Global Academy of Technology, Bengaluru–98
Department of Physics

Applied Physics for CSE Stream (Integrated) Laboratory Manual (23PHY12A)

EDITION 2023

For the First Semester B.E

Name :____

Semester : ____________ Section: __________Batch No. ______________

Roll No.:____________________ USN: _________________________

Faculty In-charge: _________________________

Prepared by :

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Approved by :
Dr N V Raju, Professor, HOD Department of Physics

GLOBAL ACADEMY OF TECHNOLOGY

Rajarajeshwari Nagar, Bengaluru – 560 098

LABORATORY CERTIFICATE

This is to certify that Mr / Ms ……………………………………

bearing USN ………………… …………of the department of

………………………………………………………………

has satisfactorily completed the course of Experiments in

…………………………………………… laboratory of this

college in the year …………………

Signature of the Teacher in charge

Marks	
Maximum	Obtained

Signature of the HOD

Date:

GLOBAL ACADEMY OF TECHNOLOGY

VISION

Become a premier institution imparting quality education in engineering and management to meet the changing needs of society.

MISSION

- **Create environment conducive for continuous learning through quality teaching and learning processes supported by modern infrastructure.**
- **Promote Research and Innovation through collaboration with industries.**
- **Inculcate ethical values and environmental consciousness through holistic education programs.**

DEPARTMENT OF SCIENCE & HUMANITIES

VISION

To be an education provider in science and humanities with emphasis on excellence in academic and research for the benefit of society.

MISSION

- **Impart fundamental knowledge in science for understanding advancement in engineering and technology.**
- **Provide students with linguistic competence in chosen language and improve communication skills for personal and professional purpose.**
- **Develop intellectual atmosphere in science and humanities for professional development.**
- **To inculcate human values and professional ethics among students for building healthier society.**

GLOBAL ACADEMY OF TECHNOLOGY
PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complexengineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modernengineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assesssocietal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutionsin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms ofthe engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineeringcommunity and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of theengineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.

Course Details

Course Name: Applied Physics for CSE Stream (Integrated)

Course Code: 23PHY12A

Course outcome

Upon successful completion of this course, students should be able to:

Subject code: 23PHY12A	**Subject: APPLIED PHYSICS FOR CSE STREAM (INTEGRATED)**	
COs	**COURSE OUTCOMES**	**CL**
CO1	Apply the concepts of LASERs and optical and their applications.	
CO2	Interpret the concepts of quantum mechanics & utilize in electrical properties of materials and quantum computing.	
CO3	Illustrate the steps involved in the working of semiconducting devices.	

Applied Physics for CSE Stream (Integrated)

Course Code	23PHY12A		
Practicalhours/week	2	CIE Marks	50

Sl. No	Title of the Experiment
1	Estimation of Fermi energy of a copper
2	Determination of the wavelength of light emitted by LED’s
3	Determine acceptance angle and numerical aperture of an optical fiber
4	Study Series and parallel LCR resonance
5	Determination of spring constants in Series and Parallel combination
6	Estimation of Energy gap of a semiconductor
7	Calculation of dielectric constant by RC charging and Discharging
8	Photo Diode Characteristics
9	Determine wavelength of semiconductor laser using LASER diffraction
10	Determine the rigidity modulus of a wire using torsional pendulum

Scheme of Evaluation for lab internals

The student has to perform TWO experiments during the practical test. The scheme of valuation shall be as follows:

Description	Marks for First experiment	Marks for second experiment
Write up : Formula, circuit diagram / ray diagram, tabular column, model graph and result statement.	2+2+2+2+2	2+2+2+2+2
Conduction :Initial set-up/circuit connection, readings, completion of tabular column	5+10+5	5+10+5
Graph, calculation, results with units and accuracy	2+2+2+2+2	2+2+2+2+2
Viva-Voce	10	10
Total	**50**	**50**

The total marks of the practical test will be reduced to 20 marks
The lab manual marks will be reduced to 30
The total marks for lab internals will be 20 + 30 = **50**

The student is required to obtain a minimum of 40% marks (20 marks) in CIE.

DOs

- Come to the lab session in-time with lab apron.
- Bring completed lab manual regularly.
- Do the write up part (formula, figure, circuit diagram, tabular column, result statement) of the experiment in advance before coming to the lab.
- Bring scientific calculator, graph sheets and other necessary items to the lab regularly.
- Handle the apparatus /equipment carefully.
- At the end of the experiment bring the knobs of the equipment to the minimum position.
- Switch off the power supply after the completion of the experiment.
- Return the collected apparatus before leaving the lab to lab attender/instructor.
- Maintain discipline inside the lab.
- Switch off the mobile phone & keep it inside the bag.

DONTs

- Unnecessarily absent yourself from lab sessions.
- Give your manual to others.
- Forget to check your belongings before leaving the lab.
- Switch ON electric / electronic equipment before getting approval by the teacher / instructor.

Instructions to students

- ✓ Studentsshouldensurethat the observation with final calculation& graphs must beapproved by the teacherslatestbynextday.
- ✓ Observation &calculationsshownlaterwill not beapproved by the teachers.
- ✓ Beforeleaving the laboratory, the students must compulsorilytake the approval of the teachers for the observations of the experiments.
- ✓ Zero marks willbeprovided to the observation which have not been approvedbeforegoing out of the laboratory.

EVALUATION SHEET

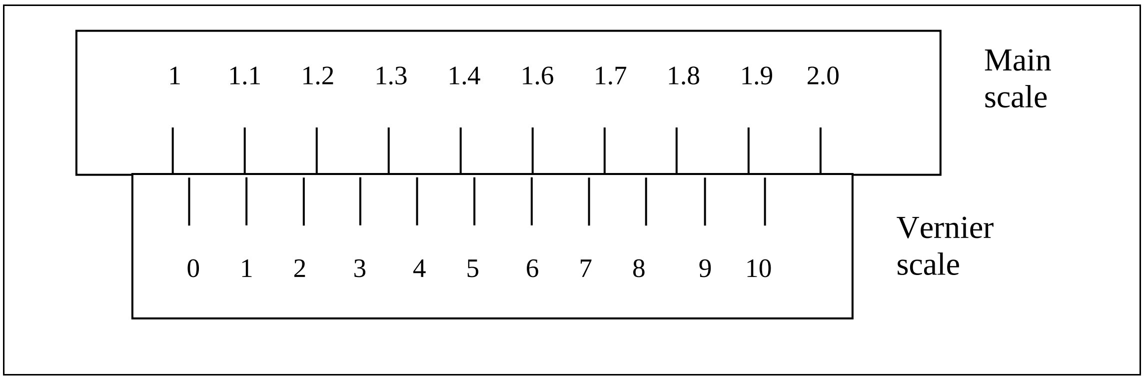
Name : USN:

Exp. No.	CONTENTS	Page No.	Marks			Total Marks (30)	Faculty signature With Date
			Viva (10)	Conduction & Calculations (15)	Manual Writing (5)		
	MEASUREMENTS	1					
1.	FERMI ENERGY OF A CONDUCTOR	5					
2.	WAVELENGTH OF LED's	11					
3.	NUMERICAL APERTURE	17					
4.	SERIES & PARALLEL LCR CIRCUITS	21					
5.	SPRING CONSTANT	28					
6.	ENERGY GAP OF SEMICONDUCTOR	37					
7.	DIELECTRIC CONSTANT	40					
8.	PHOTO DIODE	47					
9.	DIFFRACTION GRATING	53					
10.	TORSIONAL PENDULUM	59					
	VIVA VOCE	65					
	AVERAGE MARKS	→					

	MAX. MARKS	MARKS OBTAINED	Faculty Signature
Lab manual marks	30		
Lab internal marks	20		
Total (lab IA marks)	50		

MEASUREMENTS

Least count of vernier calipers



The vernier caliper has two scales – main and vernier. The main scale is graduated usually in cm while the vernier scale has no units. In fact the vernier scale is not marked with numerals. The diagram shown above has been simplified for clarity.

Least count (LC) of the vernier calipers is the ratio of the value of 1 main scale division (MSD) to the total number of vernier scale divisions (VSD).

Value of 10 MSD= 1cm
Value of 1 MSD = 0.1cm
Total number of VSD = 10

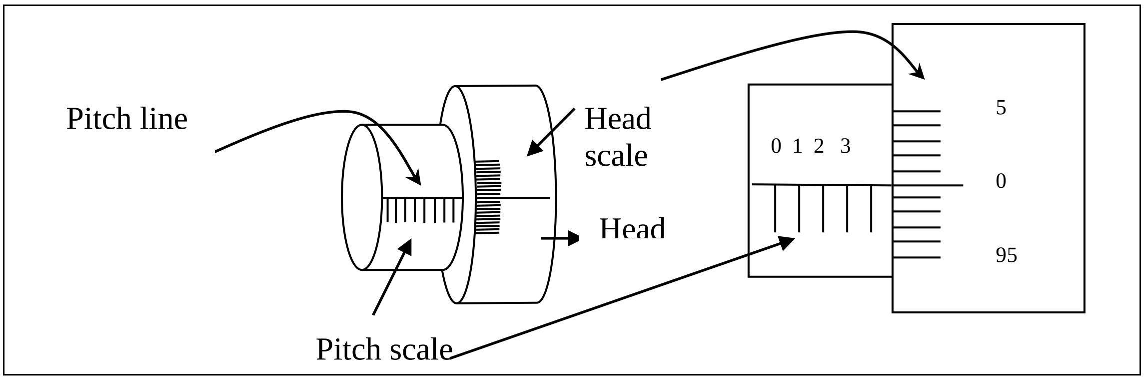
Therefore LC = Value of 1MSD / Total no. of VSD = 0.1cm/10 =0.01cm

To take readings using the calipers

- First see if the 0 of the vernier scale coincides with a main scale reading. If it coincides then take the main scale reading as the final reading.
- If the 0 of the vernier scale does not coincide with a main scale reading then see between which two readings of the main scale the 0 of the vernier lies. The lower of the two readings on the main scale is taken as the main scale reading (MSR)
- Then see which **vernier division** coincides with **a main scale reading**. This division of the vernier scale is noted as the coinciding vernier scale division (CVD)
- The total reading (TR) is then given by TR = MSR + (CVD x LC) cm

For example, referring to the above figure

MSR = 1cm
CVD = 6
TR = MSR + (CVD x LC) = 1 + (6 x 0.01) = 1.06cm



Least count of the screw gauge

The screw gauge has two scales – pitch scale and head scale. The pitch scale is usually graduated in mm while the head scale has no units.

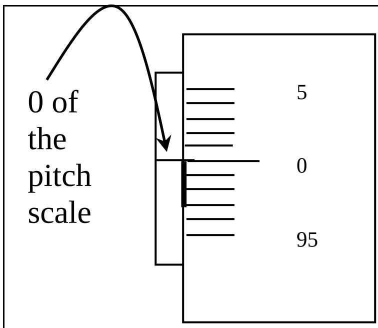
The least count (LC) of the screw gauge is the ratio of the pitch to the total number of head scale divisions.

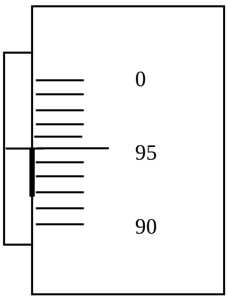
The pitch of the screw gauge is the distance moved on the pitch scale for one complete rotation of the head i.e. pitch = distance moved on pitch scale /No. of rotations given to head scale. For the screw represented here, value of pitch is 1mm.

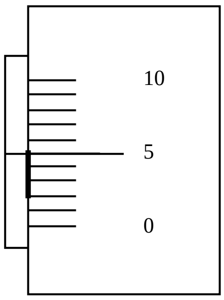
The head scale is divided into 100 divisions.

Therefore LC = pitch /total no. of head scale divisions = 0.01mm

In the screw gauge the head is rotated until the plane faces that hold the object touch each other. We have to see whether the 0 of the head scale coincides with the pitch line. If it does not then we have to note down the zero error (ZE)







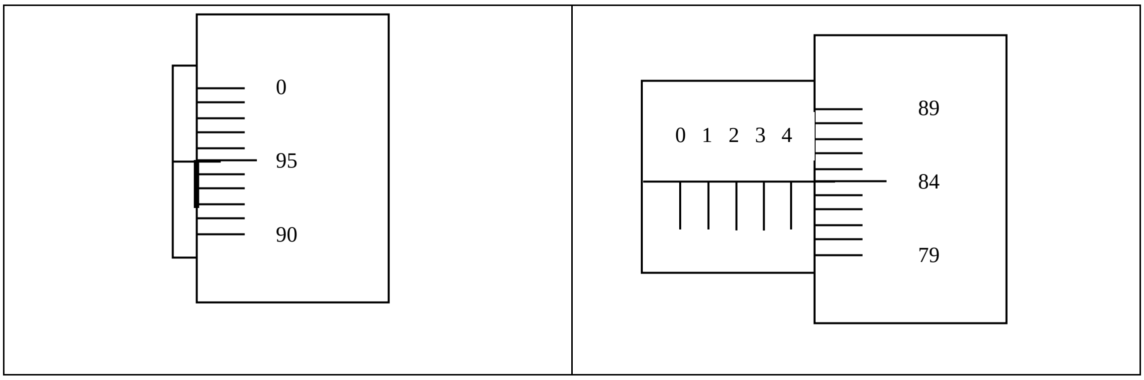
ZE = 0, ZC = 0 If the 0 of the head scale coincides with the pitch line then ZE = 0	ZE = -5, ZC = +5 If the 0 of the head scale lies above the pitch line then ZE is negative	ZE = +5, ZC = -5 If the 0 of the head scale lies below the pitch line then ZE is positive

The readings are to be taken as follows

(1) First determine the ZE
(2) Note down the reading on the pitch scale (PSR)
(3) Note down the division of the head scale that coincides with the pitch line (CHSR)
(4) Zero correction (ZC) is given by –ZE.

(5) The total reading (TR) is given by TR = PSR + (CHSR – ZE)xLC or
TR = PSR + (CHSR + ZC)xLC

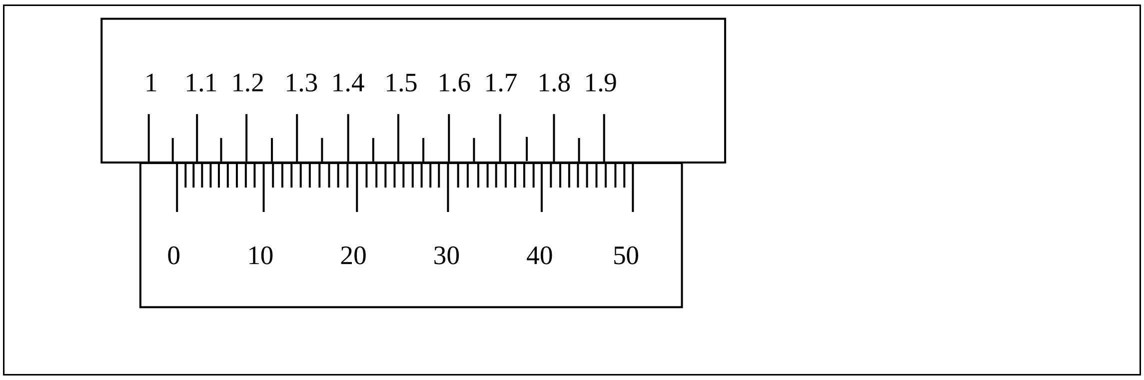
For example, referring to the diagram below



ZE = -5
ZC = +5

From the second diagram, the readings are
PSR = 4mm
CHD = 84
TR = PSR + (CHD + ZC)x LC = 4 + (84 + 5)x 0.01 = 4.89mm

Least count of the traveling microscope (T.M)



The scales on the traveling microscope are similar to those in vernier calipers. The difference being that the value of 1 main scale reading is 0.05cm and the number of divisions on the vernier are 50.

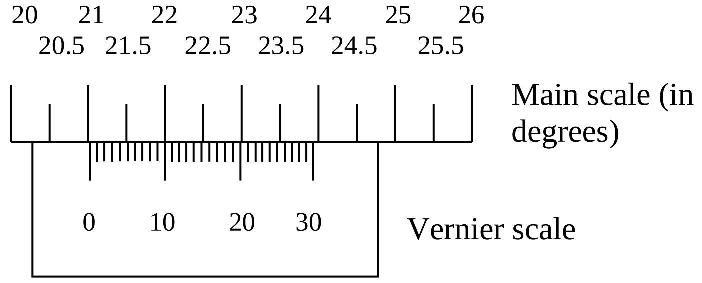
The least count (LC) of the instrument is then = value of 1main scale division / total number of vernier scale divisions = 0.05cm/50 = 0.001cm.

The procedure for taking readings is the same as for vernier calipers.
- First note down whether the 0 of the vernier scale coincides with a main scale reading. If it does then this reading is the final reading.
- If it does not coincide, then see between which two main scale readings the 0 of the vernier lies.

- Note down the lower of the two reading as the main scale reading (MSR)
- Then see which division of the vernier coincides with a main scale reading. Take the value of this division as the coinciding vernier division (CVD).
- The total reading (TR) is then given by TR = MSR + (CVD x LC) cm.

For example referring to the figure drawn above
MSR = 1.05cm
CVD = 19
TR = MSR + (CVD x LC) = 1.05 + (19 x 0.001) = 1.05 + 0.019 = 1.069cm

Least count of the spectrometer



The spectrometer has two scales - one circular scale called the main scale and the other vernier scale. The main scale is graduated in degrees while the vernier scale has no units.
The smallest value of1 main scale division is 0.5° or 30′

The number of divisions on the vernier scale are 30.

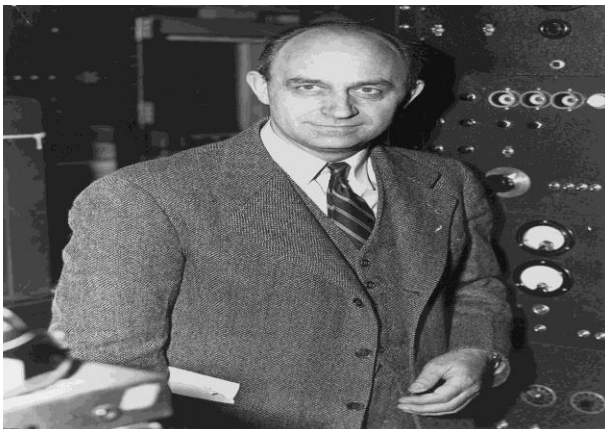
The least count (LC) of the instrument = value of 1 main scale division / total number of vernier scale divisions = 30′/30 = 1′.

To take readings

- First note whether the 0 of the vernier coincides with a main scale reading. If it does then that is taken as the total reading.
- If it does not coincide then check to see between which two main scale readings the 0 of the vernier lies.
- The lower reading on the main scale is taken as the main scale reading (MSR).
- Then the vernier division that coincides with a main scale division is noted. This is noted as the coinciding vernier scale division(CVD).
- The total reading (TR) is then calculated using TR = MSR + (CVD x LC). The answer is given generally in degrees and minutes.

For example referring to the diagram above
MSR = 21°
CVD = 10
TR = MSR + (CVD x LC) = 21° + (10 x 1′) = 21°10′

Enrico Fermi



Enrico Fermi, an Italian physicist, is well-known for his achievements in both theoretical and experimental physics. This is an exceptional achievement in a period where scientific accomplishments have focused on one aspect or the other. He is mainly remembered for his work on the advancement of the first nuclear reactor, and for his contributions to the development of quantum theory, nuclear and particle physics, and statistical mechanics.

During his time in Paris, Fermi and his team made major contributions to many practical and theoretical aspects of physics. In 1934, while at the University of Rome, Fermi carried out experiments where he bombarded a variety of elements with neutrons and discovered that slow moving neutrons were particularly effective in producing radioactive atoms. His experiments led to the discovery of nuclear fission and the creation of elements beyond uranium. In 1938, Fermi won the Nobel Prize for Physics for his work on nuclear processes.

In 1935, Fermi discovered the quantum mechanics statistical laws, nowadays known as the Fermi statistics,giving a statistical model of the atom and nucleus.

Fermi continued to conduct nuclear fission experiments at Columbia University. In 1940, Fermi and his team proved that absorption of a neutron by a uranium nucleus can cause the nucleus to split into two nearly equal parts, releasing numerous neutrons and huge amounts of energy. This was the first nuclear chain reaction.

In his later years, Fermi became interested in the origin of cosmic rays and investigated subatomic particles, especially pi mesons and muons.

Applications of Fermi Energy

1.It is used to describe insulators, metals, and semiconductors.

2.Fermi energy is applied in determining the electrical and thermal characteristics of the solids.

3.It is also important in nuclear physics to understand the stability of white dwarfs. White dwarfs are stars that have a mass comparable to the Sun but have about a hundredth of its radius.

Experiment - 1

FERMI ENERGY OF A CONDUCTOR

Aim: To determine the Fermi energy of the given specimen.

Apparatus: copper coil, thermometer, multimeter

Formula:

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho A m}{l}} \quad \text{J}$$

ρ is the density of copper (kg / $m^{3)}$

A is the area of cross section wire (m^2)

m is the slope of the graph.

l is the length of the specimen (m).

1 eV = 1.602 x 10^{-19} J

Procedure:

- The connections are made as shown in the figure.
- The copper coil is immersed in hot water which is initially heated up to 80°C.
- The resistance R of the given coil is measured using a multimeter.
- The water bath is allowed to cool.
- For every 5° C drop in temperature, resistance R is measured till it drops to 50°C.
- A graph of resistance along Y axis and temperature(in Kelvin) along X axis is plotted.
- The value of the slope m is calculated.
- The area of cross section of the coil is determined using the formula $A = \frac{\pi d^2}{4}$ where 'd' is the diameter of the specimen wire.
- The Fermi energy of the material is calculated using the formula

$$E_F = 1.36 \times 10^{-15} \sqrt{\frac{\rho A m}{l}} \quad \text{J}$$

ρ is the density of the material (kg/$m^{3).}$

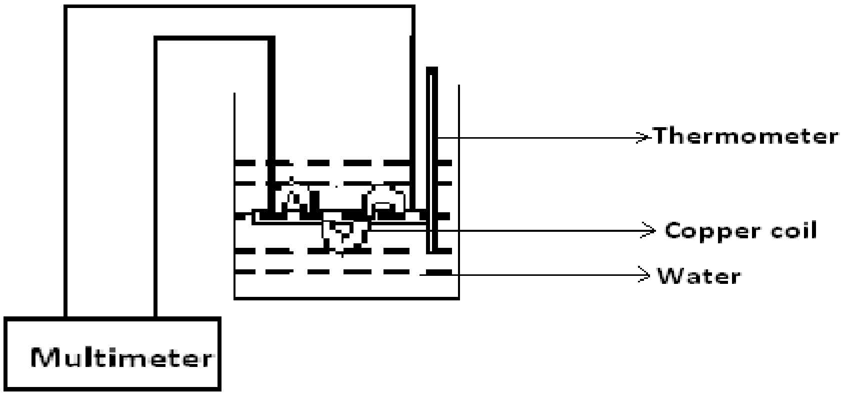
A is the area of cross section of the wire (m^2).

m is the slope of the graph.

l is the total length of the specimen (m).

Observations & calculations

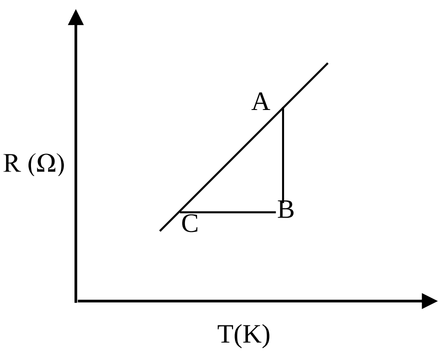
Circuit diagram :



Tabularcolumn:

T (^{o} C)	T (K)	R (ohm)

Graph:



Slope m = AB/BC

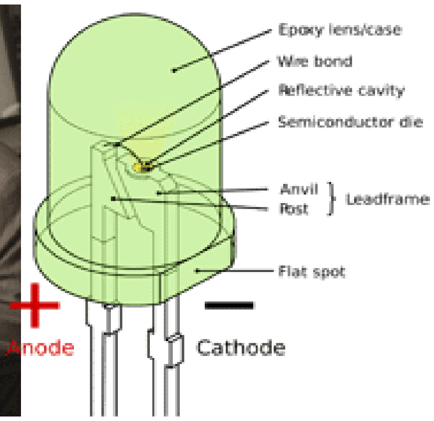
Result: The Fermi energy of the given specimen is found to be E_F= ....eV

Observations & calculations

Observations & calculations

Observations & calculations

Nick Holonyak Jr.



Nick Holonyak Jr. is an American engineer and educator. He is noted particularly for his 1962 invention of a light-emitting diode that emitted visible red light instead of infrared light. By using the semiconductor material gallium arsenide phosphide (GaAsP) and the technique of stimulated emission, in 1962 Holonyak succeeded in operating the first practical visible LED device. Holonyak’s device emitted red light. After LEDs that produce green and blue light were developed (in the 1970s and ’90s, respectively), LEDs that emit white light became possible, revolutionizing the lighting industry. Among his other work for GE, in 1959 Holonyak was the first to make silicon tunnel diodes and the first to observe phonon-assisted tunneling.

LEDs have many advantages over incandescent light sources, including lower power consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. In exchange for these generally favorable attributes, disadvantages of LEDs include electrical limitations to low voltage and generally to DC (not AC) power, inability to provide steady illumination from a pulsing DC or an AC electrical supply source, and lesser maximum operating temperature and storage temperature.

In contrast to LEDs, incandescent lamps can be made to intrinsically run at virtually any supply voltage, can utilize either AC or DC current interchangeably, and will provide steady illumination when powered by AC or pulsing DC even at a frequency as low as 50 Hz. LEDs usually need electronic support components to function, while an incandescent bulb can and usually does operate directly from an unregulated DC or AC power source.

Applications of LED

- Digital computers and calculators
- Mobile display
- LED is used as a bulb
- Traffic signals and Burglar alarms systems
- Microprocessors and multiplexers
- Camera flashes and automotive heat lamps
- Aviation lighting

Experiment – 2

WAVELENGTH OF LIGHT EMITTED BY LED'S

Aim: To determine the wavelengths of the given Light Emitting Diodes (LED s).

Apparatus : Power supply, LED's, multi meter, milli ammeter, patch cords etc.

Principle: Light emitting diode is special type of semiconductor diode. It consists of heavily doped P type and N type direct band gap semiconductor. The LED absorbs electrical energy and converts it into light energy. When the PN junction is in the forward biased the electrons from the N region migrate into P region and combine with holes. This recombination of electrons and holes results in the emission of photons.

Formula: Energy of the photons emitted by LED, $E = h\nu = \frac{hc}{\lambda} = eV_k$

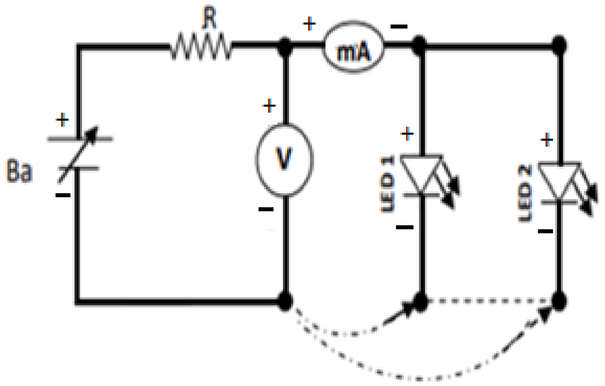
The wavelength of LED is, $\lambda = \frac{hc}{eV_k}$

Where,
'h' is Planck's constant = 6.63×10^{-34} Js;
'c' is Speed of Light = $3 \times 10^{8} ms^{-1}$
'e' is charge on electron = 1.602×10^{-19}C;
'V_K' is the Knee voltage of the LED.

Procedure:

- Make the connections as shown in the circuit diagram.
- Keep the knobs at the minimum position before switching ON the kit. Insert the LED1 in the circuit.
- Vary the voltage in convenient steps and note down the current I in the milli ammeter, take care of voltage not to go beyond 3V.
- Repeat the above procedure for the second and third LED's
- Plot a graph of current versus voltage for each LED starting with true origin on x and y axis.
- Draw a tangent at the knee of the graph and extend the tangent to intercept the voltage axis.
- The point of intersection is knee voltage V_K. Note down the knee voltage for each LED from the graph.
- Calculate the wavelength of each LED using the relevant formula.

Circuit Diagram:



Graph:

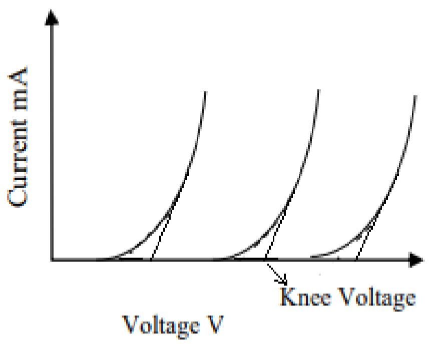


Table:

Sl No.	LED 1 Colour:		LED 2 Colour:		LED 3 Colour:	
	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)	Voltage (V)	Current (mA)
1						
2						
3						
4						
5						
6						
7						

Result: The wavelength of LED’s are found to be

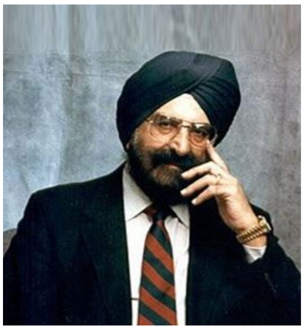
Sl. No	Colour of LED	Wavelength (nm)
1		
2		
3		

Observations & calculation

Observations & calculation

Observations & calculation

Dr Narinder Singh Kapany



Dr Narinder Singh Kapany, known as the father of fibre optics, is an Indian-born American physicist who has been a pioneer in the development and innovation of optical fibres. Taking on the roles of a physicist, a philanthropist, an entrepreneur, a businessman and a sculptor, he has been a huge contributor to the world in all sectors.

Born to a Sikh family in Punjab in 1926, his interest in physics was ignited while listening to a physics lecture as a young boy in India where his teacher taught him that light travels in a straight line. Kapany graduated from Agra University and went on to Imperial College of London for advanced study in optics where he earned his PhD in 1955. He then carried on his journey of innovation and research in the University of Rochester and later in Illinois Institute of Technology.

Kapany’s research leading towards fibre optics began in the Imperial College while he worked with the venerated Harold Hopkins, an English physicist. He demonstrated his breakthrough research in 1954 at the Department of Physics when he showed that light could travel in bent glass fibres.That demonstration paved the way for optical fibre communication that we utilize and take for granted today. He has published over hundred scientific papers in various international science journals leading to the establishment and colloquial usage of the term fibre optics.

Reducing the loss significantly and allowing information to be transmitted across large distances at much higher bandwidths, fibre optics has filled an important void in the data transmission and communication industry. It has extensive use in communications, sensors and power transmission along with its thankless contribution to medical devices. Fibre optics has led to the creation of medical devices such as gastroscope, endoscope and bronchoscope making detection and treatment of several diseases easier and affordable.

He founded Optics Technology Inc. in 1960 where he was President, Chairman of Board and Director of Research for twelve years. A while after the company went public in 1967, he founded the Kaptron Inc. in 1973 and headed it until it was bought by AMP Incorporated in 1990.

He also served as an excellent academic aside from his active participation in his numerous business endeavours. He was a Regents Professor at the University of California, Berkeley and at the University of California, Santa Cruz. He served as a Visiting Scholar in the Physics Department and a Consulting Professor in the Department of Electrical Engineering at Stanford University.

Dr Narinder Singh Kapany’s ground-breaking work on fibre optics won him many awards and titles. He received the Excellence 2000 Award from the USA Pan-Asian American Chamber of Commerce. He is also a fellow of the British Royal Academy of Engineering, the Optical Society of America, and American Association for the Advancement of Science. He was also the recipient of the Pravasi Bhartiya Samman awarded by the Indian Government.

Experiment - 3

NUMERICAL APERTURE & ACCEPTENCE ANGLE OF AN OPTICAL FIBER

Aim: To determine the numerical aperture and acceptance angle of a given optical fiber

Apparatus: Single strand plastic optical fibers of different core diameter/length, LASER source, screen

Formula :N.A = $n_o \sin \theta_A$
n_0 = Refractive index of the medium
θ_A = Angle of acceptance

Procedure:

- Connect the fiber to the LASER source.
- Take the other end of the fiber and project the light output on to the screen to obtain a bright circular spot as shown in the figure.
- Determine the diameter D of the bright spot and the distance L from the fiber end tothe screen and measure the diameter of the spot (D) and the distance between the screen & the optical fiber end (L).
- Calculate the acceptance angle using the formula $\theta_A = \tan^{-1}\left(\frac{D/2}{L}\right)$
- Numerical aperture is given by N.A = $n_o \sin \theta_A$

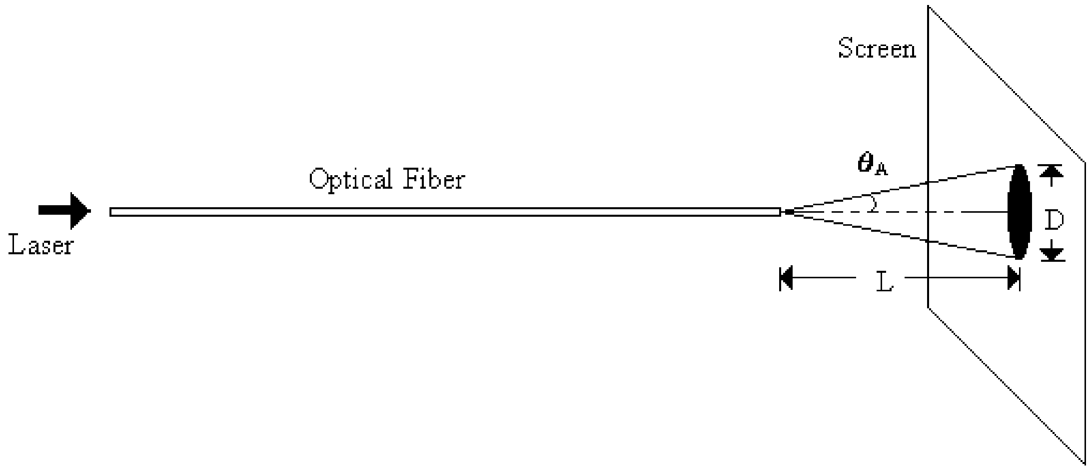
n_o is the refractive index of the medium from which light is entering (n_o =1 for air).

- For the same fiber repeat this procedure for at least four different values of distance L.
- Calculate the acceptance angle and numerical aperture in each case.
- Take the average of the four values& report the result.

Applications of Numerical Aperture

- Fiber Optics
- Lens
- Microscope Objective
- Photographic Objective

Observations & calculations



Calculation of Numerical Aperture

L(cm)	D(cm)	D/2 (cm)	Angle of Acceptance $\theta_A = \tan^{-1}\left(\frac{D/2}{L}\right)$	Numerical Aperture $= n_o \sin \theta_A$ ($n_0=1$ For Air)
5				
6				
7				
8				

Average θ_A = **Average NA =**

<u>Result:</u>The acceptance angle of the given optical fiber is found to be ……………..
The Numerical aperture for the given optical fiber is found to be ……………..

Observations & calculations

Guglielmo Marconi

Marconi was convinced that communication among people was possible via wireless radio signaling. He started conducting experiment in 1895 at his father's home in Pontecchio (60 kilometers southwest of Venice), where he was soon able to send signals over one and a half miles. During this period, he also carried out simple experiments with reflectors around the aerial to concentrate the radiated electrical energy into a beam instead of spreading it in all directions.

In 1896 Marconi traveled to England in order to get a patent for his apparatus. Later that year he was granted the world's first patent for a system of wireless telegraphy. After successfully demonstrating the system's ability to transmit radio signals in London, on Salisbury Plain and across the Bristol Channel, he established the Wireless Telegraph & Signal Company Limited in July 1897. This company was re-named as Marconi's Wireless Telegraph Company Limited in 1899.

In 1899 he established a wireless link between Britain and France across the English Channel. Further, he established permanent wireless stations at The Needles, Isle of Wight, Bournemouth, and later at the Haven Hotel in Poole, Dorset. The following year he received his patent for "tuned or systonic telegraphy."

During December 1901 Marconi proved that wireless signals were unaffected by the curvature of the earth. He transmitted the first wireless signals across the Atlantic between Poldhu, Cornwall and St, Johns, Newfoundland, a distance of 2100 miles.

The next year he demonstrated "daylight effect" relative to wireless communication and he also patented his magnetic detector, which became the standard wireless receiver for many years. In December he successfully transmitted the first complete message to Poldhu from stations at Glace Bay, Nova Scotia and Cape Cod, Massachusetts.

In 1905 Marconi patented his horizontal directional aerial and in 1912 he patented a "timed spark" system for generating continuous waves.

The Italian inventor and physicist, Guglielmo Marconi was awarded the Nobel Prize in Physics with Karl Ferdinand Braun in 1909 for their development of practical wireless telegraphy.

Applications of LCR circuits

1. Oscillator Circuit, radio receivers & television sets are used for the tuning purpose.
2. The series LCR circuit mainly involves in signal processing & communication system.
3. The series resonant LC circuit is used to provide voltage magnification.
4. Series & Parallel LC circuit are used in induction heating.
5. LCR circuits are used in low pass, high pass and band pass filters.

Experiment – 4

SERIES AND PARALLEL RESONANCE L C R CIRCUITS

Aim: To plot the frequency response of series and parallel LCR-circuit and to calculate bandwidth, quality factor &self inductance

Apparatus*:* Signal generator, inductor, resistor, capacitor, milliammeter, connecting wires.

Formula :

$$L = \frac{1}{4\pi^2 f_r{}^2 C} \quad \text{H}$$

f_r = resonant frequency in hertz
C = value of the capacitor present in the circuit (μF)
L = value of inductance

f_L, f_H= frequencies at points when the current value $\Rightarrow \begin{cases} \dfrac{I_{max}}{\sqrt{2}} & \text{for series circuit} \\ (\sqrt{2} \times I_{min}) & \text{for parallel circuit} \end{cases}$

Band width = Δf = ($f_H - f_L$) Hz

$$\text{Quality factor} = \frac{\text{Resonant frequency}}{\text{Band width}} = \frac{f_r}{\Delta f}$$

Procedure:

1.Series resonance:

- The circuit connections are made as shown in Fig 1.
- The signal amplitude from the oscillator is set to a fixed value throughout experiment.
- The frequency f is increased from 500Hz in appropriate steps of 500Hz and the corresponding readings of the current I in mA are tabulated till 5000Hz
- A graph is drawn taking the frequency f along the x-axis and current along y-axis.
- The frequency corresponding to the maximum current is noted as the resonant frequency f_r.
- The 'half-power points' A and B are found by taking $\dfrac{I_{max}}{\sqrt{2}}$ on the y-axis.
- Corresponding to A and B the frequencies f_L and f_H are noted and bandwidth Δf is computed as ($f_H - f_L$).
- Inductance L is calculated using the formula $L = \dfrac{1}{4\pi^2 f_r{}^2 C}$ H
- Quality factor Q is calculated using the formula $\dfrac{f_r}{\Delta f}$

2. Parallel resonance:

- The circuit connections are made as shown in Fig3.
- The frequency f is increased from 500Hz in appropriate steps of 500Hz and the corresponding readings of the current I in mA are tabulated till 5000Hz.
- A graph is drawn taking the frequency f along the x-axis and current I along the y-axis.
- The frequency corresponding to the minimum current is called the resonant frequency f_r .
- The 'half-power points' C and D are found by taking ($\sqrt{2} \times I_{\min}$) on the y-axis.
- Corresponding to A and B the frequencies f_L and f_H are noted and bandwidth Δf is computed as $(f_H - f_L)$Hz.
- Inductance L is calculated using the formula $L = \dfrac{1}{4\pi^2 f_r^{\,2} C}$ H
- Quality factor Q is calculated using the formula $\dfrac{f_r}{\Delta f}$

Observations & calculations

SERIES RESONANCE

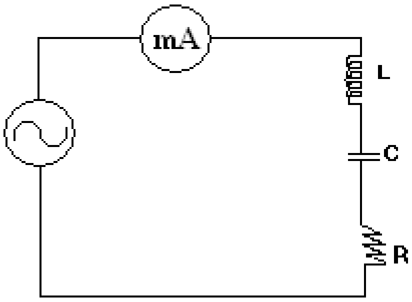


Fig 1: Series Resonance

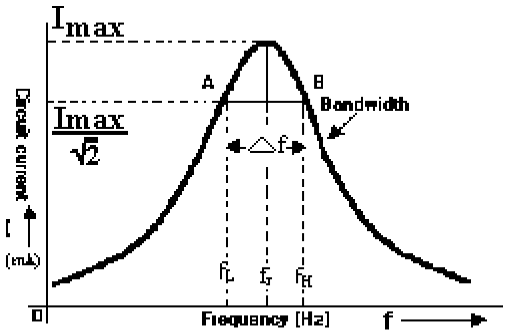


Fig 2: Series Resonance Curve

PARALLEL RESONANCE

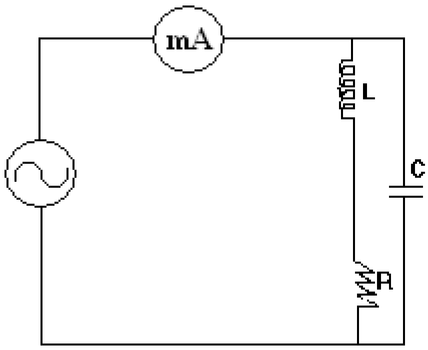


Fig 3: Parallel Resonance

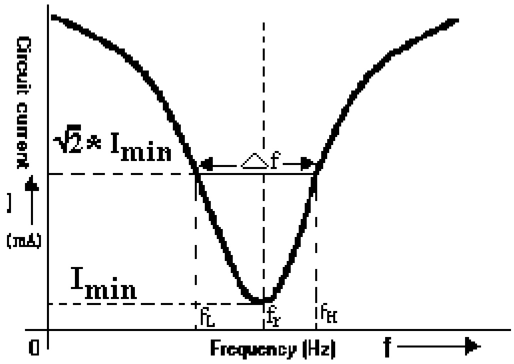


Fig 4: Parallel Resonance Curve

Table:

	Series resonance	Parallel resonance
Frequency (Hz)	Current (mA)	Current (mA)
500		
1000		
1500		
2000		
2500		
3000		
3500		
4000		
4500		
5000		

Result:

For series LCR circuit:

f_r = --------- Hz

L=----------H

Bandwidth =-------------Hz

Quality factor = ------------

For parallel LCR circuit:

f_r = ----------- Hz

L=-----------H

Bandwidth =--------------Hz

Quality factor = ---------------

Observations & calculations

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Observations & calculations

Observations & calculations

Robert Hooke

In 1660, Robert Hooke discovered *the law of elasticity*, which states that the stretching of a solid body is proportional to the force applied to it. *Hooke's Law laid the basis for studies of stress and strain and for understanding of elastic materials.* It is extensively used in all branches of science and engineering, and is the foundation of many disciplines such as *seismology, molecular mechanics* and *acoustics*. It is also the fundamental principle behind the *spring scale,* the *manometer,* and the *balance wheel* of the mechanical clock.

Hooke made tremendous contributions to the science of timekeeping. He applied himself to the improvement of the pendulum and around 1657 invented *anchor escapement* which is a mechanism to maintain the swing of the pendulum. The anchor became the *standard escapement used in almost all pendulum clocks*. Around the same time, he developed the *balance spring*, which for the *first time enabled accurate timekeeping in portable timepieces* making pocket watches useful timekeepers. He also conceived the idea that *accurate timekeeping could be used to find the longitude at sea.*

Hooke was one of the first men to build a Gregorian telescope. In *1664*, he discovered the *fifth star in Trapezium*, an asterism (mini-constellation) in the constellation Orion; the *Great Red Spot,* a prominent oval-shaped feature in the southern hemisphere of Jupiter; and *Gamma Arietis* in the northern constellation of Aries, one of the first observed double-star systems. Hooke *first suggested that Jupiter rotates on its axis* and his *detailed sketches of Mars* were used more than 200 years later, in the 19th century, to determine the *rate of rotation* of the planet.

Applications of springs

1) To apply forces and controlling motion, as in brakes and clutches.

2) Measuring forces, as in the case of a spring balance.

3) Storing energy, as in the case of springs used in watches and toys.

4) Reducing the effect of shocks and vibrations in vehicles and machine foundations.

Experiment - 5

SPRING CONSTANT

Aim:

a) To determine spring constant for the material of the given spring.
b) To determine spring constant in series and parallel combination.

Apparatus: Given springs, slotted weights

Formula: **Practical:** $k = \frac{F}{x}$ **(N/m)**

Theoretical: **(i)** $k_{series} = \frac{k_1 k_2}{k_{2+} k_1}$ **(N/m)**

(ii) $k_{parallel} = k_1 + k_2$ **(N/m)**

k is the proportionality constant known as spring constant. It is a relative measure of stiffness of the material.
F is the force expressed in newton.
x is the displacement expressed in meter for the corresponding load expressed in kg.
k_1 and k_2 are the spring constants for the first and second spring respectively.

Procedure:

- The first spring is fixed to the rigid support and a load of 50g is added to the free end and the reading corresponding to the pointer is noted.
- A 50 g load is added to the above set up & when the spring is at rest, reading corresponding to the pointer (displacement) is noted.
- Trial is continued by adding load in steps of 50 g till 300g & in each case the reading corresponding to the pointer (displacement) when the spring is at rest is noted in the tabular column.
- The displacement corresponding to a load of 50 g is computed and entered in the last column.
- The average displacement (x) for a load of 50g is calculated by computing the average of all the values in the last column of the Table 1.
- The spring constant (k_1) for the first spring is calculated using the formula $k_1 = \frac{F}{x}\ N/m$, where F =mg = 0.05x9.8=0.49N
- The first spring along with the load is removed & the second spring is fixed to the rigid support & the same experimental procedure is carried out and values are entered in Table 2.
- The spring constant (k_2) for the second spring is calculated using the formula $k_2 = \frac{F}{x}\ N/m$, where F =mg = 0.05x9.8=0.49N
- The spring & loads are removed from the rigid support.
- The two springs are connected in series combination as shown in the figure and the experimental procedure is carried out and the values are entered in Table 3.

- The spring constant for series combination is calculated using the formula $k_{series} = \frac{F}{x}\ N/m$, where F =mg = 0.05x9.8=0.49N
- The spring & loads are removed from the rigid support.
- The two springs are connected in parallel combination as shown in the figure and the experimental procedure is carried out and the values are entered in Table 4.
- The spring constant for parallel combination is calculated using the formula $k_{parallel} = \frac{F}{x}\ N/m$, where F =mg = 0.05x9.8=0.49N
- Also find the theoretical values of spring constants for both series and parallel combination of springs using the respective formula.

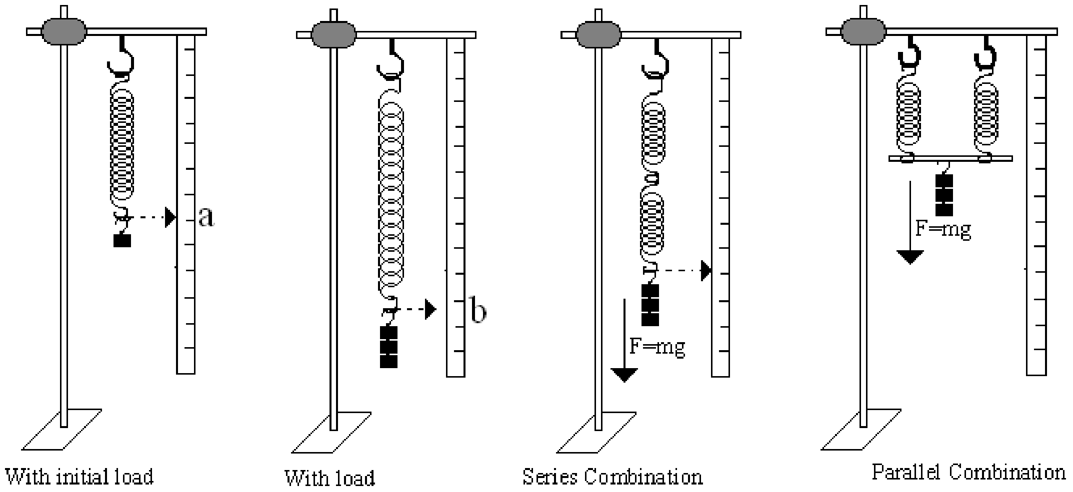

Table 1 : Spring constant of first spring (k_1)

Sl No.	load m (g)	Displacement (cm)	Displacement for 50g (cm)
1	W1= (50)		
2	W2=W1+50		
3	W3=W2+50		
4	W4=W3+50		
5	W5=W4+50		

Average displacement for 50g is x = ……………… cm = ………… m

Force F =mg = 0.05x9.8=0.49N

Spring constant $k_1 = \frac{F}{x} =$ ………… N/m

Table 2 : Spring constant of second spring (k_2)

Sl No.	load m (g)	Displacement (cm)	Displacement for 50g (cm)
1	W1= (50)		
2	W2=W1+50		
3	W3=W2+50		
4	W4=W3+50		
5	W5=W4+50		

Average displacement for 50g is x = ……………… cm = ………… m

Force F =mg = 0.05x9.8=0.49N

Spring constant $k_2 = \frac{F}{x} =$ ………… N/m

Observations & calculations

Table3 : Spring constant for series combination (k_{series})

Sl No.	load m (g)	Displacement (cm)	Displacement for 50g (cm)
1	W1= (50)		
2	W2=W1+50		
3	W3=W2+50		
4	W4=W3+50		
5	W5=W4+50		

Average displacement for 50g is x = ……………… cm = ………… m

Force F =mg = 0.05x9.8=0.49N

Spring constant $k_{series} = \frac{F}{x} =$ ………… N/m

Table 4 : Spring constant for parallel combination ($k_{parallel}$)

Sl No.	load m (g)	Displacement (cm)	Displacement for 50g (cm)
1	**W1= (150)**		
2	W2=W1+50		
3	W3=W2+50		
4	W4=W3+50		
5	W5=W4+50		

Average displacement for 50g is x = ……………… cm = ………… m

Force F =mg = 0.05x9.8=0.49N

Spring constant $k_{parallel} = \frac{F}{x} =$ ………… N/m

Result :

The spring constant of the first spring (k_1) is ………………..N/m
The spring constant of the second spring (k_2) is ………………..N/m
The spring constant for series combination, k_{series} (practical) is …………..N/m
The spring constant for parallel combination, $k_{parallel}$ (practical) is ………..N/m
The spring constant for series combination, k_{series} (theoretical) is …………..N/m
The spring constant for parallel combination, $k_{parallel}$ (theoretical) is ………..N/m

Observations & calculations

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Observations & calculations

Observations & calculations

Observations & calculations

Experiment - 6

ENERGY-GAP OF A SEMICONDUCTOR

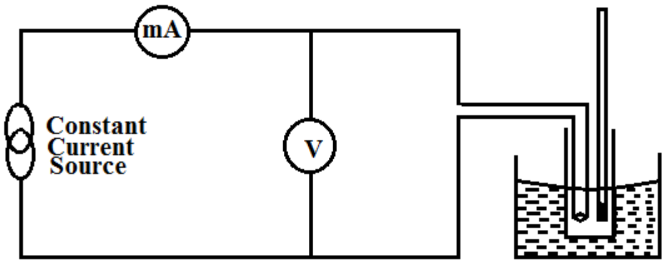
Aim: To Determine the energy gap of the given semiconductor

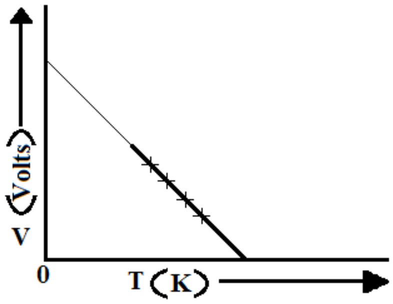
Apparatus: Semiconductor, thermometer, hot water in beaker, test tube, circuit Supporting board.

Procedure:

- The milliammeter is connected in series and voltmeter in parallel as shown in the figure.
- The p-type of the semiconductor is connected to positive and the n-side of the semiconductor is connected to negative terminal of a battery.
- Hot water is taken in a beaker.
- The mercury bulb of thermometer is tied to the semiconductor, and is inserted carefully into a test tube.
- The test tube is then slowly dipped in the beaker till it rests vertically.
- The current setting knob is adjusted till milliammter reads 0.1 mA.
- Starting from 85^{o} C, the forward voltage across the semiconductor as read by the voltmeter is noted in the tabular column at intervals of 5^{0}C as the bath cools down to a temperature close to room temperature.
- The forward current I_F is maintained constantly at 0.1mA by adjusting the knob, every time the readings are recorded.
- A graph is plotted by taking temperature in kelvin along the X—axis and junction voltage along Y –axis.
- A straight line is obtained, which is extrapolated to cut Y-axis.
- The value of the voltage at the point of intercept in the y-axis gives the energy value of the semiconductor in eV directly.

Observations & calculations





Temp (^{0}C)	Temp (k)	Junction voltage(v)

Result: The energy gap of the given semiconductor=----------eV.

Observations & calculations

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Peter Debye

Debye was a man of many talents and visions and this could be seen in his scientific works. The very first of his many major scientific contributions was in 1912 when he studied the dipole moments of molecules. A dipole happens when electron charge is unevenly distributed in a molecule which means that part of the molecule carries a slight negative charge and part carries a slight positive charge. A dipole moment measures the strength of the dipole.

Debye developed equations to calculate the size of the dipole moments and he also determined information regarding the structure of molecules. The units for molecular dipole moments, Debye units, are named after him. In the same year, he devised the Debye model for specific heat which estimated the phonon contribution to the specific heat (heat capacity) in a solid.

From 1914-15, Debye worked with Paul Scherrer on X-ray diffraction and together they devised a way to use powdered samples of crystalline, instead of preparing time consuming crystals, developing the Debye-Scherrer method of X-ray diffraction.

In 1923, Debye and his assistant Erich Huckel devised the Debye-Hückel equation, improving Svante Arrhenius's theory of electrical conductivity in electrolyte solutions.

That same year, in 1923, Peter Debye developed a theory to help understand the Compton Effect, named after American physicist Arthur Compton, discovering independently that the wavelength of X-rays increases when they collide with electrons.

He received the 1936 Nobel Prize in Chemistry "for his contributions to the study of molecular structure," for his work on dipole moments and X-ray diffraction.

Applications of dielectric materials

1. They are used for energy storage in capacitors.
2. To enhance the performance of the semiconductor devices, high permittivity dielectric materials are used.
3. Barium Strontium Titanate thin films are dielectric which are used in microwave tunable devices providing high tunability and low leakage current.
4. Castor oil is used in high-voltage capacitors to increase its capacitance value.

Experiment –7

DIELECTRIC CONSTANT BY CHARGING AND DISCHARGING OF A CAPACITOR

Aim: To determine dielectric constant by using a DC charging and discharging circuit.

Apparatus: DC power supply, voltmeter, timer, resistors of knownvalues and capacitor with known values of dimensions of the dielectric material within itself, circuit unit and patch cords.

Formula:

$$k = \frac{d t_{1/2} 10^{-6}}{0.693 \varepsilon_o A R}$$

d is the thickness of the dielectric material = ……. (m)

A is the area of the dielectric material $= \ell$ x b =………. (m^2)

ℓ is the length & b is the breadth of the dielectric material

ε_o is the permittivity of free space = 8.854×10^{-12} Fm^{-1}

R is the resistance in the circuit = ……. Ω

Procedure :

- The required circuit is made as shown in the figure.
- The power supply is switched on.
- The capacitor is discharged completely by keeping the switch S_1 in discharge position.
- To begin with the toggle in the switch S_2 is set to halt position.
- The timer is set to zero by pressing the reset button.

Charge mode studies :

- Tostart with the toggle of the switch S_1 is set to charge mode.
- Next the toggle in switch S_2 is flicked to start position, at which instant the capacitor begins to charge to higher voltage and the timer starts counting simultaneously.
- Immediately start noting down the voltage readings ‘V’ in the voltmeter at every ten seconds interval from t = zero second until the voltage becomes practically constant (i.e., when two or three consecutive readings remain same).
- The voltage readings are entered in the tabular column under charge mode.

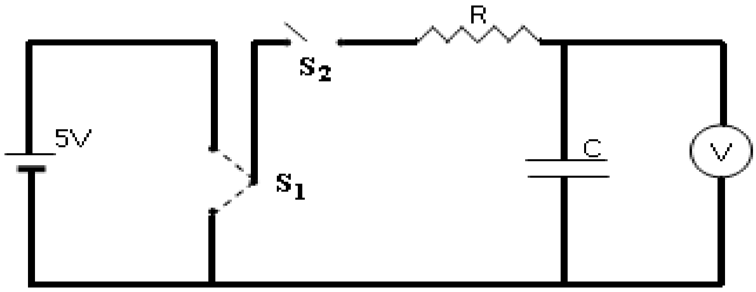
Discharge mode studies:

- As the timer progresses to zero, the toggle in switch S_1 is changed to discharge mode.
- Voltage readings are noted at every ten seconds interval till it becomes zero and are tabulated under discharge mode (for t = 0s, the entry for voltage must be same as the maximum voltage value attained during charge mode)

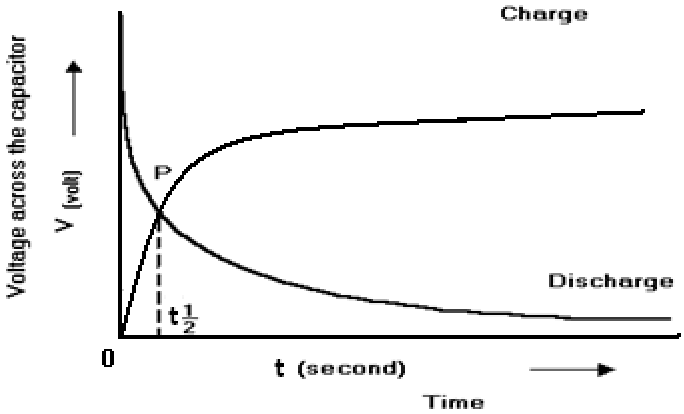
Evaluation of unknown :

- From the tabular column readings, a graph is plotted with time t in seconds taken along X-axis, and the voltage V in volts along Y-axis.
- The charge mode curve and the discharge mode curve intersect at the point P.
- By referring the position of 'P' on time axis, the value of its abscissa $t_{1/2}$ in seconds is found out.
- The value of the dielectric constant k is calculated using the above formula.

Observations & calculations



Time sec (t)	R =………..ohm Voltage across C in volts (V)	
	Charge mode	Discharge mode
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		



<u>Result</u> : The value of the dielectric constant of the material in the capacitor is found to be k = ……………….

Observations & calculations

Observations & calculations

Observations & calculations

John Northrup Shive

John Northrup Shive was an American physicist and inventor. He made notable contributions in electronic engineering and solid-state physics during the early days of transistor development at Bell Laboratories. In particular, he produced experimental evidence that holes could diffuse through bulk germanium, and not just along the surface as previously thought. This paved the way from Bardeen and Brattain's point contact transistor to Shockley's more-robust junction transistor. Shive is best known for inventing the phototransistor in 1948 (a device that combines the sensitivity to light of a photodiode and the current gain of a transistor).

Shive was a gifted lecturer, and became Director of Education and Training at Bell Telephone Laboratories, he was responsible for curriculum and administration of educational programs provided to employees of Bell Laboratories.

He invented the Shive wave machine (also known as the Shive wave generator), the wave generator illustrates wave motion using a series of steel rods joined by a thin torsion wire which transmits energy from one rod to the next. The high moment of inertia of each rod ensures the wave takes several seconds to traverse the entire series of rods, making the dynamics easily visible, the motion is analogous to high-frequency waves that are invisible to the human eye, such as electromagnetic waves on a transmission line. The wave generator could illustrate wave reflection, standing waves, resonance, partial reflection, and impedance matching. Shive made two educational films in which he demonstrated the machine, *Simple Waves* and *Similarities in Wave Behavior*, and wrote a book with the same name as the latter.

Experiment - 8

PHOTO DIODE CHARACTERISTICS

Aim: Todetermine responsivity of a photodiode and to study the I–V characteristics in reverse bias.

Apparatus: Regulated power supply, dc ammeter, dc voltmeter, white light LED and photo diode.

Formula: Responsivity $R_\lambda = \left(\frac{\Delta I_{PD}}{\Delta P_{LED}}\right) = slope$ A/W

I_{PD} is the photodiode current, $P_{LED}$is the power across LED.

Procedure:

Part A: Determination of responsivity

- The white light LED and photo diode (PD) are placed face-to-face at a distance of 10cm apart.
- By varying the pot in the emitter circuit the LED current is varied.
- A dial is provided for the potentiometer which directly reads the LED input power ($P_{LED}= V_{LED}\ I_{LED}$).
- The LED light arrangement is switched on.
- Positive terminal of the PD is connected to the negative terminal of the power supply and negative of the PD is connected to positive terminal of the power supply. This reverse biases the photo diode.
- The LED power is set from 0 to 50 mW in steps of 10 mW.
- At each step V_{PD} is set to 2V and the corresponding PD current is noted & tabulated in Table-1.
- A graph showing the variation of LED power on X-axis and PD current on Y axis is drawn.
- A straight line graph is obtained, slope of which gives the value of responsivity.

Part B: To study I-V characteristics of a photo diode

- The LED power is set to 10mW and V_{PD} is set to 0V to -2V only in steps of -0.5V and the corresponding I_{PD} is noted& tabulated in Table-2.
- The experiment is repeated by increasing the LED power to 20 mW, 30mW and 40 mW.
- A graph is drawn taking V_{PD} along X-axis and I_{PD} along Y-axis.
- This graph represents the I-V characteristics of a photodiode.

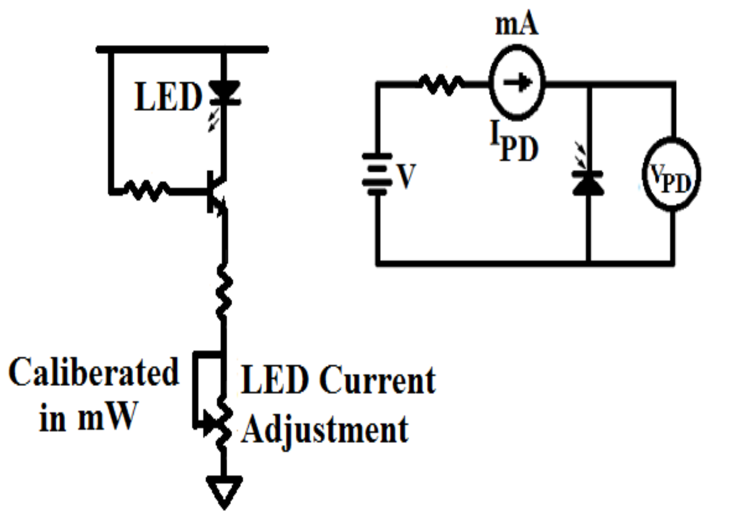
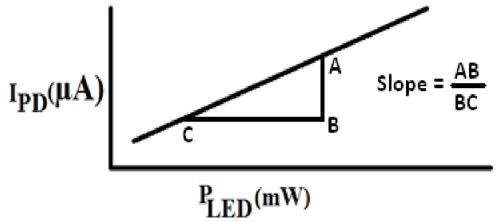


Table-1.
Variation of current with LED Power

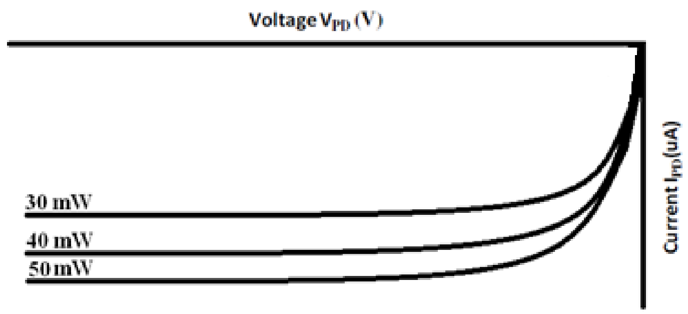
P_{LED} (mW)	I_{PD}(μA)
0	
10	
11	
12	
13	
14	
15	



Variation of PD current with LED power

Table-2
I-V Characteristics of PD

V_{PD} (V)	I_{PD} (μA)		
	P_{LED} =10mW	P_{LED} =15mW	P_{LED} =30mW
0			
-0.5			
-1			
-1.5			
-2			



I-V characteristic curves of PD

Result : Responsivity R_λ = ………………. A/W

Observations & calculations

Observations & calculations

Observations & calculations

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Theodore H. Maiman

Theodore Harold "Ted" Maiman was an American engineer and physicist who was widely, but not universally, credited with the invention of the laser (Others attribute the invention to Gordon Gould).Maiman's laser led to the subsequent development of many other types of lasers. The laser was successfully fired on May 16, 1960. In a July 7, 1960 press conference in Manhattan, Maiman and his employer, Hughes Aircraft Company, announced the laser to the world.Maiman was granted a patent for his invention, and he received many awards and honors for his work. Maiman's experiences in developing the first laser and subsequent related events are described in his book, *The Laser Odyssey*

Dr Maiman is mentioned in the following popular publications : Time 100, "A century of Science"; Business week's "100 Years of Innovation"; Los Angeles Times, "Great Moments in Science and Technology"; Who's who in the World; Who's Who in America; Who's who in Frontier Science and Technology; WhoDid What (a compendium of the 5,000 people deemed most influential in shaping our world, from the earliest recorded history to the present); and Modern Men of Science.

Applications of diffraction grating

In optical communications, they are used for

1. Wavelength Selection: Splitting and/or combining optical signals.
2. Pulse Compression: Normally as reflectors in external cavity DBR lasers.

Experiment – 9

DIFFRACTION GRATING

Aim: To determine the wavelength of laser light using diffraction grating

Apparatus: Laser source, grating, image screen

Formula:

$$\lambda = d\left(\frac{\sin\theta_n}{n}\right)_{avg} \text{ nm}$$

λ = wavelength of the light (nm)
n = order of the spectrum
d = grating constant (m)
θ_n = deviation produced (deg)

Procedure :

- The laser is placed on a sturdy table.
- At about one meter away on the path of the laser a screen is placed.
- The leveling screws of the laser are adjusted and switched on such that the laser beam exactly falls on the centre of the screen.
- The exact distance between the grating stand and image screen (f) is noted.
- The grating is now placed on the grating stand close to the laser source and graph sheet is fixed on the screen, and the diffraction pattern is observed.
- Equally spaced diffracted laser light spots are observed for different order (n) of spectrum.
- The total numberof spots are counted.
- The central direct ray is very bright, as the order increases the brightness decreases.
- The centre of the spots of the diffraction pattern are marked on the graph sheet usinga pencil.
- After marking the entire diffraction pattern, graph sheetis removed and the distances between consecutive orders of diffraction are measured using a scale and tabulated in the tabular column.
- The distance between the two first order diffraction spots, second order, third order diffraction spots,…. till eighth order diffraction spots ($2X_n$) are measured, from which X_n calculated.
- Using the equation $\theta_n = \tan^{-1}\left(\frac{X_n}{f}\right)$, diffraction angles are calculated for different orders of diffraction & sin θ_n calculated & tabulated.
- The average value $\left(\frac{\sin\theta_n}{n}\right)_{avg}$ is calculated & then the wavelength of the laser source is determined using the formula

$$\lambda = d\left(\frac{\sin\theta_n}{n}\right)_{avg} \text{ nm}$$

Observations & calculations

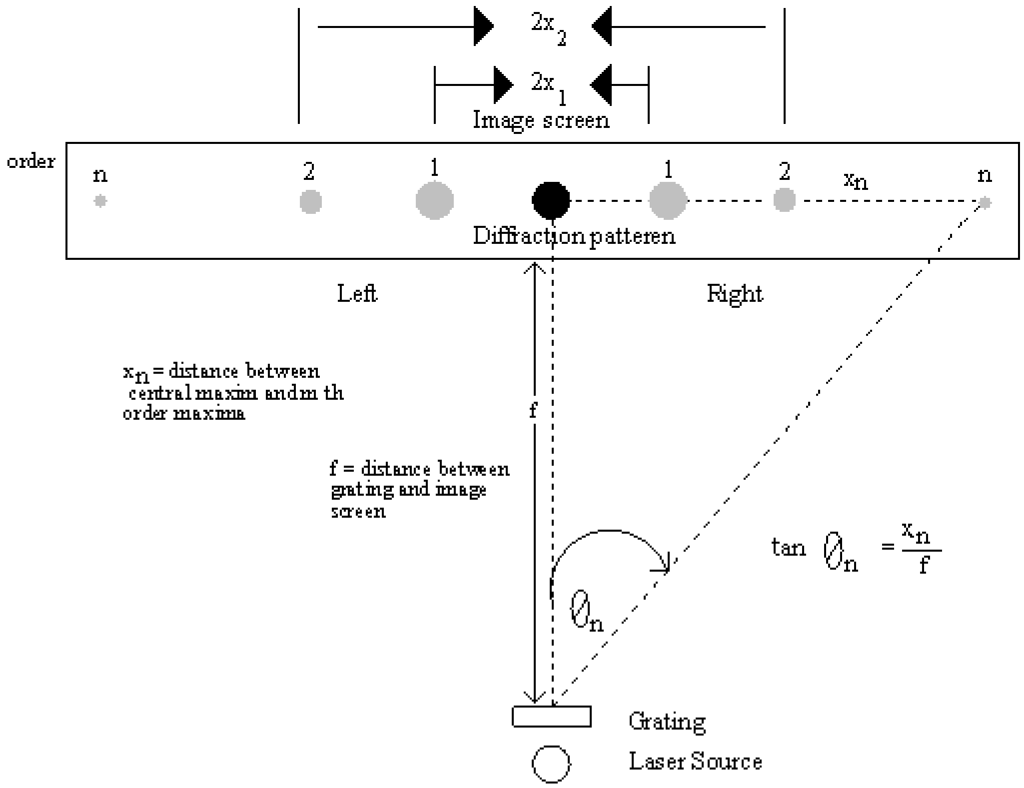
Grating constant $d = \dfrac{1}{N} = \dfrac{2.54 \times 10^{-2}}{500} =$ ………….. m

(for a grating having N = 500 lines per inch)

f = …………… cm

Sl No.	Order of diffraction (n)	Distance $2x_n$ (cm)	Distance x_n (cm)	$\theta_n = \tan^{-1}\left(\frac{x_n}{f}\right)$ (deg)	$\sin\theta_n$	$\frac{\sin\theta_n}{n}$
1						
2						
3						
4						
5						
6						

Wavelength $\lambda = d\left(\dfrac{\sin\theta_n}{n}\right)_{avg}$ = …………….. nm



Result : The wavelength of laser source using diffraction grating is ……….. nm

Observations & calculations

Observations & calculations

Observations & calculations

Robert Leslie

The torsion pendulum was invented by Robert Leslie in 1793. The torsion pendulum clock was first invented and patented by American Aaron Crane in 1841. He made clocks that would run up to one year on a winding. He also attempted to make precision astronomical regulator clocks based on the torsion pendulum.

The German Anton Harder apparently independently invented and patented the torsion clock in 1879-1880. He was inspired by watching a hanging chandelier rotate after a servant had turned it to light the candles. He formed the firm Jahresuhrenfabrik ('Year Clock Factory') and designed a clock that would run for a year, but its accuracy was bad. He sold the patent in 1884 to F. A. L. deGruyter of Amsterdam, who allowed the patent to expire in 1887. Other firms entered the market, beginning the German mass production of these clocks.

Although they were successful commercially, torsion clocks remained poor timekeepers. In 1951, Charles Terwilliger of the Horolovar Co. invented a temperature compensating suspension spring, which allowed fairly accurate clocks to be made.

Torsion clocks are capable of running much longer between windings than clocks with an ordinary pendulum, because the torsion pendulum rotates slowly and takes little energy. However they are difficult to set up and are usually not as accurate as clocks with ordinary pendulums. One reason is that the oscillation period of the torsion pendulum changes with temperature due to temperature-dependent change in elasticity of the spring. The rate of the clock can be made faster or slower by an adjustment screw mechanism on the torsion pendulum that moves the weight balls in or out from the axis. The closer in the balls are, the smaller the moment of inertia of the torsion pendulum and the faster it will turn, like a spinning ice skater who pulls in her arms. This causes the clock to speed up.

Experiment - 10

TORSIONAL PENDULUM

Aim: To determine the moment of inertia of the given body and rigidity modulus of the given wire by torsional pendulum.

Apparatus: Rectangular plate, circular plate, stand with clamp, steel wire fixed with chuck nuts, thread, meter scale, stop clock.

Formula: Rigidity modulus of given wire is

$$\eta = \frac{8\pi l}{r^4}\left(\frac{I}{T^2}\right)_{mean} - \quad N/m^2$$

r- radius of the experiment wire in(m)

l- length of the wire between the two chuck nuts in (m)

I- moment of inertia in(kg m^2)

T- period of oscillation in(s)

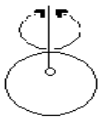
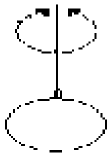
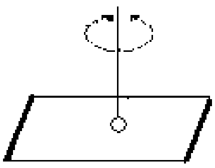
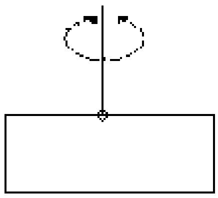
Procedure :

- For thegiven circular plateof mass M_1find the radius R by measuring the circumference using thread.
- Now suspend the plate by fixing the given experimental wire perpendicular to the plane and then along the diameter.
- In both the cases, find out the period of oscillation(T).
- For thegiven rectangularplateof mass M_2, find the length L and breadth B.
- Suspend the plate using the given experimental wire along the two axes (perpendicular to the plane & perpendicular to the length) and in each case find out the period of oscillation (T).
- The moment of inertia (I) for the plates suspended in a particular orientation is calculated using the formulae given in the tabular column.
- For each of the orientation, calculate (I/T^2) and then mean of (I/T^2)
- Using mean of (I/T^2) and other variables, calculate the rigidity modulus of the given wire using the above formula.

Result :

1. The moment of inertia of a given circular plate about an axis
   (a) perpendicular to the plane is = kgm^2
   (b) along the diameter is = kgm^2
2. The moment of inertia of a given rectangular plate about an axis
   (a) perpendicular to the plane is = kgm^2
   (b) perpendicular to the length is = kgm^2
3. Rigidity modulus of the given wire = N/m^2

Observations & calculations

Body	Axis	I = Moment of inertia (kg m^2)	Time for 10 oscillation in sec			Period $T = \frac{t}{10}$ in sec	$\left(\frac{I}{T^2}\right)$ kgm^2/s^2
			Trial1	Trial2	Mean (t)		
Circular body	Perpendicular to its plane 	$I = \frac{M_1R^2}{2}$					
	along the diameter 	$I = \frac{M_1R^2}{4}$					
Rectangular body	Perpendicular to its plane 	$I = \frac{M_2\left(L^2 + B^2\right)}{12}$					
	Perpendicular to its length 	$I = \frac{M_2L^2}{12}$					

Mean $\frac{I}{T^2}$ = kgm^2/s^2

Radius of the experiment wire r = d/2= ______________________________ m

Length of the wire between the two chuck nuts l = ________ cm= _______m

Mass of the circular body M_1= ______________________________kg

Radius of the circular body R = (circumference / 2π) =______cm =______m

Mass of the rectangular body M_2= ___________________________________kg

Length of the rectangular body L = ______________cm = ______________m

Breadth of the rectangular body B = _______________cm = _____________m

Observations & calculations

Observations & calculations

Observations & calculations

VIVA –VOCE

1. FERMI ENRGY

1. What is meant by Fermi energy?
It is the energy of the highest occupied level of the electrons at zero absolute.
2. What is the unit for Fermi energy?
Unit of Fermi energy is eV (1eV=1.6×10^{-19} J)
3. What is meant by Fermi factor?
It is the probability of occupation of given energy state for a material in thermal equilibrium.
7. What is meant by Fermi temperature T_F?
It is the temperature at which the average thermal energy of the free electrons in a solid becomes equal to the Fermi energy at 0K.
8. What is the relation between E_F& T_F?
A $E_F=k_BT_F$ where k_B is the Boltzmann's constant.
9. What is meant by Fermi velocity?
It is the velocity of those electrons which occupy the Fermi level.
10. What is meant by Fermi Dirac distribution?
It is the representation which depicts the details of distribution of electrons among the various available energy levels of a material under thermal equilibrium conditions. Fermi factor is called as Fermi Dirac distribution function.

11. State Pauli's exclusion principle?
It states that no 2 electrons having same quantum number can occupy the same energy level at the same time.

12. What are the values of Fermi factor at different temperatures?
1.when $E>E_F$, T=0K, f (E) =0
2. When $E<E_F$, T=0K, f (E) =1
3. When T>0K, $E=E_F$, f (E) =1/2
13. What is meant by mean free path (λ)?
It is the average distance travelled by the conduction electrons between successive collisions with lattice ions. It is measured in m.

14. What is meant by mean collision time (τ)?
The average time that elapse between two successive collisions of an electron with the lattice points is called mean collision time.
15. What is meant by relaxation time (τ_r)?
Due to sudden disappearance of an electric field across a metal the average velocity of its conduction electrons decays exponentially to zero. And the time required in this process for the average velocity to reduce to 1/e times its value just when the field is turned off, is known as relaxation time.
16. What is meant by drift velocity?
The velocity of the electron in the steady state in an applied electric field is called the drift velocity (m/s)

2. WAVELENGTH OF LEDs

1. What is LED?
Ans: LED is the abbreviation of LIGHT EMITTING DIODE.

2. What is Light Emitting Diodes used for?
LEDs have a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display different types of data.
3. How do LEDs work?
LEDs work on the principle of Electroluminescence. On passing a current through the diode, minority charge carriers and majority charge carriers recombine at the junction. On recombination, energy is released in the form of photons. As the forward voltage increases, the intensity of the light increases and reaches a maximum.
4. What is Electroluminescence?
Electroluminescence is an optical phenomenon, and electrical phenomenon where a material emits light in response to an electric current passed through it.
5. What are the advantages of LEDs?
LEDs consume less power, and they require low operational voltage. No warm-up time is needed for LEDs.
6. What determines the colour of an LED?
The colour of an LED is determined by the material used in the semiconducting element.
7. What are the primary materials used in LEDs?
The two primary materials used in LEDs are aluminium gallium indium phosphide alloys and indium gallium nitride alloys. Aluminium alloys are used to obtain red, orange and yellow light, and indium alloys are used to get green, blue and white light. Slight changes in the composition of these alloys change the colour of the emitted light.
8. What do you mean by forward bias?
The battery connection that permits current to flow across the P-N junction such as by making P-section connected to positive of the battery and N-section connected to negative of the battery is known as forward bias.
9. Explain the flow of electrons across P-N junction with forward bias?
When forward bias is applied to the P-N junction making P- section positive and N-section negative, the holes in the P-section will be repelled by the positive force set up by the power source and move towards the junction between P-and N-type material. At the same time, the electrons in N-section will also be repelled by the negative force set up by the battery voltage and move towards the junction. Normally a potential barrier at the junction prevents electrons and holes moving and combining. The applied voltage gives sufficient energy to these carriers to overcome the potential barrier at the junction and holes move to the right across the junction and the electrons move to left. In the region of P-N junction, electrons and holes meet and combine and cease to exist as mobile charge carries, for each electron-hole combination a covalent bond near the positive terminal of the battery breaks down, an electron is liberated and enters the positive terminal. Due to this action a new hole is created which again moves in the right towards the junction.
In the N region near negative terminal more electrons arrive from the negative battery terminal and enter the N-region to replace the electrons lost by combination with holes near the junction. These electrons again move towards the P-region where they again combine with holes arriving there at the junction. This constant movement of electron towards the left and holes towards the right produces a large current flowing through the junction.
10. What is reverse bias?

A reverse bias is the battery connection across P-N junction making P-section connected to negative of the battery and N-section connected to the positive of the battery.

11. Explain the flow of electrons across a P-N junction with reverse bias.

If the P-N junction is reverse biased, the holes are attracted to negative battery terminal and move away from the junction, while the electrons in N section also move away from the junction because of attraction of the positive terminal. Since there are no hole and electron carriers in the vicinity of the junction, flow of current stops. A small reverse current still flows across the junction. If the reverse bias is made very high the covalent bonds near the junction break down and a large number of electron-hole pairs will be liberated and then reverse current increases abruptly.

12. What are minority carriers and what is their function?

When electrons are liberated due to normal heat energy of crystal, electrons move towards right across the junction, while holes move to the left. These electrons associated with holes become carriers of a small reverse current and are known as minority carriers.

13. What is depletion region?

The positive holes from P-type and negative electrons from N-type combine with each other near the junction to form a charge-free region known as depletion region.(A region devoid of mobile charge carriers)

14. What happens if the reverse bias is made very high?

If the reverse bias is made very high the covalent bonds near the junction break down and a large number of electron-hole pairs will be liberated, the reverse current then increases abruptly to large value.

15. Define knee voltage?

It is that forward voltage at which current starts increasing due to zero resistance of barrier. Knee voltage depends on the material.

16. Distinguish between covalent and ionic bond?

Ionic bonds takes place due transfer of electron ex NaCl. Covalent bond due to sharing of electron .ex silicon

3.NUMERICAL APERTURE

1. **What is numerical aperture**
   Ans. The light gathering capability of the optical fiber is called as numerical aperture.
2. **Define acceptance angle**
   Ans. It is the maximum angle of a ray against the fiber axis hitting the fiber core which allows the incident light to be guided by the core.
3. **What is the phenomenon behind the propagation mechanism of optical fiber**
   Ans. Total internal reflection
4. **What is total internal reflection**
   Ans. When a ray of light moves from denser to rarer medium with an angle of incidence greater than the critical angle the light reflects back to the same medium is called total internal reflection.
5. **What is the condition for the propagation of light inside the optical fiber in terms of acceptance angle.**
   Ans. The angle of incidence must be less than the acceptance angle.
6. **Name the types of optical fibers**.

Ans. Single mode fiber, step index multimode fiber and graded index multimode fiber.

7. **Mention some applications of optical fibers**
   Ans. Point to point communication, submarine cable systems, data links etc
8. **Define attenuation**
   Ans. Attenuation is the loss of power suffered by the optical signal as it propagates through the fiber.
9. **Define V- number**
   Ans. The number of modes supported for propagation in the fiber is determined by a parameter called V- number.
10. **What is the unit for numerical aperture**
    Ans. It is unit less.

4. SERIES AND PARALLEL LCR CIRCUIT

1. Define R, C & L?
R, resistance is the opposition offered by the material for the flow of current. C, Capacitance of a capacitor is defined as the ability of the capacitor to store charge. L, self induction of the coil is defined as the emf induced in the coil when the current through the circuit varies at one ampere per second. Capacitor is short for ac but open for dc. Inductor is short for dc but open for ac.

2. Distinguish between acceptor and rejector circuit?
Series circuit is called acceptor circuit because current at resonance reaches maximum due to minimum impedance where as parallel circuit is called rejector circuit because at resonance current reaches a minimum value due to the maximum impedance of the circuit.

3. Define quality factor and impedance?
Quality factor is defined as the ratio of resonant frequency to the band width. It describes how under-damped an oscillator or resonator is. Resistance offered by the circuit for the flow of ac is called impedance.

4. Define a choke?
It is an inductor which offers very high resistance for the flow of ac.

5. Define mutual inductance?
It is the phenomenon of inducing emf in one coil by varying current in the other.

6. What is the condition of resonance?
When reactive capacitance (opposition offered by the capacitor for the flow of ac) balance inductive reactance (opposition offered by the inductor for the flow of ac) then resonance takes place. At resonance applied frequency balances natural frequency of the circuit.

7. What is meant by time constant?
It is the time taken by the capacitor to get charge to 63% of its maximum value.

8. When I & V will be in phase?
When power factor $\cos\Phi=1=R/Z$ i.e. $R=Z$

9. Define Resonance?
When the applied frequency of the system matches with the natural frequency, the system is said to be under resonance.

10. Define henry?
The inductance of an inductor is said to be 1 henry if 1 volt of emf is induced in the coil when current through it changes at one amp/second.

11. Define a farad?
A capacitor has a capacitance of 1F when a charge of 1 volt across the capacitor produces a current of 1 Ampere through it.
12. Define inductive reactance.
Opposition to the flow of AC current produced by an inductor. Measured in Ohms and is directly proportion to frequency.

$$X_L = \omega L = 2\pi f L$$

13. Define capacitive reactance.
The opposition to current flow provided by a capacitor. Capacitive reactance is measured in ohms and varies inversely with frequency.

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

14. Define impedance.
The total opposition that a circuit offers to the flow of alternating current or any other varying current at a particular frequency. It is a combination of resistance R and reactance X, measured in ohms.
15. How do you identify the resonance in LCR circuits?
The resonance in the LCR circuit is identified by observing the current in the circuit. In series LCR circuit, at resonance current will be maximum and impedance will be minimum. In parallel LCR circuit at resonance the current will be minimum and impedance will be maximum
16. What is the total impedance of the series LCR circuit at resonance?
For a series LCR circuit, the total impedance is given by $z = \sqrt{R^2 + (X_L - X_C)^2}$
17. What is the effective impedance of parallel LCR circuit?
The effective impedance in a parallel LCR circuit is $z = \dfrac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_c}\right)^2}}$

18. What is the energy stored in an Inductor?
The energy stored in an inductor is E= $\frac{1}{2}$ L I^2 , where, L is the self inductance and I is the current.
19. What is the energy stored in a Capacitor?
The energy stored in a capacitor is E= $\frac{1}{2}$ CV^2 , where C is the capacitance and V is the p.d. across the capacitor plates.
20. Series circuit is also called as acceptor circuit. Why?
It will give maximum response to that component of frequency which is equal to its resonant frequency. Hence it is called acceptor circuit.
21. Why parallel circuit is called as rejector circuit?
It takes minimum current of the signal having the frequency which is equal to its resonant frequency
22. What is band width?
Band width is the range of frequencies within which the rms value of current flows.
23. Define upper and lower half power frequencies.
If the series LCR circuit is driven by a variable frequency at a constant voltage, then the magnitude of the current I is proportional to the impedance Z, therefore at

resonance the power absorbed by the circuit must be at its maximum value as $P = I_{max}^2 Z$. If we now reduce or increase the frequency until the average power absorbed by the resistor in the series resonance circuit is half that of its maximum value at resonance, we produce two frequency points called the half-power points. These give us a current value that is 70.7% of its maximum resonant value as: $0.5(I_{max}^2 R) = (0.707 \times I_{max})^2 R$. Then the point corresponding to the lower frequency at half the power is called the "lower cut-off frequency", labelled f_L with the point corresponding to the upper frequency at half power being called the "upper cut-off frequency", labelled f_H. But with respect to parallel resonance circuit, these are the frequencies corresponding to the value of current equal to $I_{min} \cdot \sqrt{2}$

24. Explain why the current is zero at resonance in parallel LCR circuit.

The capacitor draws a leading current, while the inductor draws a lagging current. At resonance the branch currents are equal and opposite. Hence they cancel out and as a result circuit draws minimum current (almost zero) as the impedance is maximum.

5. SPRING CONSTANT

1.Define spring constant

Ans. The quantity that specifies the stiffness of a spring is called the spring constant.

2What is the unit for spring constant ?

Ans. The unit of spring constant is N/m

3.When are springs said to be in series ?

Ans. Two or more springs are said to be in series when they are connected end to end or point to point.

4.What is the equivalent spring constant when they are connected in series ?

Ans. The equivalent spring constant when they are connected in series is given by

$$k_{eq} = \frac{k_1 k_2}{k_1 + k_2}$$

5.When springs are said to be in parallel ?

Ans. Two or more springs are said to be in parallel when they are connected side by side.

6.What is the equivalent spring constant when they are connected in parallel ?

Ans. The equivalent spring constant when they are connected in parallel is given by

$$k_{eq} = k_1 + k_2$$

7.What is the equivalent force when springs are connected in series ?

Ans. $F_{eq} = F_1 = F_2$

8.What is the equivalent force when springs are connected in parallel ?

Ans. $F_{eq} = F_1 + F_2$

9.Define compliance

Ans. The property of a material undergoing elastic deformation or change in volume when subjected to an applied force. It is equal to the reciprocal of spring constant i.e.

$$C = \frac{1}{k}$$

10.Define characteristic of a spring

Ans. A characteristic of a spring is defined as the ratio of the force affecting on the spring to the displacement caused by it.

11.Mention some applications of spring

Ans. The applications of the spring are in the following:

Electric staplers, timing devices, door closures, computer racking system.

6. ENERGY GAP OF SEMICONDUCTOR

1. What is a semiconductor?
Ans. It is a substance with conduction properties between metals and insulators.
2. What is meant by intrinsic semiconductor?
Ans. A pure semiconductor completely free from impurities is called intrinsic semiconductor.
3. What is the order of energy gap in a pure semiconductor?
Ans. 1 eV.
4. What do you mean by an extrinsic semiconductor?
Ans. It is a semiconductor to which an impurity from group 13 or group 15 has been added.
5. What do you mean by a doped semiconductor?
Ans. It is a semiconductor to which an impurity from group 13 or group 15 has been added. Or Extrinsic semiconductor is called doped semicondutor.
6. What is doping?
Ans. It is the process of addition of impurity to a pure semiconductor in order to alter its conduction properties.
7. What are two different types of impurities ?
Ans. The impurities are p-type and n-type.
8. To which group does a (i) p-type, (ii) n type impurity belong?
Ans. p-type impurity belongs to group 13 and n-type to group 15.
9. What are the charge carriers in a pure semiconductor?
Ans. A pure semiconductor has electrons and holes as charge carriers. Their number densities are equal.
10. What are the charge carriers in n-type semiconductor?
Ans. In n-type semiconductor, electrons are majority charge carriers and holes are minority charge carriers.
11. What is the effect of temperature on conductivity of a semiconductor?
Ans. It increases with rise in temperature.
12. What is junction diode?
Ans. A junction diode is formed when a p-type semiconductor is in intimate contact with n-type semiconductor.
13. What is meant by forward bias?
Ans. A pn junction is said to be forward biased when p-region is connected to positive terminal and n-region to the negative terminal of battery.

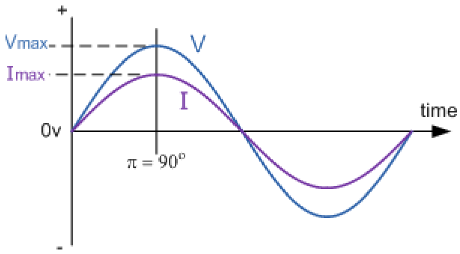
7. DIELECTRIC CONSTANT

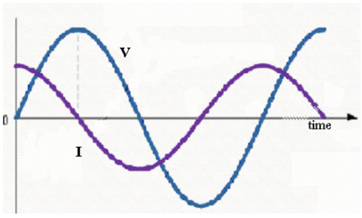
1. What is a capacitor?
Capacitor is a device which is used to store charge.
2. What is meant by capacitance?
Ability to store charge in a capacitor is called capacitance and it is measured in farad(F).

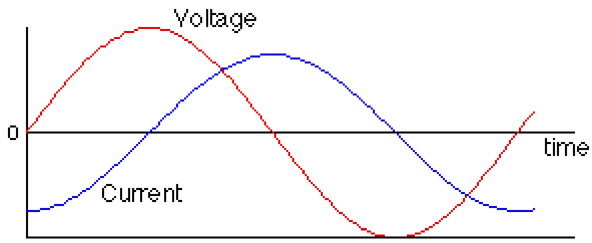
3. What is the relation between Q, C & V?
Q = CV, Q is the charge stored (coulomb), C capacitance (Farad), V (voltage)
4. Define one farad?
It is the amount of charge required to raise the potential by 1 volt.

5. What is dielectric?
Dielectric is a non conducting material which is used to increase the capacitance of the capacitor.

6. Classify dielectric materials.
Dielectric materials are classified into two types, polar and non-polar dielectrics
7. Describe the phase diagram for pure resistor, capacitor and inductor
In a pure resistor, I & V will been phase. In a capacitor I leads V by 90 degree but in case of a inductor V lead I by 90 degree.







8. Define magnitude of polarization
It is the ratio of dipole moment to unit volume. It is measured in C/m^2
9. Define dielectric constant ε_r?
It is the ratio of capacitance in presence of a dielectric to capacitance in presence of vacuum.

10. Show that $\varepsilon_r = \frac{dT_{1/2}\, 10^{-6}}{0.693\, \varepsilon_0 AR}$

We know that $q = q_0 e^{-T/CR}$
When $t = T_{1/2}$, $q = q_0/2$ then $q_0/2 = q_0 e^{-T_{1/2}/CR}$
Taking natural log both sides $CR \ln_e 2 = T_{1/2}$

$$0.693CR = 0.693\, \varepsilon_0 \varepsilon_r A/d = T_{1/2}$$

$$\text{Then } \varepsilon_r = \frac{dT_{1/2}\, 10^{-6}}{0.693\, \varepsilon_0 AR}$$

11. Define electric susceptibility (χ)?
It is the ease with which dielectric material gets polarized. It is dimensionless.
$\chi = (\varepsilon_r - 1)$
12. Define dielectric displacement D?
It is the ratio of dielectric flux per unit area. It unit is C/m^2
13. What are polar and non polar dielectrics?

In case of polar dielectrics the effective center of positive & negative charges does not coincide. Ex Hcl, nitro benzene. In case of non-polar, effective center of positive and negative charges coincide ex. Paraffin.

14. Explain polarization in case of polar dielectrics?
When an electric field is applied across a polar dielectrics, dipoles align along the direction of electric field and neutralization of charges takes place & electric field inside the dielectrics will be created opposite to that of the field, but it gets polarized along the direction of field. Hence the voltage across the dielectrics decreases, the battery drives some charges to the capacitor till the applied voltage balance. By the time voltage balance more charges will be stored inside the capacitor, the capacitance of the capacitance increase.

15. Explain polarization in case of non-polar dielectrics?
When an electric field is applied across the non-polar dielectrics, positive charges and negative charges move apart and dipoles form. Then dipoles align along the direction of field, neutralization takes place and polarization takes place along the direction of field.

16. Name the different types of polarization mechanism?
The different types of polarization mechanisms are electronic, ionic, orientational & space charge polarization.

17. What is the advantage of dielectric strength?
Higher the dielectric strength lower will be the thickness of the dielectrics and the size of the capacitor decreases.

18. What is the equation of potential energy stored in a capacitor?
Potential energy stored in a capacitor is = $\frac{1}{2}CV^2$

19. If area or thickness of the dielectrics is varied will it affect the value ofdielectrics?
No, because the dielectric constant of dielectrics depends on the material rather than dimensions.

20. What is the effect of C &R on the time constant $T_{1/2}$?
As the value of C or R or both decreased, the value of time constant increases then capacitor takes more time for charging and discharging.

21. Define dielectric loss?
It is the loss of energy in the form of heat when an ac field is applied across a dielectric material.

<u>8. PHOTO DIODE CHARACTERISTICS</u>

1. What are photodiodes?
Photodiodes are semiconductor devices that respond to light energy particles & photons

2. What are the three major types of photodiodes & explain briefly about them?
The three major types of photodiodes are (i)PN junction diode, (ii)PIN junction photodiode & (iii) Avalanche photodiode.
PN junction photodiode comprise of a two electrode, radiation sensitive PN junction formed in a semiconductor material in which reverse current varies with the amount of illumination.

PIN junction photodiodes are diodes with large intrinsic region sandwiched between p-doped & n-doped semiconductor regions. Photons absorbed in this region create electron-hole pairs that are separated by an electric field thus generating an electric current in a load.
Avalanche photodiodes are devices that utilize avalanche multiplication of current by means of hole-electron pairs created by absorbed photons. When reverse bias voltage of the diode approaches breakdown level, hole-electron pairs collide with ions to create additional hole-electron pairs, thus resulting in signal gain.
3. What does the photodiode acts like when it is illuminated ?
Photodiode acts like a current source when it is illuminated.
4. Define responsivity
It is the ratio of photo current I_{PD} to the incident light power P at a given wavelength. It is the effectiveness of the conversion of light power into electrical current.
5. On what factors does the responsivity depend on
Responsivity varies with the wavelength of the incident light as well as the applied reverse bias & temperature.
Responsivity increases slightly with applied reverse bias due to the improved charge collection efficiency of photodiode. Also it varies due to change in the temperature. This is due to the decrease or increase of the band gap because of the increase or decrease in the temperature respectively.

9. DIFFRACTION GRATING

1. What is diffraction of light ?
The deviation of a light ray from its rectilinear path, when it passes across objects whose dimensions are comparable to the wavelength of the light is called diffraction. It is classified into two types Fresnel diffraction, Fraunhoffer diffraction.
2. Distinguish between Fresnel &Fraunhoffer diffraction?
Fresnel diffraction is the diffraction effect observed when spherical or cylindrical wavefronts are involved. No lenses are needed to enable observing the effect since the source & screen are at finite distances from the obstacle or aperture. Examples are diffraction effect produced when light passes across a thin straight edge (as that of a razor), or a thin straight wire.
Fraunhoffer diffraction is the diffraction effect observed only when a plane wavefront is involved. Such a condition necessitates establishing a gap of infinite distance between both the source and the screen from the obstacle or aperture, which is manipulated by employing two lenses suitably. The diffraction effect produced by a diffraction grating is the most important example in this class of diffraction.
3. Distinguish between interference and diffraction
(a) Interference is due to the resultant effect of overlapping of light waves, originating from two coherent sources.
Diffraction is due to the resultant effect of overlapping of light waves originating from every point on the exposed part of the same wavefront.
(b) In interference, the intensity of light varies between zero and a fixed maximum value for successive dark and bright fringes
In diffraction, the intensity of light varies between minimum and maximum for successive dark and bright fringes in which the difference between the maximum and minimum values decrease rapidly.

(c) The fringe width in case of interference could be either constant (ex : air-wedge fringes) or varying (ex: Newton's rings).
In diffraction, fringe width always varies.

4. Distinguish between diffraction and dispersion

Diffraction: Bending of light around the edges of an obstacle is called diffraction. In this case lower the wave length lower will be the deviation.

Dispersion: When white light pass through a prism it splits into its constituent colors. This phenomenon is called dispersion. In this case lower the wave length higher will be the deviation.

5. What is the condition for diffraction?

Size of the obstacle should be comparable with that of the wave length of the light source.

6. What is a diffraction grating?

An optically plane glass plate on which a very large number of equally spaced parallel opaque straight rulings are made is called a diffraction grating.

7. What is grating constant or grating element ?

In a grating it is absolutely essential that the width 'a' of a clear transparent interspace is same throughout the grating. Similarly, the width 'b' of the ruling, which also constitutes the spread of the opaque part on the grating must be same anywhere in the grating. Thus the sum (a+b)=c, remains a constant for a grating, and it is called the grating element or grating constant.

8. Distinguish between polychromatic & monochromatic source.

Polychromatic source is one which produces radiations having different wave lengths. Ex. Mercury vapour lamp.

Monochromatic source: is one which produces radiations having single wave length. Ex. Laser source.

9. Distinguish between transmitting & reflecting grating.

If rulings are drawn on a transparent glass plate by a diamond point it is called transmitting grating. If the rulings are drawn on a silvered glass plate then it is called reflecting grating.

10. What is the acronym for LASER?

Light amplification by stimulated emission of radiation.

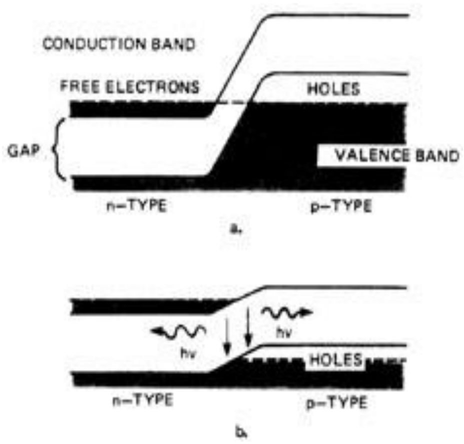
11. What is the type of laser is used in the experiment?

A Semi conductor diode laser is used in the experiment.

12. Describe the working of a semiconductor diode laser.

- When the p-n junction is heavily forward biased with large current, electrons jump from valence band to conduction band.
- It is an unstable state & within small interval of time ($\sim 10^{-13}$ s) the electrons in the conduction band drop to the lowest level in that band.
- At the same time the electrons near the top of the valence band will drop to the lowest unoccupied levels, leaving behind the holes.
- Now the lowest level of the conduction band is full of electrons while the top of the valence band is full of holes.
- This indicates the population inversion between valence band & conduction band.
- At some instant one of the excited electron from conduction band falls back into the valence band to recombine with a hole and the energy associated with this recombination is emitted as a photon of light.
- This photon while moving stimulates the recombination of another excited electron with a hole and releases another photon.

- These two photons are in phase with each other and have same wavelength thus travel together and get reflected at the end face.
- While they travel back they stimulate more electron hole recombination with the release of additional photons & thus becomes a part of monochromatic & coherent laser beam.
- This beam by traveling back &forth finally leaves through the partially reflecting face.



10. TORSIONAL PENDULUM

1.Define time period ?
Time taken for one complete oscillation.
2.What is torsional pendulum?
A body suspended from a rigid support by means of a long and thin elastic wire& undergoing torsional oscillations is called torsional pendulum.
3.On what factors does the time perioddepends on?
It depends upon (a) moment of inertia of the body (b) rigidity of wire i.e., length, radius and material of the wire.
4.What is S.H.M ?
A body is said to have a S.H.M , if its acceleration is always directed towards a fixed point on its path and is proportional to its displacement from the fixed point.
5.Definerigidity modulus ?
When tangential surface forces are applied on a body, the successive layers of the material are moved or sheared.This type of strain is called shearing strain. “The ratio of tangential stress to shearing strain is called Rigidity of modulus”
6.Define moment of inertia ?
It is the measure of the inertia of a body in rotatory motion. It depends upon the axis of rotation, mass of the body and also on the distribution of the mass about the axis.
7.What is the difference between simple pendulum and torsional pendulum ?
In a simple pendulum the simple harmonic motion is due to the restoring force which is the component of the weight of the bob. In a torsional pendulum the simple harmonic motion is due to the restoring couple arising out of torsion and shearing strain.