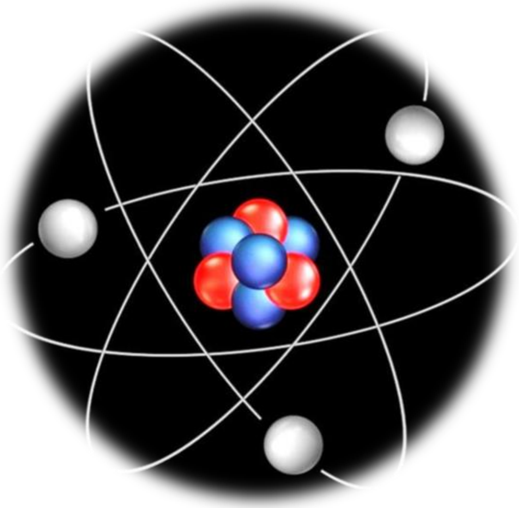
SOMAIYA VIDYAVIHAR UNIVERSITY
K J Somaiya College of Engineering

Department of Science and Humanities
Engineering Physics Laboratory



Laboratory Manual

(As per Revised Curriculum SVU R-2023)

FY B Tech AY 2024-25

SEMESTER I

SET - 1

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
Energy Band Gap	Hands-on

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 13, 14) for each experiment.** 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. Diagrams, observation tables, graphs, calculations etc. should be handwritten. 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

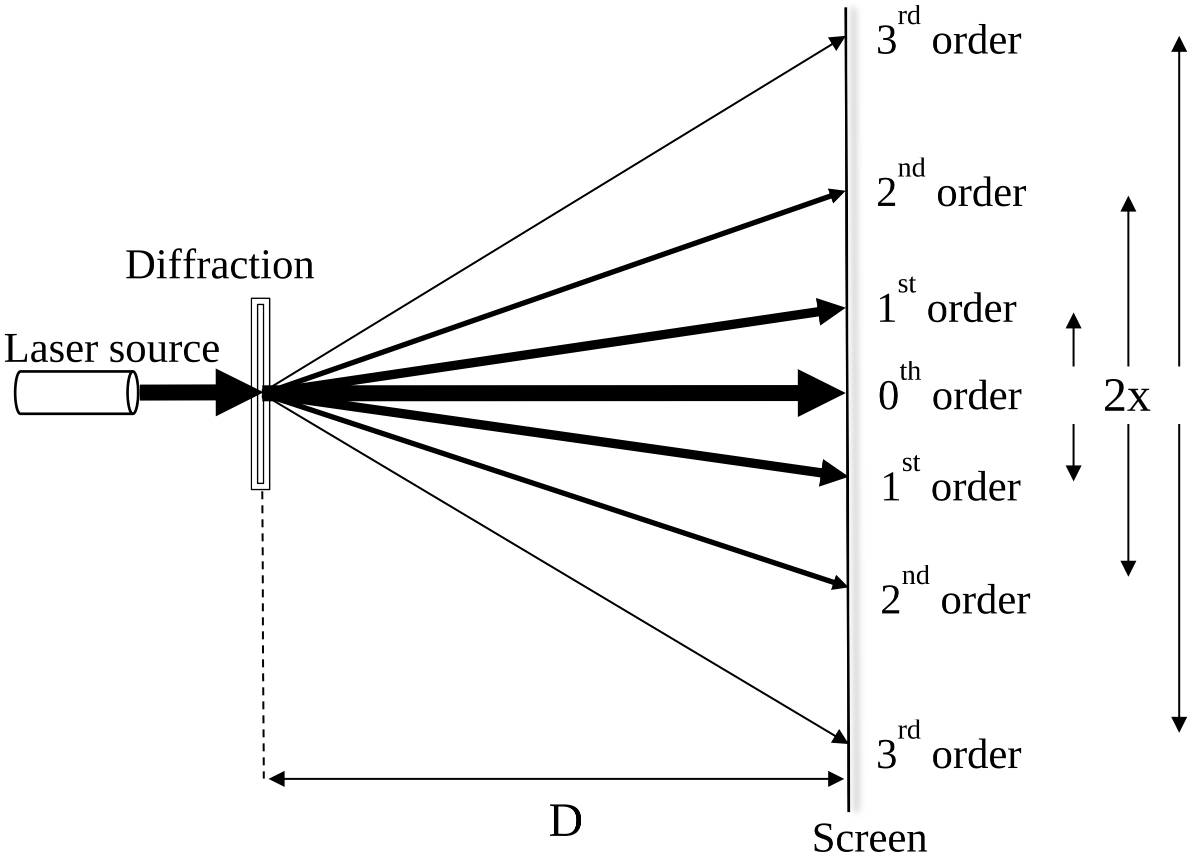
*remaining 20 marks are allotted to Lab quizzes based on experiments performed

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:

Screen distance D = ________ cm grating number: ______				
Order of maxima m	Separation of diffraction maxima from central maximum		Angle of diffraction θ	Sin θ
	2x (cm)	x (cm)		
1				
--				
--				
7				

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:

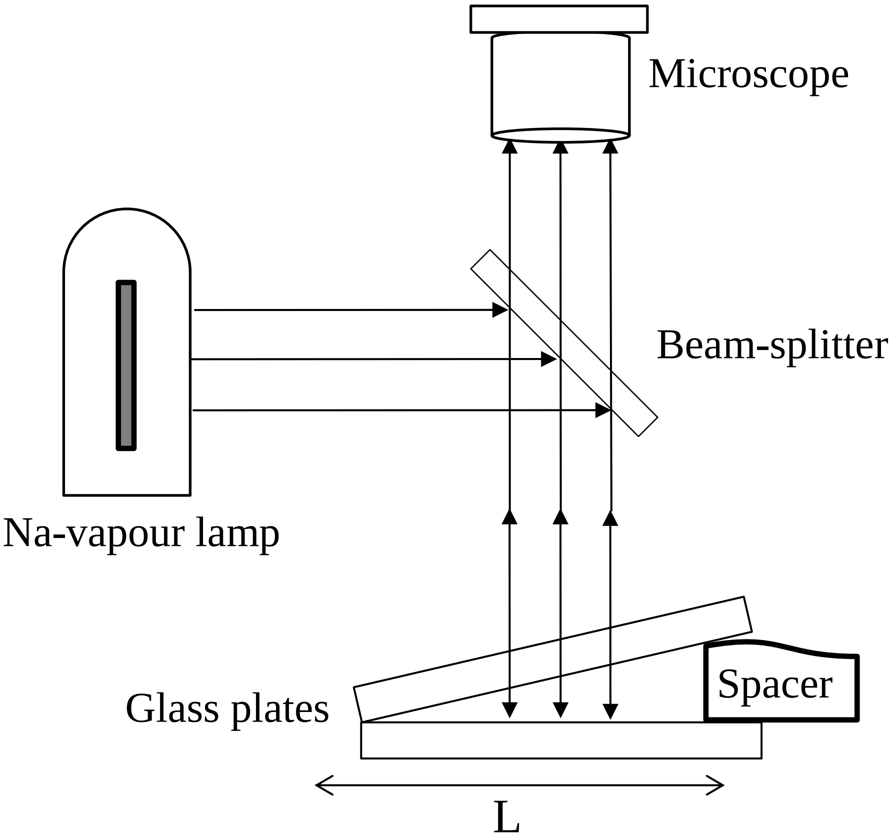
Re-calculate the separations x' for all orders for green laser (wavelength = 532 nm) using $\sin\theta = \mathrm{mN}\lambda$. Use the same screen distance (D) used in the experiment for calculations. Tabulate your answers. Show calculation for any one order in detail.

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 5^{th} dark fringe from the 0^{th} 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 10^{th}, 15^{th}, 20^{th} 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 $\mathrm{d} = \frac{\lambda \mathrm{L}}{2\beta}$.
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

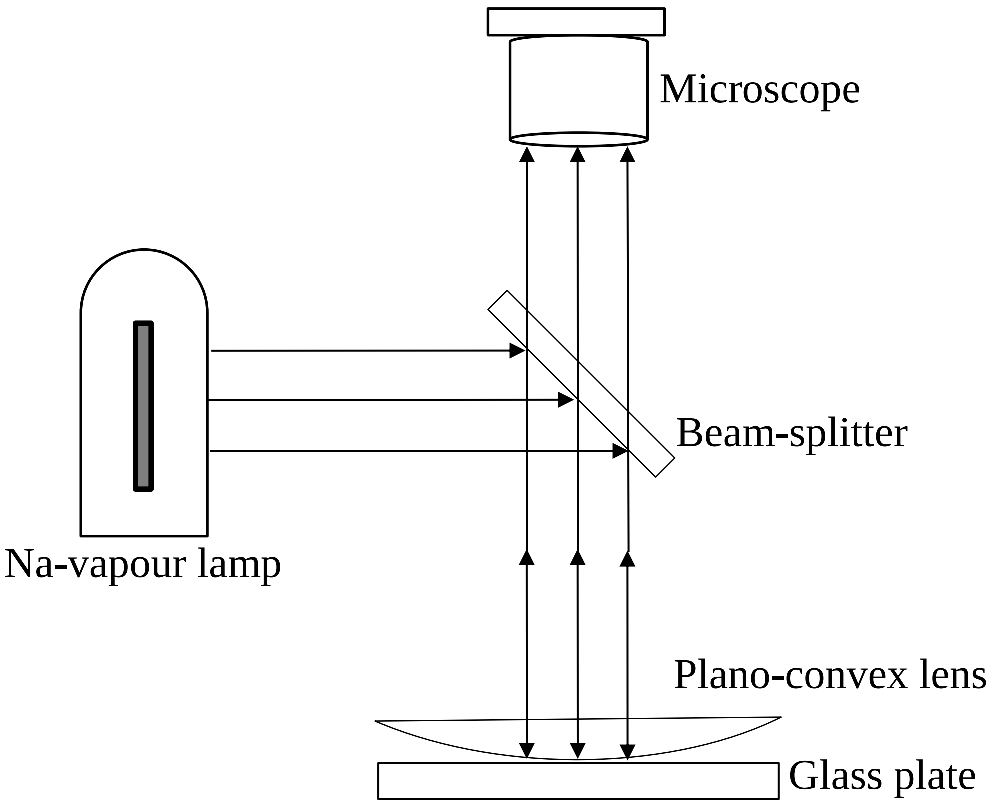
Assignment:
Determine the wedge angle $\theta \approx \frac{\lambda}{2\beta}$. Calculate total number of fringes $\mathrm{N} = \frac{\mathrm{L}}{\beta}$. Now if the wavelength is changed to 540 nm, calculate the wedge angle and number of fringes. (Note: when wavelength changes, fringewidth will also 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 10^{th} 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 8^{th} dark ring. Follow step 2. Continue this procedure for inner dark rings by skipping one dark ring in-between until you complete reading for 2^{nd} 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 2^{nd} 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 10^{th} 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.

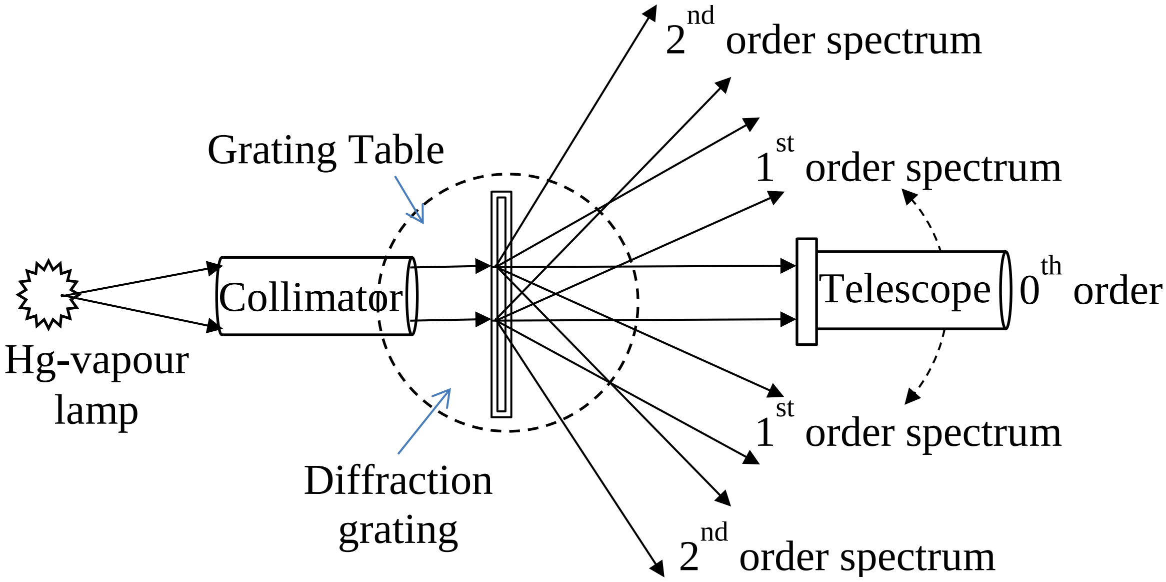
Assignment:
If the entire set-up is immersed in water, diameters of the rings will change. Re-calculate these diameters using the equation: $D_n'^2 = \frac{4n\lambda R}{\mu}$ where, μ is refractive index of water and $D_n'^2$ are diameters of dark rings in water. Tabulate your answers. Plot a graph of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

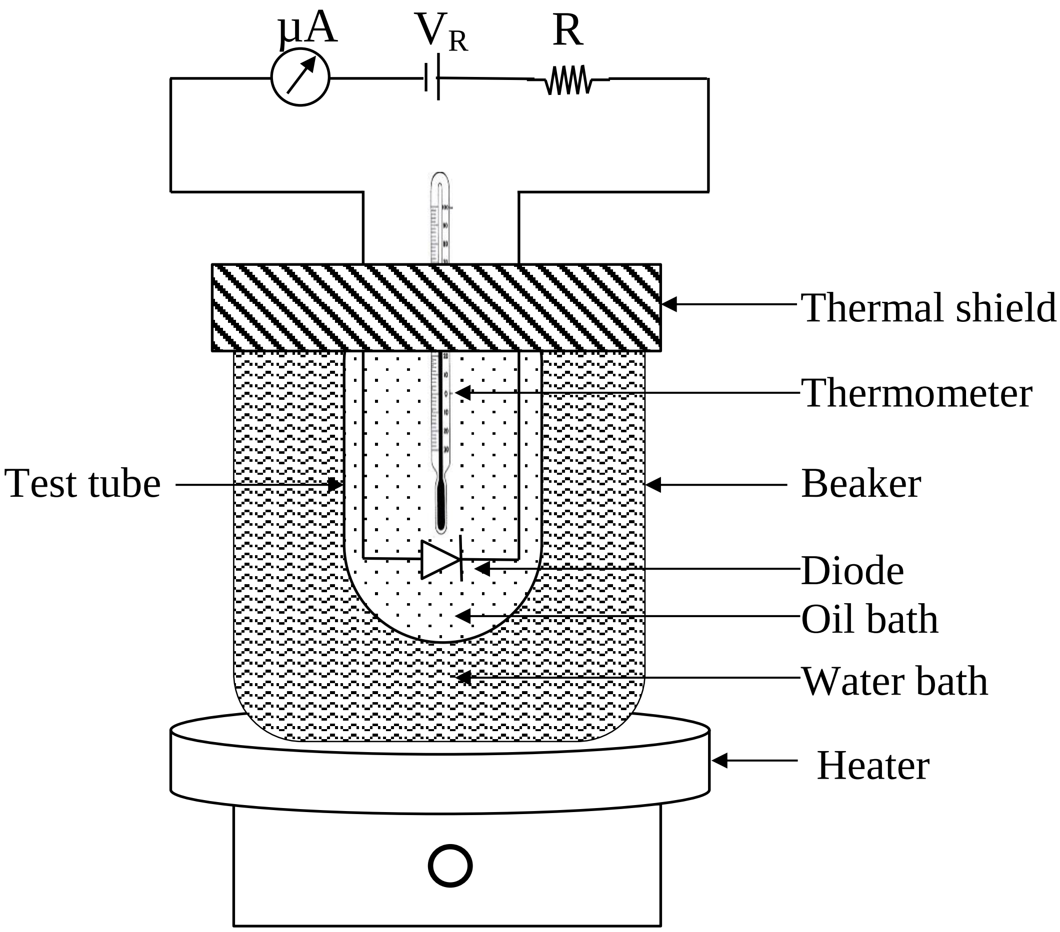
Assignment:
Determine highest order of diffraction maxima possible for all the above spectral lines using $m_{max} = \frac{1}{N\lambda}$. (Note: m_{max} is an integer value. This will be the integer part of the answer and not the rounded-off value). Next, re-calculate the angles of diffraction (θ′) for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

Title of the experiment: 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 = 1.38×10^{-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 4th 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 = 3.16×10^{-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).

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

Title of the Experiment:

Aim:

Apparatus:

Diagram:

Observations:

Calculations:

Result/s and Conclusion/s: