) From the combo box, select the desired laser source.
3) Then fix a detector distance, say 100 cm, using the slider **Detector distance Z**.
4) The z distance can be varied from 50 cm to 200 cm.
5) For a particular z distance, change the detector distance x, from minimum to maximum intensity, using the slider **Detector distance X**.
6) Note the micrometer distances and the corresponding output currents. The x distances can be read from the zoomed view of the micrometer and the current can be note from the digital display of the output device.
7) Draw the graph and calculate the beam divergence and spot size.

Observations:
Detector distance $\mathbf{Z_1}$ = __________ cm

Sr. No	Screw gauge reading				Detector current I (μA)*
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector distance **X** = M + V (mm)	
1					
2					
--					
--#					
--					
9					

*Write only up to three decimal places
#reading at peak current

Detector distance $\mathbf{Z_2}$ = __________ cm

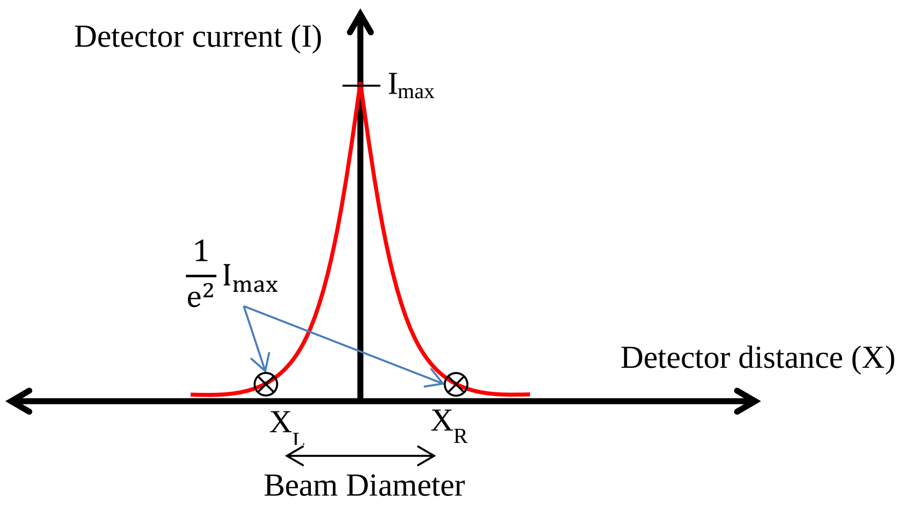
Sr. No	Screw gauge reading				Detector current I (µA)*
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector distance **X** = M + V (mm)	
1					
2					
--					
--#					
--					
9					

*Write only up to three decimal places
#reading at peak current

Formula: $\Phi = \frac{d_1 - d_2}{Z_1 - Z_2}$
Φ: Divergence
Z_1, Z_2: axial/perpendicular distance of detector from laser
d_1, d_2: diameters of laser beam at distance Z_1, Z_2 respectively. Beam diameters are obtained from the graph as given below.

Graph: Plot Intensity/detector current (I) as a function of detector distance X. Take I along Y-axis and X along X-axis.

Calculation: On the I v/s **X** plot, mark points at which intensity/current becomes $\frac{1}{e^2} I_{max}$ as shown in the figure. Take e = 2.718. Find the corresponding **X**-values say X_L and X_R. Difference between these values i.e. X_R-X_L gives beam diameter at the selected detector distance **Z**. Find beam diameter for both values of detector distance i.e. Z_1 and Z_2.



Result: Divergence of laser beam (Φ) = ______________

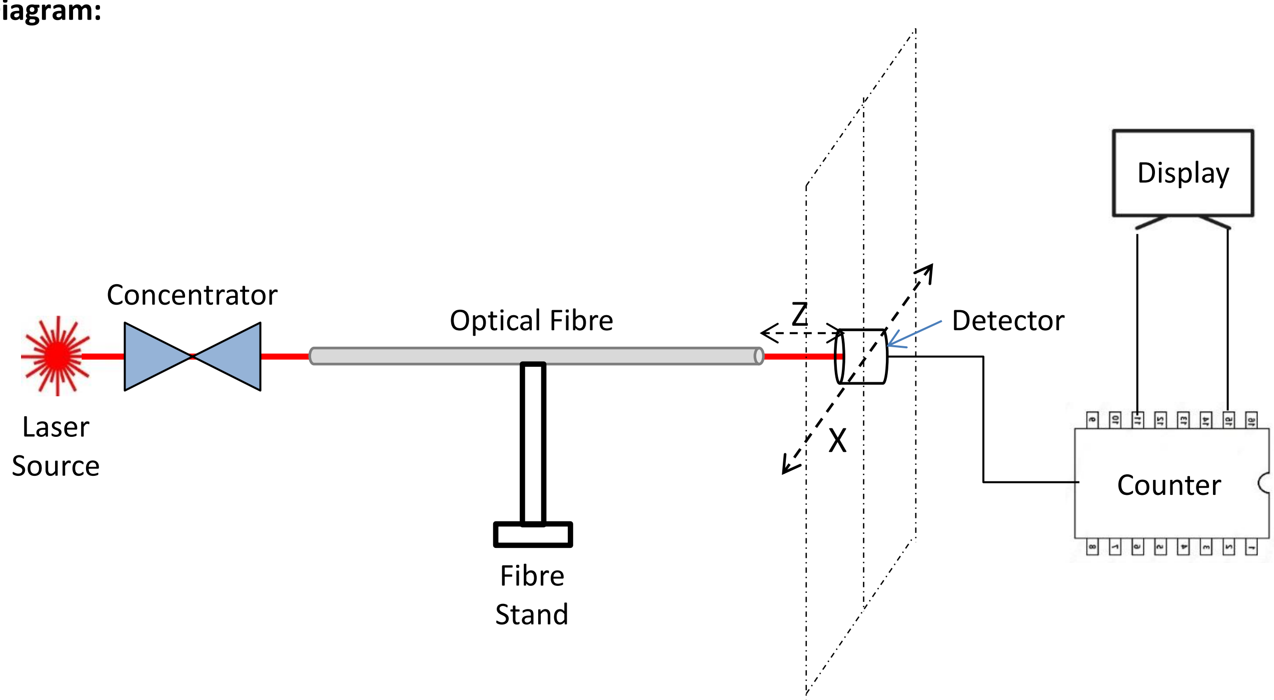
Title of the experiment: Numerical Aperture of Optical Fibre

Aim: To determine Numerical Aperture of an Optical Fibre

Apparatus: Laser source, Concentrator, Optical fibre with fibre stand, photodetector, counter

url: https://vlab.amrita.edu/?sub=1&brch=189&sim=343&cnt=4

Diagram:



Procedure:

1) Drag and drop each apparatus in to the optical table as shown in the figure in "Procedure" section on the virtual lab experiment link given above. Then Click "Start" button.
2) Click "Switch On". (now you can see a spot in the middle of the detector)
3) After that select the Fibre and Laser for performing the experiment from the control options Set the detector distance **Z**.
4) Vary the detector distance **X** by an order of 0.5 mm, using the screw gauge (use up and down arrow on the screw gauge to rotate it).
5) Measure the detector reading from output unit and tabulate it.

Observations:

Detector distance **Z** = ___________ cm

Sr. No	Screw gauge reading				Detector current I (μA)*
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector distance **X** = M + V (mm)	
1					
2					
--					
--#					
--					
9					

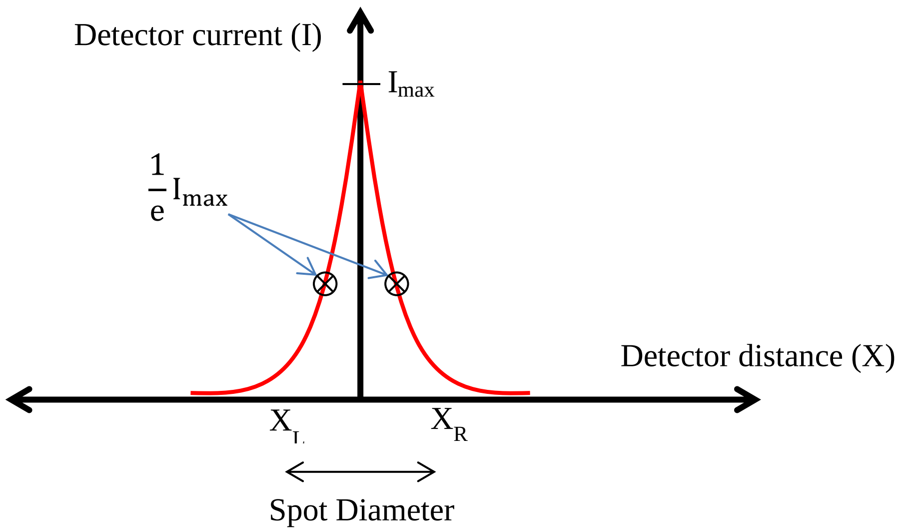
*Write only up to three decimal places
#reading at peak current

Formula: $NA = \frac{r}{\sqrt{r^2+Z^2}}$

NA: Numerical Aperture
r: Radius of spot
d: Distance between fibre and detector

Graph: Plot Intensity/detector current (I) as a function of detector distance X. Take I along Y-axis and X along X-axis.

Calculation: On the I v/s **X** plot, mark points at which intensity/current becomes $\frac{1}{e}I_{max}$ as shown in the figure. Take e = 2.718. Find the corresponding **X**-values say X_L and X_R. Difference between these values i.e. X_R-X_L gives beam diameter at the selected detector distance **Z**. Radius of spot is half of this. Calculate Numerical Aperture using the formula given.



Result: Numerical Aperture of optical fibre (NA) = ________________

Name:
Roll Number:
Batch:
Experiment performed on (date):

Title of the Experiment:

Aim:

Apparatus:

Diagram:

Observations:

Calculations:

Result/s and Conclusion/s: