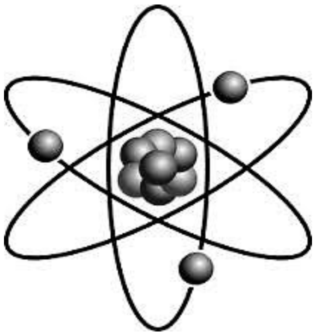
Laboratory Write-up

Engineering Physics (**116U06C102**)



F. Y. B. Tech.

SEMESTER I 2022-23

Expt. No		Planck’s constant	Date:	
Batch:		Roll No:		
			(Marks & Signature of Faculty I/c)	

Aim:	Determination of Planck’s constant
Apparatus:	0-10 V power supply, a one way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1 K resistor and different known wavelength LED’s (Light-Emitting Diodes).

Diagram:

Observation Table:

LED: Red **Wavelength:**		**LED: Yellow** **Wavelength:**		**LED: Green** **Wavelength:**	
Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)
	0		0		0
V_{th} =		V_{th} =		V_{th} =	
4		4		4	

V_{th}: Threshold voltage/knee voltage

Sr. No.	Wavelength λ (nm)	$1/\lambda$ (nm^{-1})	V_{th} (volt)
1.			
2.			
3.			

Graphs:

1. Plot voltage (X-axis) v/s current (Y-axis) for different three LEDs: Red, Yellow and Green on the same graph paper
2. Plot threshold voltage (X-axis) v/s reciprocal of wavelength (Y-axis)

Calculation:

Determine slope of the graph #2 above. Calculate Planck's constant using:

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

Where

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

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

- **Home Assignment**: Perform similar steps for either Blue or IR LED. Determine wavelength of this LED (Blue or IR) using $\lambda = \frac{\text{slope}}{V_{th}}$. Use slope as calculated above (graph #2). Take V_{th} of the corresponding LED (Blue or IR)

Expt. No		**Numerical Aperture**		**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)	

Aim:	To find the numerical aperture of a given optic fibre and hence to find its acceptance angle.
Apparatus:	Simulator

Diagram:

Observation Table:

LC of screw gauge = 0.01 mm

Type of optical fibre: _______________

Light used: ______________

Detector axial distance from the fibre (Z) = 2 mm

Sr. No	Screw gauge reading				Detector current (μA)
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector lateral distance (X) = M + V (mm)	
1					
2					
3					
4					
5					
6*					
7					
8					
9					
10					
11					

*This should be reading corresponding to peak current

Graph:
Plot detector lateral distance X (on X-axis) v/s detector current (on Y-axis) for both the values of detector axial distance (Z) on the same graph paper

Calculation:

A. Determination of spot radius:
   1. Find $\frac{1}{\sqrt{2}}$ value of the peak detector current (I_P) = $\frac{I_P}{0.71}$
   2. These will be two values about the peak value (I_P) as show in the diagram
   3. Find the corresponding detector lateral distance values say X_1 and X_2
   4. Spot radius (r) is calculated as $r = \frac{X_2 - X_1}{2}$

B. Determination of numerical aperture (NA):

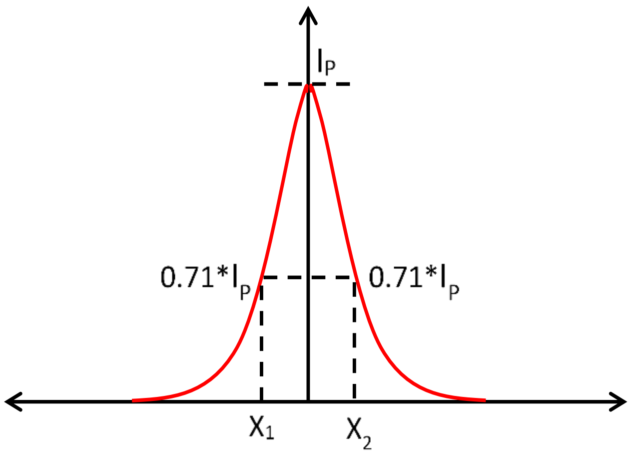
$$NA = \frac{r}{\sqrt{r^2 + Z^2}}$$

C. Determine acceptance angle (θ):

$$\theta = \sin^{-1} NA$$

Result:
Numerical Aperture of the optical fibre NA = __________

Acceptance angle θ = __________



Home Assignment:
Determine NA using light of different colour for any Z=2 mm. Hence conclude whether NA is dependent or independent on the wavelength of light used.

Observation table for home assignment:

Type of optical fibre: _______________
Light used: _______________

Detector axial distance from the fibre (Z) = 4 mm

Sr. No	Screw gauge reading				Detector current (μA)
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector lateral distance (X) = M + V (mm)	
1					
2					
3					
4					
5					
6*					I_P =
7					
8					
9					
10					
11					

*This should be reading corresponding to peak current

Result:

Numerical Aperture of the optical fibre NA = __________

Acceptance angle θ = __________

Conclusion:

Expt. No		**Four probe method**	**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)

Aim:	To determine the resistivity of 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)

Diagram:

Observation Table:

Material: Germanium/Silicon

Constant current = ___________ mA

Temperature (T) K	Voltage (V) mV	Current (I) mA	Resistivity* (ρ) (Ω-m)	In(ρ)	$\frac{1}{T}$ (K^{-1})
298 (RT)					

*With geometric correction

Formula: resistivity (with geometrical correction factor) at a given temperature (T)
$\rho = 2.13 \times 10^{-3} \frac{V}{I}$

Result:

Conclusion:

Home Assignment:

Plot a graph of ln(ρ) (Y-axis) v/s 1/T (X-axis). Determine its slope. Calculate energy band gap using the formula: $E_g = 2k \times$ slope; where k is Boltzmann constant = 8.62 x 10^{-5} eV/K.

Result:
Energy band gap of Ge/Si = ___________ eV.

Expt. No		**Laser Beam Divergence**		**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)	

Aim:	To calculate the beam divergence and spot size of the given laser beam.
Apparatus:	Simulator on Virtual lab

Diagram:

Procedure:

1. Arrange the laser and detector in an optical bench arrangement. The laser is switched on and is made to incident on the photodiode.

2. Fix the distance, z between the detector and the laser source. By adjusting the micrometer of the detector, move the spot in the horizontal direction, from left to right. Note the output current for each distance, x from the measuring device. Then the beam profile is plotted with the micrometer distance along the X-axis and intensity of current along Y-axis. We will get a gaussian curve
3. The experiment is repeated for different detector distances. Note the points in the graph where the intensity equals $1/e^2$ of the maximum intensity, say it as $I_.$
4. Find the micrometer distance across the beam corresponding to these points of the curve for a pair of detector distances z_1 and z_2. Half of this distance is noted as $w_1$and w_2.Then the divergence and spot size of the laser beam can be calculated from the equations.

Observation and calculation:

To find the Least Count of Screw gauge
One pitchscale division (n) = ... mm
Number of divisions on head scale (m) = ...
Least Count (L.C) = n/m = ...

Detector axial distance from the fibre (Z) =

Sr. No	Screw gauge reading				Detector current (μA)
	Main scale reading M (mm)	Matching division of circular scale (D)	Vernier reading V = D x LC (mm)	detector lateral distance (X) = M + V (mm)	
1					
2					
3					
4					
5					
6*					
7					
8					
9					
10					
11					

*This should be reading corresponding to peak current

$1/e^2$ of maximum intensity,Ie =................ mA
Diameter of the beam corresponds to $I_{e,}$ d_1= ....mm

Detector axial distance from the fibre (Z) =

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 lateral distance X = M + V (mm)	
1					
2					
3					

4					
5					
6*					I_P =
7					
8					
9					
10					
11					

$1/e^2$ of maximum intensity,Ie =................ mA
Diameter of the beam corresponds to I_e, d_2= ....mm
Divergence angle (Θ) = $(d_2-d_1)/(z_2-z_1)$ = ... mrad

Result:

Conclusion:

Home Assignment:

Prove inverse square law for intensity corresponding to the peak current value.

Expt. No		**Hall Effect**	**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)

Aim:	To determine carrier concentration and mobility of charge carriers in the given semiconductor sample by using Hall Effect
Apparatus:	Electromagnet, power supply for electromagnet, current source, voltmeter, ammeter, Hall probe

Diagram:

Procedure:

1) Connect electromagnet to its power supply. Connect hall probe into probe socket. Keep magnet current and probe current knobs in middle 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 –100 mA to +100 mA in equal steps and note Hall voltage (V_H). Repeat for I_P varied in reverse order.
5) Now set I_P to +100 mA. Vary I_M from -200 mA to +200 mA in equal steps and note Hall voltage (V_H). Repeat for I_M varied in reverse order.

Observations:

Part I: I_M = +200 mA

Sr. No	I_P (mA)	V_H (mV)				
		Observed	*Corrected	Observed	*Corrected	Average Corrected
		For I_P from -100 to +100 mA		For I_P from +100 to -100 mA		
1	-100					
2	-75					
3	-50					
4	-25					
5	0					
6	+25					
7	+50					
8	+75					
9	+100					

Part II: I_P = +100 mA

Sr. No	I_M (mA)	B (gauss)	V_H (mV)				
			Observed	*Corrected	Observed	*Corrected	Average Corrected
			For I_M from -200 to +200 mA		For I_M from +200 to -200 mA		
1	-200						
2	-150						
3	-100						
4	-50						
5	0						
6	+50						
7	+100						
8	+150						
9	+200						

* Refer to Lab sheet

Formulae:	**Symbols:**

Data:

Elementary charge q	
Thickness of sample t	
Resistivity of sample ρ	

Slope:

Plot of V_H (corrected) vs I_P	
Plot of V_H (corrected) vs. B	

Calculations:

Results:

Carrier concentration (n) of the sample: ____________

Mobility (μ) of charge carriers: ____________

Home Assignment:

Change the orientation of the sample with respect to the magnet (30°, 45°, 180° etc.) and note the change in the hall voltage.

Expt. No		**Photoelectric Effect**		**Date:**	
Batch:		**Roll No:**			
				(Marks & Signature of Faculty I/c)	

Aim:	To analyse dependence of photocurrent and stopping potential on intensity and frequency of incident radiation and hence to determine the value of Planck's constant
Apparatus:	Vacuum tube photocell, voltmeter, ammeter, optical filters, polychromatic light source, scale etc.

Diagram:

Procedure:

1) Keep the lamp host at 6 cm from the integrated photocell unit (IPU). Insert filter 1 in the filter slot on IPU. Switch on IPU and set applied voltage V = 0 by adjusting the knob.
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 increase V to +4 volt and note down i_{ph}. Do not exceed 4 volt.
4) Reduce V towards zero slowly as per the steps given in observation table and note down i_{ph}. Reduce V further to negative values in small steps (say 0.1 volt) and note down i_{ph} until it becomes zero. The negative voltage at which, i_{ph} becomes zero is the stopping potential at incident frequency. Set V = 0 again after this step.
5) By keeping the filter in its position, increase distance between the lamp host and IPU to 8 cm and repeat steps 2 to 4.
6) Cover photocell with a cover plate or switch off the lamp and replace filter 1 by filter 2. Repeat steps 2 to 4.
7) Repeat same procedure with filter 3.

Observations: Part I: Filter 1:

Distance D = 6 cm

Sr. No	1	2	3	4	5	6	7	8	9	10	11	12
V (volt)	+4	+3	+2	+1	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	
i_{ph} (μA)												0

Distance D = 8 cm,

Sr. No	1	2	3	4	5	6	7	8	9	10	11	12
V (volt)	+4	+3	+2	+1	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	
i_{ph} (μA)												0

Observations: Part II:

Filter 1, Wavelength λ_1 = ________, Distance D_1 = _________

Sr. No	1	2	3	4	5	6	7	8	9	10	11	12
V (volt)	+4	+3	+2	+1	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	
i_{ph} (μA)												0

Filter 2, Wavelength λ_2 = ________, Distance D_1 = _________

Sr. No	1	2	3	4	5	6	7	8	9	10	11	-
V (volt)	+4	+3	+2	+1	0	-0.1	-0.2	-0.3	-0.4	-0.5		-
i_{ph} (μA)											0	-

Filter 3, Wavelength λ_3 = ________, Distance D_3 = _________

Sr. No	1	2	3	4	5	6	7	8	9	10	11	12
V (volt)	+4	+3	+2	+1	0	-0.1	-0.2	-0.3	-0.4		-	-
i_{ph} (μA)										0	-	-

Home Assignment:
Plot a graph of (V_s) on Y-axis vs. frequency f on X-axis to calculate the value of planck's constant.

$h = q \times slope.$

Expt. No		**Newton's Rings**		**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)	

Aim:	To determine radius of curvature of plano-convex lens
Apparatus:	Newton's rings set-up (glass plate, plano-convex lens, beam-splitter, black box), monochromatic source (Na-vapour lamp), 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 12^{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 10^{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 12^{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:

L. C. of Travelling Microscope: __________

Sr. No	n	Micrometer reading (cm)						D_n (cm)	*D_n^2 (cm^2) x 10^{-2}
		L (on left)			R (on right)				
		MSR	VR	TR_L	MSR	VR	TR_R		
1	12								
2	10								
3	8								
4	6								
5	4								
6	2								

*Write values after taking 10^{-2} factor common.

MSR: Main Scale Reading, VSR: Vernier Reading, TR: Total Reading

Formula:	**Symbols:**

Data:

Wavelength of light λ	

Slope:

Plot of D_n^2 vs n	

Calculations:

Results:
Radius of curvature of lens: ____________

Home assignment:
Determination of refractive index of liquids using Newton's rings experiment from the virtual lab.

Expt. No		**Hg-Spectrum**		**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)	

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

L. C. of Spectrometer: ___________

Spectral line	Spectrometer reading						θ
	On left side of collimator			On right side of collimator			
	Window 1			Window 1			
	MSR	VSR	TR_L	MSR	VSR	TR_R	
Violet/Blue							
Green							
Yellow							
Red							

Formula:	**Symbols:**

Data:

Number of lines/unit length of the grating N	

Calculations:

Result:
Wavelengths of spectral lines (in Å) from Hg-source:
(Round-off to nearest integer value)

1) Violet/Blue: __________

2) Green: __________

3) Yellow: __________

4) Red: __________

Home assignment:
Observe the 2nd order spectrum and calculate the wavelength of either of the spectral line that appears bright. (For calculation substitute n=2)

Expt. No		**Grating Constant**		**Date:**	
Batch:		**Roll No:**		(Marks & Signature of Faculty I/c)	

Aim:	To determine the number of lines per unit length of the given plane transmission diffraction gratings
Apparatus:	Different diffraction gratings, laser source, screen, 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 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.
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.
5) Repeat steps 2 to 4 for other diffraction gratings.

Observations:

Grating 1: Distance D_1 =					
n	2*x* (cm)	*x* (cm)	θ	(a + b) (cm)	#N (cm^{-1})
1					
2					
3					
Grating 1: Distance D_2 =					
1					
2					
3					
Grating 2: Distance D_1 =					
1					
2					
3					
Grating 2: Distance D_2 =					
1					
2					
3					

#Round-off to nearest integer

Formulae:	**Symbols:**

Data:

Wavelength of light from laser source λ	

Calculations:

Results:

Average N for Grating 1: ___________

Average N for Grating 2: ___________

Home assignment: Use a green/blue laser light and perform the experiment for n=1for any one grating used above.