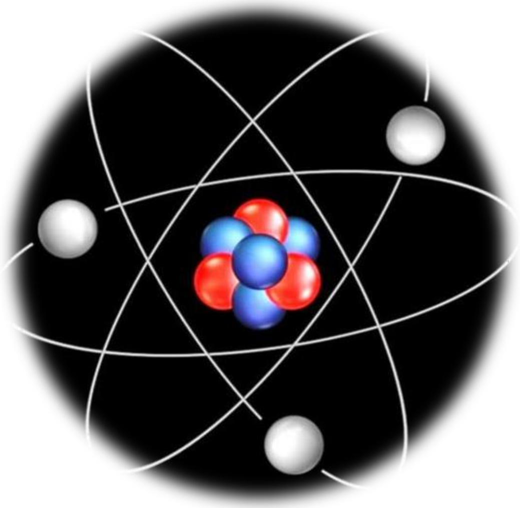
Department of Science and Humanities Applied Science Laboratory



Laboratory Manual

(As per Revised Curriculum SVU R-2025)

FY B Tech AY 2025-26 SEMESTER I

List of Experiments:

Title of the Experiment
Wedge-Shaped Film
Grating Constant
Numerical Aperture
Energy Band Gap
Planck's Constant

Note:

In order to successfully complete the Lab CA in Physics Lab Course (Course code: 316U06L102), students need to perform and prepare a written record of e xperiments.

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, written record of experiment and its verification	20	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
Total	30	Average of all experiments will be considered for grading the journal

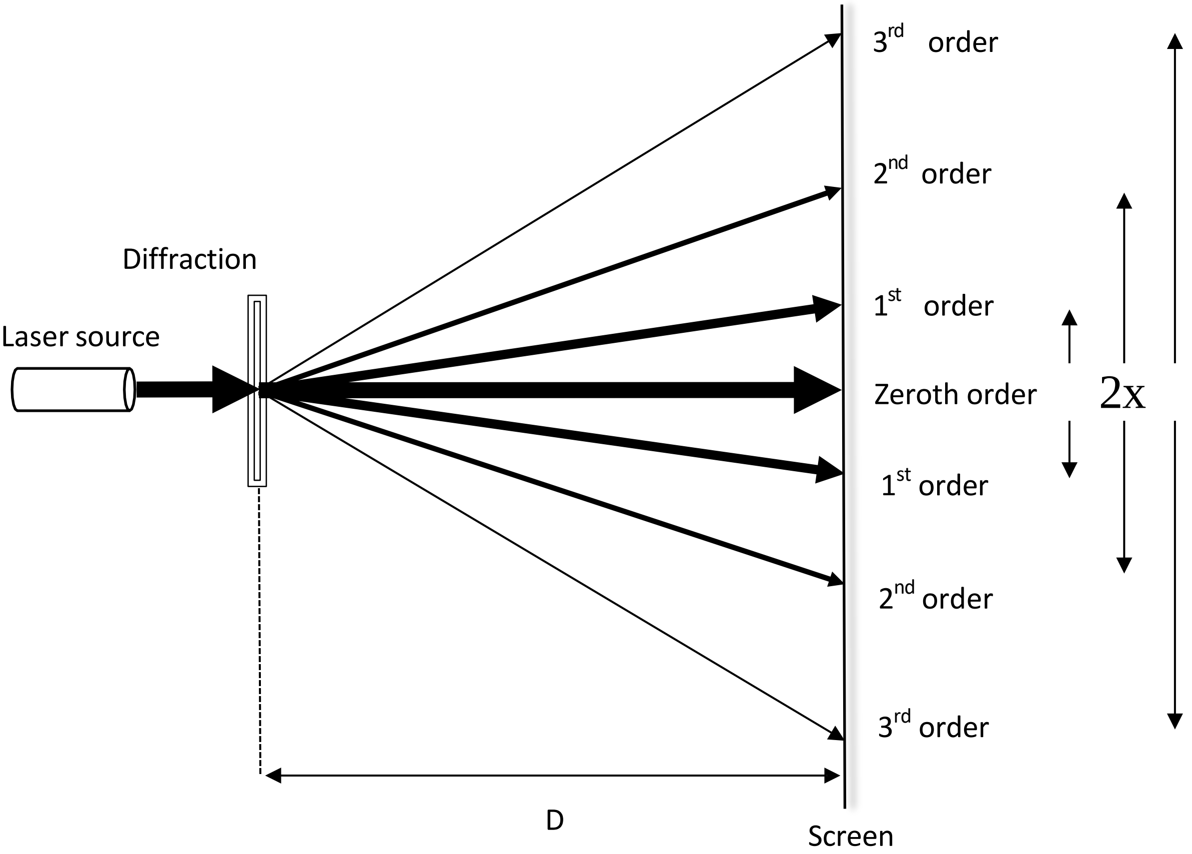
***remaining 20 marks are allotted to Lab quizzes based on experiments performed**

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 meter 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 $\boldsymbol{N} = \frac{\boldsymbol{Slope}}{\boldsymbol{4\lambda}}$

slope: slope of line sin θ v/s m

θ: angle of diffraction maxima , $\boldsymbol{\theta = tan^{-1}\frac{x}{D}}$

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:

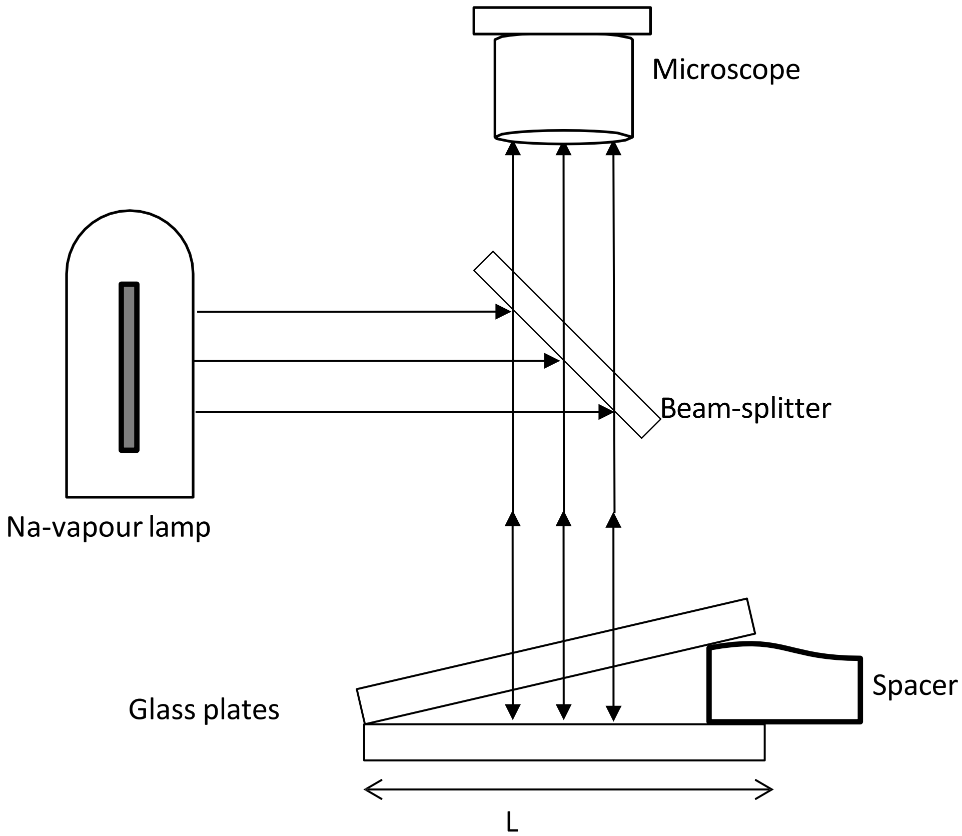
Re-calculate the separations x' for all orders for green laser (wavelength = 532 nm) using sin θ = mNλ. Use the same screen distance (D) used in the experiment for calculations. Tabulate your answers. Show calculation for any one order in detail.

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 $\boldsymbol{d = \frac{\lambda L}{2\beta}}$

λ: wavelength of light from Na-vapor lamp = 589 nm L: length of glass plates = 4 cm

β: Fringe width (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 fringe width of interference pattern. Calculate spacer thickness using the formula given.

Result/s and Conclusion:

Thickness of spacer $\boldsymbol{d}$ = ___________cm

Assignment:

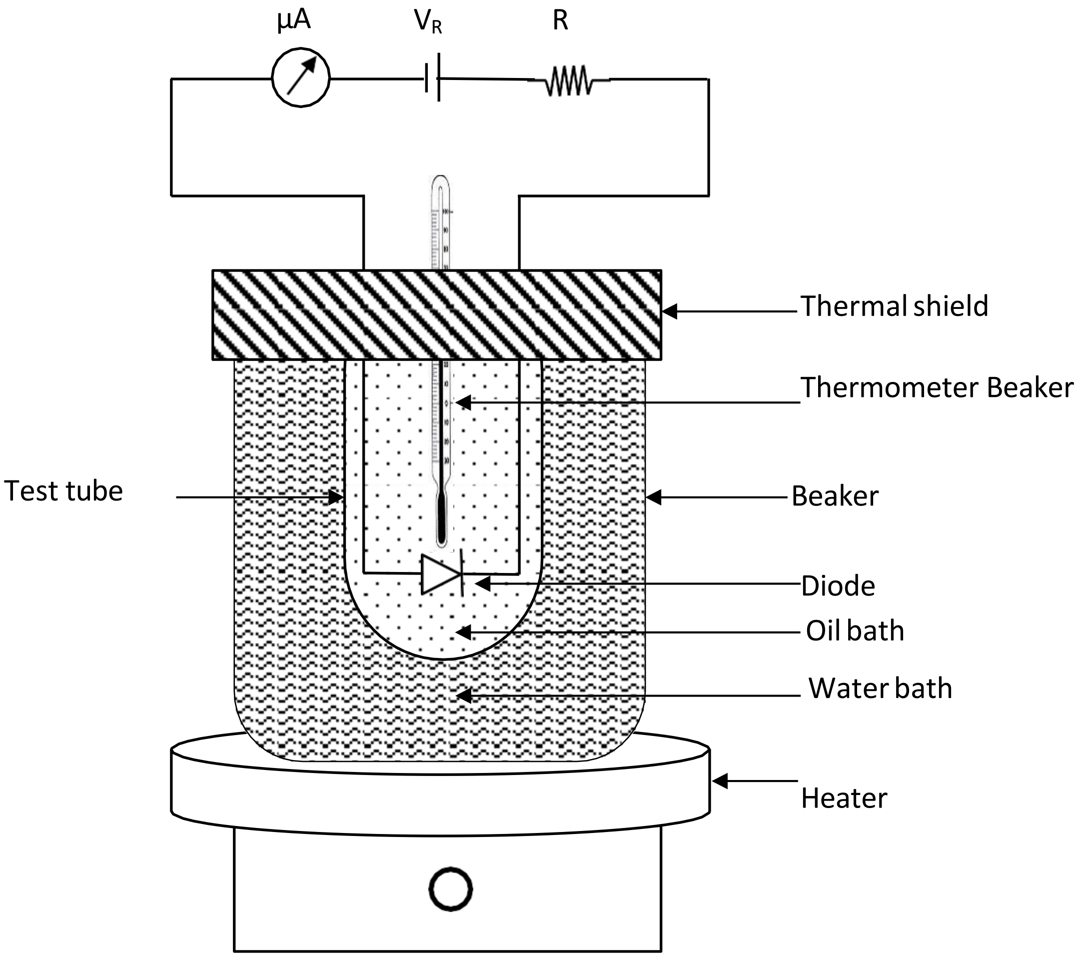
Determine the wedge angle $\boldsymbol{\theta \approx \frac{\lambda}{2\beta}}$ Calculate total number of fringes $\boldsymbol{N = \frac{L}{\beta}}$ Now if the Wavelength is changed to 540 nm, calculate the wedge angle and number of fringes. (Note: when wavelength changes, fringe width will also change)

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)		Reverse current I_S (amp)	1/T (K^{-1})	$\ln(\frac{I_s}{T^2})$
	°C	kelvin			
1	RT				
2	40				
--	--				
--	--				
--	--				
8	70				

Formula: Energy Band Gap E_g = κ × |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 $\boldsymbol{ln\frac{I_s}{T^2}}$ as a function of $\boldsymbol{\frac{1}{T}}$. 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.

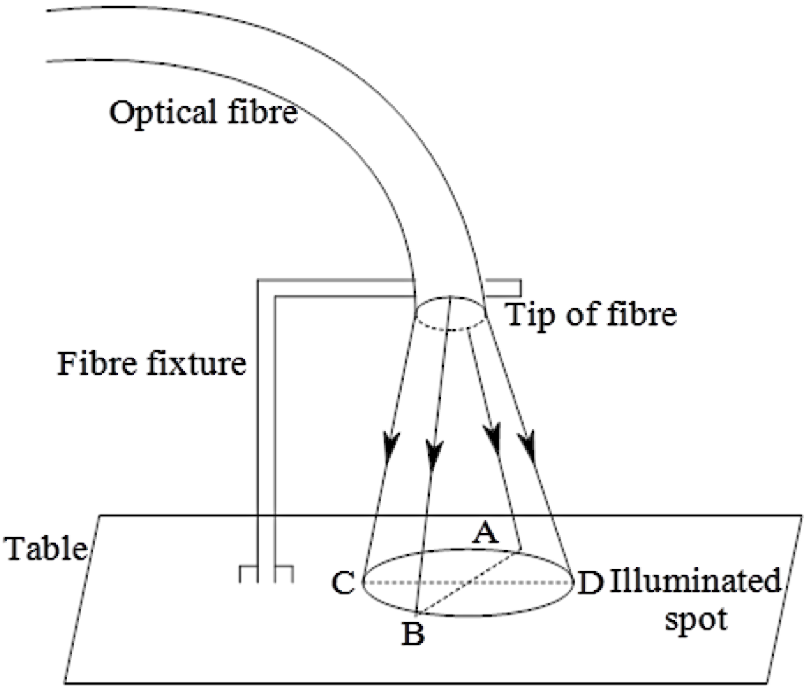
Assignment:
1. Why paraffin oil bath is used for heating not water bath during the experiment.
2. In above experiment, explain the process if the diode is kept under forward bias condition.

Title of the experiment: Numerical Aperture

Aim: To determine Numerical Aperture (NA) of given optical fibre

Apparatus: Optical fibre transmitter kit with 660 nm LED output (red light), 1 mm diameter plastic optical fibre, fibre fixture.

Diagram:



AB & CD: cross diameters

Procedure:

1) Select the digital/analogue switch of transmitter kit for digital Transmission. Connect one end of the fibre (coupler end) to the LED output (at 660 nm). Insert other end of the fibre (open end) into the fibre fixture as shown in the diagram. Adjust the fibre such that its tip is 10 mm from the screen below.
2) Now observe the illuminated circular spot of light on the screen. Measure the diameter of the illuminated circular spot in two perpendicular directions. Calculate mean radius.
3) Measure the distance between the tip of the fibre and the screen accurately.

4) Calculate NA using given formula. Repeat it for different distances by moving tip of the fibre.

Observations:

Sr. No.	Dist of fibre *l* (cm)	Dimensions of the illuminated spot (cm)			NA
		d_1	d_2	R	
1					
2					
3					
				Average NA =	

Formulae:

$$\mathrm{NA} = \frac{\mathrm{r}}{\sqrt{\mathrm{r}^2 + l^2}} \quad \& \quad \theta_{max} = \sin^{-1}(\mathrm{NA})$$

Symbols:
NA: Numerical Aperture
r: Radius of illuminated spot
l: Distance of fibre tip from screen
θ_{max}: Maximum acceptance angle

Results & Conclusion:
1) NA of given optical fibre is ___________

2) Acceptance angle θ_{max} = ___________

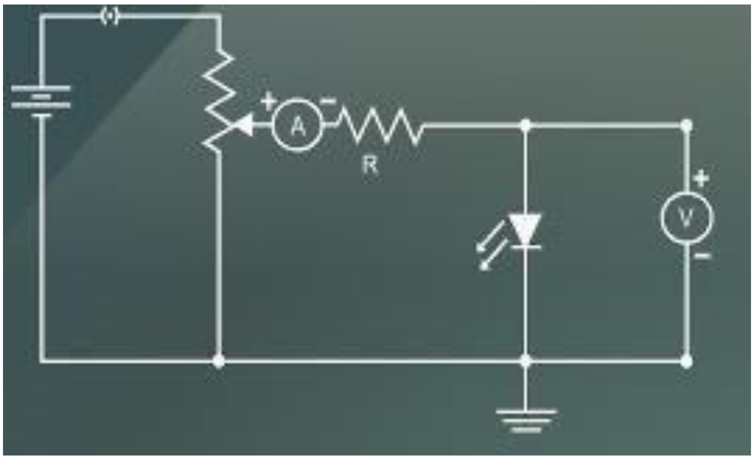
Assignment:
1. Explain how the refractive indices of the core and cladding in an optical fiber affect its numerical aperture and acceptance angle.
2. In an optical fibre the refractive indices of core and cladding are 1.46 and 1.44 respectively. Find the angle of acceptance of the optical fibre. If the entire set up is kept in water of refractive index 1.33, discuss what will happen to numerical aperture and acceptance angle.

Title of the experiment: Planck's constant

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

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)	$1/\lambda$ (nm^{-1})	V_{th} (volt)
1.	RED			
2.	YELLOW			
3.	GREEN			
4	BLUE			

	IR			

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

Slope: slope of line V_{th} v/s 1/ λ
λ: wavelength of light for a particular
LED: charge '*e*' = 1.6×10^{-19} C
c = 3×10^{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 IR and blue LEDs from the marked points.

Result:

Value of Planck's constant (h) = _______________Js

Assignment:

Measure the 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

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

Title of the Experiment: Aim:

Apparatus:

Diagram:

Observations:

Calculations:

Result/s and Conclusion/s: