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Aim of the Experiment :-

Determination of Velocity of ultra-sonic waves in liquids by stationary wave method.

Apparatus Required :-

- Ultra-sonic Inferometer
- High frequency Generator
- Measuring Cell
- Sample liquids

Date 01/oct/2020

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EXPERIMENT - 1

Aim of the Experiment

Determination of velocity of ultra-sonic waves in liquids by stationary wave method

Apparatus Required

- Ultra-Sonic Inferometer
- High Frequency Generator
- Measuring Cell
- Sample liquids

Theory

~~the~~ Ultrasonic Inferometer is a simple device which yields accurate and consistent data from which one can determine the velocity of ultrasonic sounds in the liquid medium.

⇒ Ultrasonics : ultrasonic sounds refers to the sound pressure greater than the human audible range (20 Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over very short distance in direction parallel to the longitudinal wave. This cause the wave to pass through the medium.

Teacher's Signature :

Observation Table :

Least Count of Circular Scale = 0.01

Main Scale Reading (mm)	Circular Scale reading × L.C (0.01)	MS + CS	$X_n - X_{n-1}$	Total (mm)
17	.47	17.47	17.82 − 17.47	0.35
17.5	.32	17.82	18.18 − 17.82	0.36
18	.18	18.18	18.57 − 18.18	0.39
18.5	.07	18.57	18.93 − 18.57	0.36
18.5	.43	18.93	19.29 − 18.93	0.36
19	.29	19.29	19.63 − 19.29	0.34
19.5	.15	19.63	20.02 − 19.63	0.39
20	.02	20.02	—	—

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⇒ Generation of Ultrasound

Piezoelectric Generator is used to generate the ultrasound. When a mechanical pressure is applied to opposite faces of certain crystals which are cut suitably, electric fields are produced. Similarly, when subjected to an electric field, these crystals contract or expand, depending upon the direction of field. Thus a proper oriented rapid alternating electric field causes a piezoelectric crystal to vibrate mechanically. This vibration largest when the crystal is at resonance is used to produce a longitudnal wave ie a sound wave.

⇒ Ultrasonic Inferometer:

In ultrasonic inferometer, the ultrasonic waves are produced by the piezo electric method. In a fixed frequency variable path inferometer, the wavelength of the sound in an experimental liquid medium is measured and from this one can calculate its velocity than its medium. The apparatus consists of an ultrasonic cell which is double walled brass cell with chromium plated surface having capacity of 10 ml. The double wall allows water circulation around the experimental medium to maintain it at a known constant temprature.

The micrometer scale is marked in units = 0.01 mm and

Teacher's Signature :

Calculations :

Thus, mean (d)

$$d = \frac{0.35+0.36+0.39+0.36+0.36+0.34+0.39}{7}$$

$$\boxed{d = 0.36428 \text{ mm}}$$

Thus, wavelength (λ)

$$\lambda = 2 \times d = 2 \times 0.36428$$

$$\boxed{\lambda = 0.72856 \text{ mm}}$$

Thus, velocity (v)

v = frequency (f) × wavelength (λ)

$$v = f \times \lambda$$

frequency of the ultrasonic waves is 2 MHz

$$\Rightarrow v = (2 \times 10^6) \times (0.72856 \times 10^{-3})$$

$$\boxed{v = 1457.12 \text{ m/s}}$$

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has an overall length of 25 mm. Ultrasonic waves of frequency are produced by a quartz crystal which is fixed at the bottom of the cell. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half-wavelength of sound, standing waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in the anode current of the piezo electric generator.

If we increase or decrease the distance by exactly one of the half of the wavelength ($\lambda/2$) or an integer multiple of the one half wavelength, the anode current gain become maximum. If d is separation between successive adjacent maxima of anode current then $d = \lambda/2$

we have, the velocity (v) of a wave is related to its wavelength (λ) by the relation $v = \lambda f$

where f is the frequency

then $v = \lambda f$

$v = 2d \cdot f$

Teacher's Signature : ______

Results :

Thus the velocity of the ultrasonic waves in liquids ~~in~~ is 1457.12 m/s .

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Procedure :

- Insert the quartz crystal in the socket at the base and clamp it tightly with the help of a screw provided on one side of the ~~moment~~ instrument.

- Unscrew the knurled cap of the cell and ~~fit~~ lift it away. fill the middle portion with the experimental liquid and screw the knurled cap tightly.

- Then connect the high frequency generator with the cell.

- There are two knobs on the instrument - "Adj" and "Gain". With "Adj" position of the needle on the ammeter is adjusted. The knob "Gain" is used to increase sensitivity of the instrument.

- Increase the ammeter setting till the anode current in the ammeter shows maximum. Note down the readings.

- Continue to increase the micro ammeter readings. Note the reading at each maximum. Note near about 7 or 8 readings.

- The distance between the two consective crest should

Teacher's Signature :

Results :-

Thus the velocity of ultrasonic waves in liquids is 1457.12 m/s .

Sources of Errors :-

- Sometimes knob is related in excess that causes Problem or error in calculations. Screw gauge rotation causes error.
- Sometimes readings of screw gauge are not taken Properly.
- Current has not reach the maxima and readings are noted down that leads to error.

be calculated which will be equal to the $\lambda/2$.

- Record all the values of Main scale as well as circular scale. Note Now multiply the value of circular scale with least count of the circular scale.
- Add ~~all~~ the main scale reading with the least ~~count~~ circular scale reading multiplied with least count.
- Now substract the consective values in order to get the value.

Sources of Error

- Sometimes knob is rotated in excess that cause Problem or error in calculation. Screw gauge rotation causes error.
- Sometimes reading of screw gauge are not taken Properly.
- Current has not reach the maxima and readings are noted down that leads to error.

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Precautions :

- Small rotation of the frequency knob can make a large change in frequency of ultrasonic wave. So rotate it very slowly.
- Screw gauge reading should be taken Properly.
- Wait for current to reach the maxima only then reading should be taken.
- Gauge should be rotated in one direction otherwise it leads to backlash error.

Results :

The velocity of the ultra-sonic waves in liquids by stationary wave method is 1457.12 m/s.

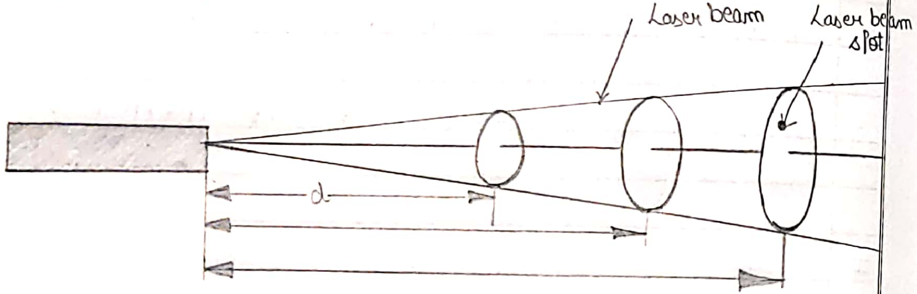
Teacher's Signature : ______

Aim of the Experiment :

To determine beam divergence and beam intensity of a laser beam.

Apparatus Required :

- Laser (He-Ne)
- Inch-tape
- Graph Paper
- Cello-tape



Observation Table :

S.No	Distance (m)	Diameter (mm) Horizontal	Vertical	Average	Radius (m)	Spot Area (m^2)	Beam Intensity
1	1m	3mm	3mm	3mm	1.5×10^{-3} m	$7.06\times10^{-6}\ m^2$	283.93 W/m^2
2	2m	4.5 mm	4.5mm	4.5mm	2.25×10^{-3} m	$15.89\times10^{-6}\ m^2$	125.86 W/m^2
3	3m	7mm	7mm	7mm	3.5×10^{-3} m	$38.46\times10^{-6}\ m^2$	52.002 W/m^2
4	4m	8.5	8.5mm	8.5mm	4.25×10^{-3} m	$56.71\times10^{-6}\ m^2$	35.26 W/m^2
5	5m	10mm	10mm	10mm	5×10^{-3} m	$78.5\times10^{-6}\ m^2$	25.641 W/m^2

Experiment - 2

Aim of the Experiment :

To determine beam divergence and beam intensity of a laser beam.

Apparatus Required :

- Laser (He-Ne)
- Inch tape
- Graph Paper
- Cello-tape

Procedure :

A) Beam Divergence

- Paste the graph paper on a wall using cellotape.
- Place a laser about 5m away from the graph paper such that the laser spot is formed clearly on it. Note its diameter.
- Take the similar readings at 4m, 3m, 2m & 1m.
- Plot a graph between spot size and distance which shows that the laser beam divorges as we move away from the graph paper.

B) Beam Intensity

- Find the area of laser beam spots for all the positions taken under (A).

formula used :

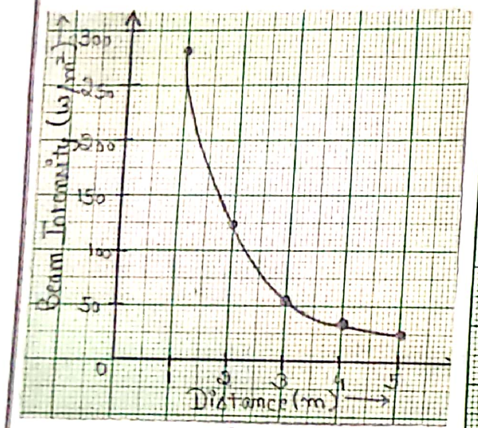
Radius (m) $= \dfrac{\text{diameter}^{(mm)}}{2} \times 10^{-3}$ m

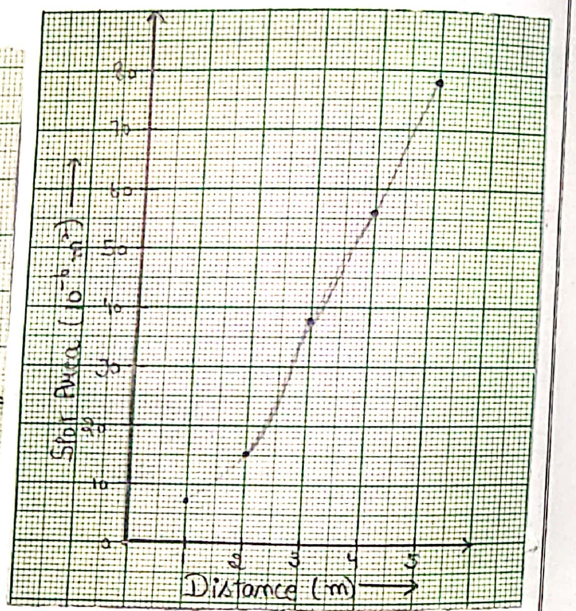
Spot Area $= \pi r^2$ (m^2)

Beam Intensity $= \dfrac{\text{Power}}{\text{Spot Area}}$

$\boxed{\text{Power} = 2\,mW = 2 \times 10^{-3}\ W}$

Graph :





Results :

- Laser beam diverges with distance.
- Laser beam intensity falls with distance.

- Divide laser beam Power by these spots areas for each laser Position. The given laser beam intensity at different Positions of the laser.

- Plot a graph between The beam intensity and distance which shows fall of beam intensity as the laser is moved away from the graph paper.

Precautions

- Avoid direct exposure to the laser beam.
- While marking the spot one must be careful that the mark is at the Periphery of the laser beam. It must not be very inward or outward of the beam.

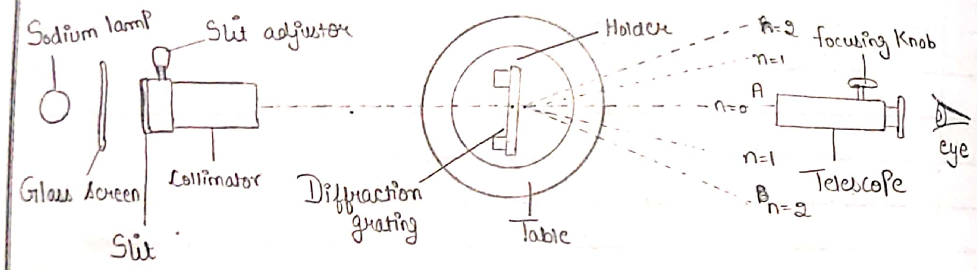
Results :

- Laser beam diverges with distance.
- Laser beam intensity falls with distance.

Experiment - 3

Aim of the Experiment :
To determine the dispersive Power of a Na D-line using grating.

Apparatus Required :
- Spectrometer
- Grating element
- Collimator
- Sodium lamp
- Magnifier
- Telescope



Observation Table :

	n	MSR	VSR	Total	θ
Centeral	0	341.5	8	341.633	
1st Right	1	351.0	27	351.450	9.817
2nd Right	2	361.0	15	361.250	19.617
1st Left	-1	331.0	15	331.250	10.383
2nd Left	-2	320.0	10	320.167	21.467

$n=1 \quad \theta_1 = \frac{9.817+10.383}{2} = 10.1$

$n=2 \quad \theta_2 = \frac{19.617+21.467}{2} = 20.542$

Experiment-3

Aim of the Experiment :
To determine the dispersive Power of a Na D-line using grating.

Apparatus Required :
- Spectrometer
- Diffraction grating OR Grating element
- Collimator
- Sodium lamp
- Magnifier
- Telescope

Theory : Departure from the expectations of any ray optics are broadly classed under the term diffraction. A diffracted image thus means an image off the line of sights due to deviation of light from the straight line Path. A series of such images at increasing angle of deviation are called as 1st, 2nd, 3rd .... order images respectively shown as P_1, P_2, P_3 etc. P_0 is the direct image (centeral order) where all diffracted rays are meeting in phase.

The condition to obtain P_1, P_2 .... etc

As Dispersive Power

$$\frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

Wavelength $\lambda = \frac{(a+b)\sin\theta}{n}$

$$\lambda_1 = \frac{(a+b)\sin\theta_1}{n} = \frac{(1/300\,mm)[\sin(10.00)]}{1} = 584.556\,nm = 5845.56\,A^\circ$$

$$\lambda_2 = \frac{(a+b)\sin\theta_2}{n} = \frac{(1/300\,mm)[\sin(20.542)]}{2} = 584.823\,nm = 5848.23\,A^\circ$$

Dispersive Power

$$\left[\frac{d\theta}{d\lambda}\right]_{n=1} = \frac{n}{(a+b)\cos\theta} = \frac{1}{(1/300\,mm)\cos(10.1)} = 304.792\ rad/mm$$

$$\left[\frac{d\theta}{d\lambda}\right]_{n=2} = \frac{n}{(a+b)\cos\theta} = \frac{2}{(1/300\,mm)\cos(20.542)} = 640.741\ rad/mm$$

Error :

$$\%\ Error = \frac{5896.00 - 5846.895}{5896.00} \times 100$$

$\boxed{\%\ Error = 0.832\ \%}$

Results :

Wavelength of Na-D lines = 5846.895 A°

images (ie points of maximum intensity) is that the path difference at a given point on the screen between the two rays coming from the corresponding points of the slits is an integral multiple of ie the wavelength of the incident light. Clearly, this condition is represented by the equation :

$$(a+b)\sin\theta = n\lambda$$

$$\text{Dispersive Power} = \frac{d\theta}{d\lambda} = \frac{n}{(a+b)\cos\theta}$$

where $(a+b)$ is the grating element
a = width of transparency
b = width of an opacity
n = order of the spectrum
θ = angle of diffraction

Measure θ as explained below and make use of the above equation to find the dispersive power of Na-D line.

Procedure :

After setting the fine slit, telescope and collimator for parallel rays and grating normal to incident yellow light from sodium lamp.

Measurement of θ

1. Set the telescope on the yellow line of the sodium light spectrum.
2. Rotate the telescope on either side of the centeral position of the telescope for the first and second

order in succession and record these readings.

3. The half of the diffrence between these readings corresponding to 1st and 2nd order gives the angle of diffraction for respective orders.

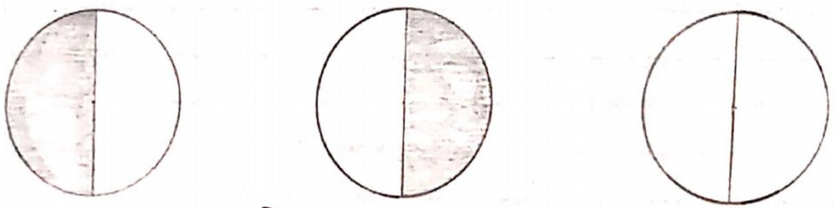
Precautions and Sources of Error

- The focusing of collimator and the telescope after adjusted for parallel rays should not be disturbed through out the experiment.
- Once the grating is properly adjusted on the turntable it should be locked.
- while taking measurements at different positions of the telescope. It must be always be in locked condition.
- While rotating the telescope arm if the vernier crosses over 0° (360°) on the circular scale take the angular diffrence appropriately.

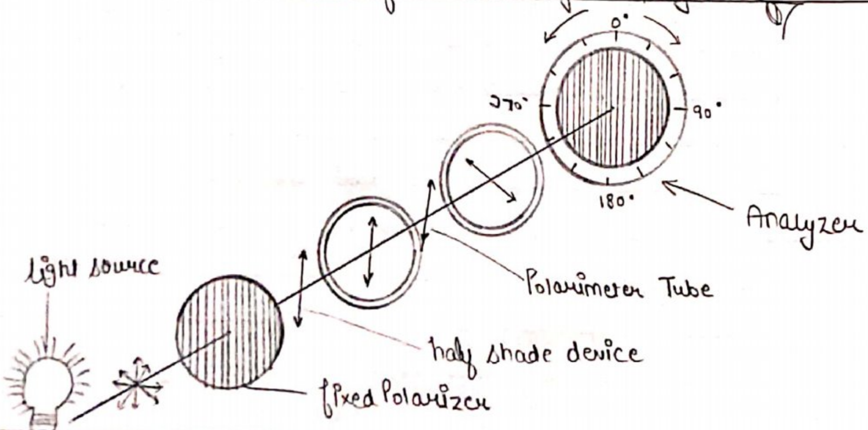
Experiment - 4

Aim : To determine the specific rotation of cane sugar dissolved in water.

Apparatus Required :
- Polarimeter
- 100 CC flask
- Polarimeter tube (2 dm)
- Sugar (5gm)



Field of views through analyzer



Experiment - 4

Aim of the Experiment :

To determine the specific rotation of cane sugar dissolved in water.

Apparatus Required :

- Polarimeter
- 100 cc flask
- Polarimeter tube (2dm)
- Sugar (5gm)

Theory :

The rotation produced by an optically active substance depends upon :

1. The wavelength of light used.
2. The temprature.
3. The path traveled by ray of light (length of polarimeter tube)
4. The density or concentration of the solution.

Suppose the length of the polarimeter tube = l unit
Concentration of solution used. = gm/cc

The angular rotation produced (corresponding to given wavelength and temprature) $\theta = \alpha l c$

Observation Table :

Room Temp = 35°C , Length of Polarimeter = 2 decimeter
Mass of sugar dissolved = 20gm
Volume of solution = 100 CC

With water			With Cane Sugar Solution			Angle of rotation θ
Analyzer Reading			Analyzer's Reading			$\theta = \theta_S - \theta_w$
Main Scale (MS)	Vernier Scale (VS)	θ_w T= MS+VS	Main Scale (MS)	Vernier Scale (VS)	θ_S T= MS+VS	
154	0.5	154.5	180	0.1	180.1	$\theta_1 = 25.6°$
27	0.3	27.3	51	0.8	51.8	$\theta_2 = 24.5°$
86	0.1	86.1	110	0.4	110.4	$\theta_3 = 24.3°$

$$\text{Average} = \frac{\theta_1+\theta_2+\theta_3}{3} = \frac{25.6+24.5+24.3}{3}$$

$$\boxed{\text{Average } \theta = 24.8°}$$

Results :

$$\alpha = \frac{\theta}{l} \times \frac{V}{x} = \frac{24.8}{2} \times \frac{100}{20} = 62° dm^{-1} (g/cc)^{-1}$$

$$\boxed{\alpha = 62° dm^{-1} (g/cc)^{-1}}$$

where α is specific rotation
θ = Rotation in degree
l = length of solution tube in dm
V = Volume of solution in CC
x = weight of dissolved sugar in gm

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Where α is the specific rotation.

$$\alpha = \frac{\theta}{lC} = \frac{\text{rotation in degree}}{\text{length in decimeter} \times \text{concentration}(gm/cc)}$$

When $l = 1$ decimeter , $C = 1$ gm/cc , then $\alpha = \theta$

So we can define specific rotation as the rotation produced by one decimeter length of solution of a unit concentration for a given wavelength and at the given temprature.

Procedure :

1. Clean Polarimeter tube and fill it with distilled water. Place the tube inside the apparatus at its given position. So the field of view at equal intensity. and note the readings of the position of angle from both the scales. Mark them as θ_w and θ'_w.

2. Now Pour out of water from the tube and fill it with the given sugar ~~con~~ solution. Again set the field of view at same position as before. Note down the reading of the position of angle from both the scales. Mark them as θ_S and θ'_S.

3. The angle of rotation $\theta_1 = \theta_S - \theta_w$, $\theta_2 = \theta'_S - \theta'_w$

Teacher's Signature :

Percentage Error:

$$\alpha = \frac{\theta}{l \times C}$$

taking log on both sides $\log \alpha = \log \theta - \log l - \log C$

differentiating both sides $\frac{d\alpha}{\alpha} = \frac{d\theta}{\theta} - \frac{dl}{l} - \frac{dC}{C}$

Since l and C are constants, dl and dC = 0

$$\therefore \frac{d\alpha}{\alpha} = \frac{d\theta}{\theta}$$

$\%\ \text{Error} = \frac{d\theta}{\theta} \times 100$

$d\theta$ = least count

θ = average value of angle of rotation.

$\%\ \text{Error} = \frac{0.1}{24.8} \times 100 = 1.16\%$

$$\boxed{\%\ \text{Error} = 1.16\%}$$

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Angular rotation $\theta = \frac{\theta_1 + \theta_2}{2}$

4. Calculate specific rotation of given salt solution by

$$\alpha = \frac{\theta}{lC}$$

Results:

The specific rotation of given cane sugar solution is

$\alpha = 62\ \text{deg}\ dm^{-1}\ (g/cc)^{-1}$.

Precautions:

1. The polarimeter should be cleaned properly.
2. There should not be any air bubble in the tube filled with water/solution.
3. Solution should be clear and dust free.
4. Equally bright positions should be used for taking readings.
5. The position of the analyzer should be set accurately.
6. The temprature and wavelength of light must be stated.
7. Switch off the lamp after completing the experiment.

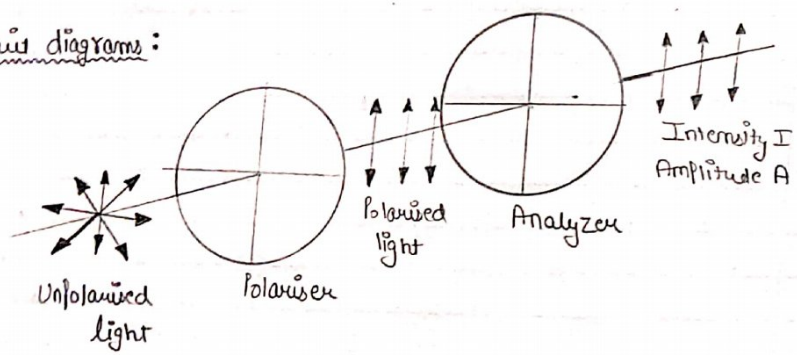
Teacher's Signature :

Experiment - 5

Aim of Experiment :
To study and verify Malus law.

Apparatus Required :
Optical bench with Polarizer, analyzer lens and detector along with lamp, multimeter, Voltage stabliser.

Circuit diagrams :



Observation Table :

$I_0 = 9.14 mA$

S.No	θ (degree)	$\cos^2\theta$	I (V_0=12V)	$I_0 * \cos^2\theta$
1	0	1.000	9.14	9.14
2	15	0.933	8.76	8.52
3	30	0.750	7.64	6.85
4	45	0.500	5.78	4.57
5	60	0.250	3.54	2.28
6	75	0.060	1.24	0.54
7	90	0.000	0.25	0.00

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Experiment - 5

Aim of the Experiment :
To ~~ver~~ verify Malus law.

Apparatus Required :
Optical bench with Polarizer, analyser, lens and detector along with lamp, multimeter, voltage stabiliser.

Procedure :

1. Set voltage at 16V to achieve maximum lamp intensity.
2. Set lamp, Polarizer, analyser, lens and detector in one line.
3. Set Polarizer, analyzer at zero Position and look for current value. It should be maximum.
4. Change Polariser Position in steps of 15° and note down the value of current.
5. Current values will corresponds to I and Position difference between Polarizer and analyzer as θ.
6. Record your observations in a suitable table.
7. Draw curve between I and $\cos^2\theta$ and also between I and θ.

formula used :

$$I = I_0 \cos^2\theta$$

Teacher's Signature : ________

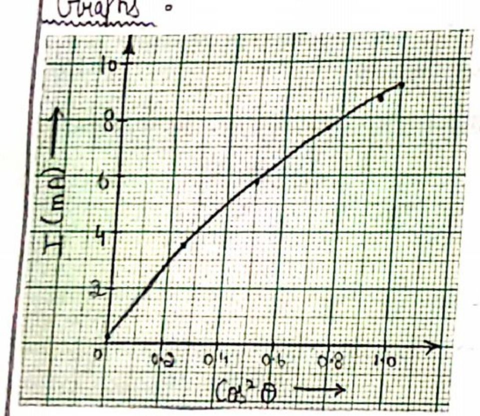
Formula used : $\boxed{I = I_0 \cos^2\theta}$

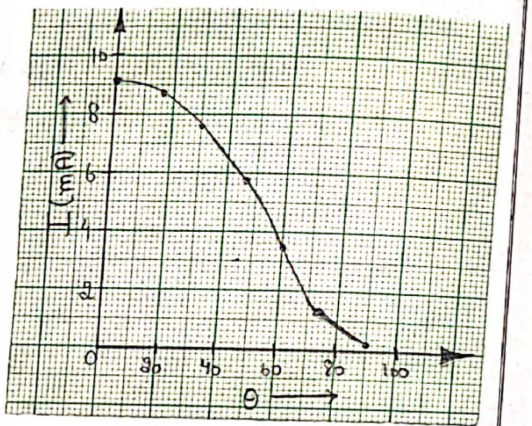
Calculations : Maximum Intensity of light, $I_0 = 9.14$ mA

Intensity $(\Sigma I_0 \cos^2\theta) = 9.14 + 8.52 + 6.85 + 4.57 + 2.28 + 0.54 + 0 = 31.9$

Intensity $(I) = 9.14 + 8.76 + 7.64 + 5.78 + 3.54 + 1.24 + 0.25 = 36.35$

Graphs :





Percentage Error :

$$\% \text{ Error} = \frac{|\Sigma I_0 \cos^2\theta - \Sigma I|}{\Sigma I_0 \cos^2\theta} \times 100 = \frac{|31.90 - 36.35|}{31.90} \times 100$$

$$\boxed{\% \text{ Error} = 13.9\%}$$

Results :

The Malus law is verified with an error of 13.9 %.

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I_0 = maximum intensity of light passing through analyzer when angle b/w the plane of Polariser and analyzer is 0°.

I = intensity of light when θ is not zero.

θ = angle b/w transmission axis of polarizer and analyzer.

Sources of Error

- Experiments must be performed within dark rooms
- Lamp, Polariser and analyzer should be aligned linearly.
- Position of Polariser should not be disturbed.
- Note all the readings and plot the graph carefully.

Percentage Error

$$\% \text{ Error} = \frac{[\Sigma I_0 \cos^2\theta - \Sigma I]}{\Sigma I_0 \cos^2\theta} \times 100$$

$$\% \text{ Error} = \frac{(31.90 - 36.35)}{31.90} \times 100 = 13.9\%$$

Results :

Thus Malus law is verified with an error of 13.9 %.

Teacher's Signature :

Experiment -6

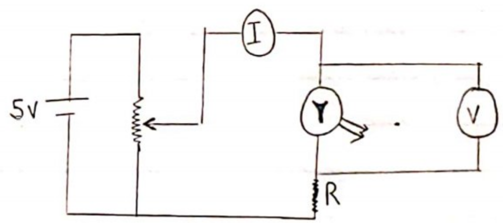
Aim of the Experiment :

To determine the value of Planck's constant.

Apparatus Required :

- Ammeter
- Voltmeter
- Connecting wires
- LED Bulbs

Circuit diagram :



Observation Table :

Wavelength (λ) of red colour = 780nm

Wavelength (λ) of yellow colour = 597nm

Wavelength (λ) of green colour = 577nm

Wavelength (λ) of blue colour = 492nm

e = q = electronic charge

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

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

Experiment-5

Aim of the Experiment:

To determine the value of Planck's Constant.

Apparatus Required:

- Ammeter
- Voltmeter
- Connecting Wires
- LED Bulbs

Theory: Max Plancks first proposed the idea that light was emitted in discrete packets or quanta in order to avoid the infamous ultra-violet catastrophe. With one problem resolved other questions soon followed. Primarily how big was a given packet? It was subsequently determined that the energy of a given photon is given by the eq.

$$E = h\nu \quad — (1)$$

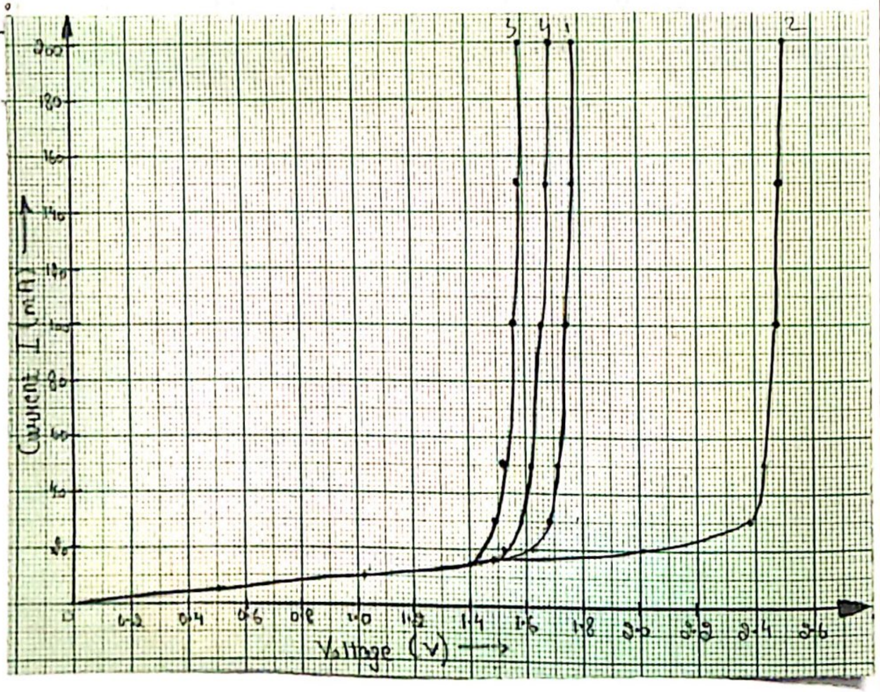
where E is the energy of the photon and ν is the frequency and h is the Planck's constant.

The objective of this experiment is to determine Planck's constant using light emitting diodes (LED's) by observing the "reserve photo electric effect".

Observation Table :

Green		Blue		Red		Yellow	
Voltage (V)	Current (A)	Voltage(V)	Current (A)	Voltage(V)	Current(A)	Voltage(V)	Current (A)
0	0	0	0	0	0	0	0
0.53	5	0.5	5	0.51	5	0.5	5
1.02	10	1.02	10	1.01	10	1.01	10
1.48	15	1.51	15	1.40	15	1.43	15
1.63	20	2.01	20	1.46	20	1.52	20
1.68	30	2.38	30	1.49	30	1.58	30
1.71	50	2.43	50	1.52	50	1.62	50
1.75	100	2.47	100	1.56	100	1.66	100
1.77	150	2.48	150	1.58	150	1.68	150
1.78	200	2.50	200	1.59	200	1.70	200

Graph :



In semiconductors, the electrons behave much as they do in metal. In the sense that all valence electrons are shared among all the atoms in the lattice. Each orbital of each atom can be thought of as a band existing extending across the crystal lattice. Lower filled band is known as valence band. Upper energy band is known as conduction band. These bands are separated by a energy gap. LED's are just PN Junctions, In these bands don't always line up and there exists a barrier potential. If a bias voltage is passes across the diode, which is equal or greater than the difference in energy of the bands ie barrier potential. then bands will line up and current flows. During the process when an electron falls on hole and energy is released in the form of a photon. The energy of this photon is equal to the band gap energy of the diode. It follows that if the linear portion of the voltage equal the barrier potential, then energy of the photons emitted should be the same as the energy of a given electron. Since

$$P = VI \qquad -(2)$$

where P is the power, I is the current and V is the voltage of the system.

The energy of one electron is the charge of an electron (ie the current flow of one electron per sec in amp) times the voltage. Using this knowledge we then form equilibrium.

S.No.	LED Colour	Breakdown Voltage (v)	Wavelength, λ (nm)	Frequency, ν $\nu = c/\lambda$	Energy, E $E = qV$
1.	Red	1.5 V	780	3.84×10^{14}	2.4×10^{-19}
2.	Yellow	1.6V	597	5.02×10^{14}	2.56×10^{-19}
3.	Green	1.7V	577	5.19×10^{14}	2.72×10^{-19}
4.	Blue	2.4V	492	6.09×10^{14}	3.84×10^{-19}

As we know $E = h\nu = \frac{hc}{\lambda} \Rightarrow h = \frac{eV\lambda}{c}$

for red $h = \frac{(1.6\times10^{-19})\times(1.5)\times(7.8\times10^{-7})}{3\times10^{8}} = 6.241\times10^{-34}$ Js

for yellow $h = \frac{(1.6\times10^{-19})\times(1.6)\times(5.97\times10^{-7})}{3\times10^{8}} = 5.0944\times10^{-34}$ Js

for green $h = \frac{(1.6\times10^{-19})\times(1.7)\times(5.77\times10^{-7})}{3\times10^{8}} = 5.231\times10^{-34}$ Js

for blue $h = \frac{(1.6\times10^{-19})\times(2.4)\times(4.92\times10^{-7})}{3\times10^{8}} = 6.292\times10^{-34}$ Js

Now $h = \frac{(6.241 + 5.0944 + 5.231 + 6.292)\times10^{-34}}{4}$

$\boxed{h_{exp} = 5.7136\times10^{-34}}$ Js

Theoretical value of $h = 6.626\times10^{-34}$ Js

S.No	LED Colour	Breakdown Voltage (v)	1/wavelength (λ^{-1})
1.	Red	1.5V	1.28×10^{6}
2.	Yellow	1.6V	1.67×10^{6}
3.	Green	1.7V	1.73×10^{6}
4.	Blue	2.4V	2.03×10^{6}

$$E = eV \quad —③$$

where $e = 1.6\times10^{-19}$ C

We then solve equation (1) for h and replace the E term with the equivalent of E in equation (3) as well as replace ν with : $\nu = c/\lambda$

where $c = 3\times10^{8}$ m/s

then we get

$$h = \frac{eV\lambda}{c} \quad — ④$$

It is the equation that we will use to determine Planck's constant.

Procedure :

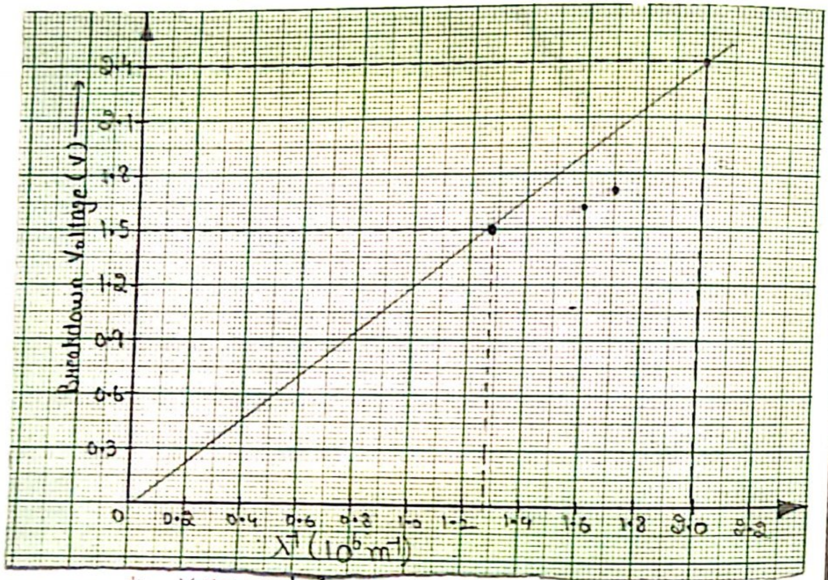
1. Connect the LED to the jack provided on the front panel and switch on the unit.
2. Take the different voltage and current measurement of LED (as tabulated below) for V-I characteristics of LED.
   S.No Voltage (V) Current (mA).
3. Take different LED's and follow step 2.
4. Now plot the V-I characteristics of all the LED's on graph paper and takes voltages corresponding to a current which is constant based on observation taken in step 2. Draw a line parallel to y-axis and note down the values of voltages corresponding to different LED's.

As we know $E = eV$ — ①

Energy of the Photon $E = h\nu = \frac{hc}{\lambda}$ — ②

Equating the eq ① and eq ②

$$eV = \frac{hc}{\lambda} \Rightarrow \boxed{h = \frac{eV\lambda}{c}}$$



Graph between the Voltage and inverse of wavelength.

$$V = \frac{hc}{e} \times (\lambda^{-1})$$

$$\text{Slope} = \frac{V_2 - V_1}{1/\lambda_2 - 1/\lambda_1} = \frac{hc}{e} = \frac{2.4 - 1.5}{(2.03 - 1.28) \times 10^6} = \frac{0.9}{0.75} \times 10^{-6}$$

$$\boxed{\text{Slope} = 1.2 \times 10^{-6}} \rightarrow \boxed{1.24375 \times 10^{-6}}$$

Hence we will get the value of Planck's constant.

Results:

Experimental value of Planck's constant is found.

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5. Make the table which contain LED colour, Voltage, wavelength, frequency, and Energy.

6. Now plot a graph between voltage V and λ^{-1} and determine the slope of the line. It will give the value of hc/e. Now substitute the value of c (3×10^8 m/s) and e (1.6×10^{-19} C) deduce the value of Planck's constant 'h'.

Precautions:

- Rotate all the knobs very slowly.
- After completing the experiment turn off the switch.
- Don't use approximations while calculating the 'h' otherwise there will be large error.
- Note all the readings very carefully.

Percentage Error:

$$\%\ \text{Error} = \frac{|\text{Experimental value} - \text{Theoretical value}|}{\text{Theoretical value}} \times 100\ \%$$

$$\%\ \text{Error} = \frac{|5.7136 \times 10^{-34} - 6.626 \times 10^{-34}|}{6.626 \times 10^{-34}} \times 100\ \%$$

$$\boxed{\%\ \text{Error} = 13.77\ \%}$$

Results:

- Experimental value of Planck's constant is found.

Teacher's Signature: ________

Experiment - 7

Aim of the Experiment :
Determine the wavelength of sodium light using Newton's rings method.

Apparatus Required :
- Newtons ring apparatus
- Travelling Microscope
- Sodium lamp.
- Plano- Convex lens.

Observation Table :

LC of MS = 0.1mm   LC of CS = 0.01mm

S.No	No. of rings	Left Side Readings			Right Side Readings			Diameter of the ring	Wavelength 'λ' (nm)
		MSR (mm)	CSR	Total (mm)	MSR (mm)	CSR	Total (mm)		
1.	3	10	92	10.92	8	8	8.08	2.84	—
2.	6	11	38	11.38	7	53	7.53	3.85	511.886
3.	9	11	85	11.85	7	12	7.12	4.73	572.000
4.	12	12	20	12.20	6	78	6.78	5.42	530.568
5.	15	12	90	12.90	6	20	6.20	6.70	1175.273

$\lambda_{avg} = 697.4317nm$

Formula Used :

$$\text{Wavelength of light used} = \lambda = \frac{D_{n+m}^2 - D_m^2}{4mR}$$

Radius of curvature = 1100mm

Experiment - 7

Aim of the Experiment :
Determination of wavelength of sodium light using Newton's rings method.

Apparatus Required :
Newton's ring apparatus
travelling microscope
sodium lamp
Plano-~~con~~ convex lens

Theory :
When the interference of light occurs in the air between a plane glass ring-shaped fringes plate and a plano-convex lens of large focal length, the fringes formed are circular. These ring-shaped fringes are called Newton's rings. These are alternate bright and dark rings with a centeral spot which is dark in reflected light.

For purposes of measurement, the observations are usually made at normal incidence by an arrangement such that where the glass plate G, reflects the light down on the plates. A low-powder microscope, M-focused on the air-firm shows a series of Newton's rings. Measuring diameters of these rings and using eq. the wavelength of sodium light can be determined.

where D_{n+m} = diameter of $(n+m)_{th}$ ring

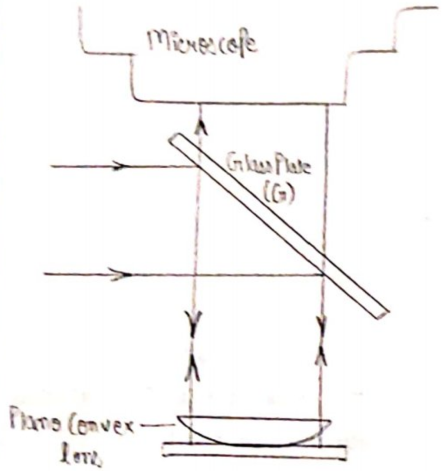
D_m = diameter of m_{th} ring

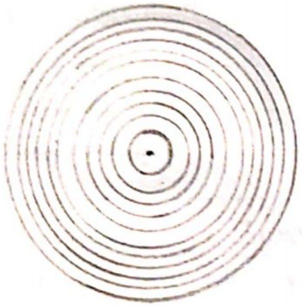
n = order of the ring

m = rings diffrence

R = radius of the curvature of curved surface of the lens

Diagram:





Percentage Error: Standard Value = 589 nm

$$\% \text{ Error} = \frac{|\text{Experimental Value} - \text{Theoretical Value}|}{\text{Theoretical Value}} \times 100\%$$

$$\% \text{ Error} = \left|\frac{697.4317 - 589}{589}\right| \times 100\%$$

$$\boxed{\% \text{ Error} = 18.41\%}$$

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Procedure:

Switch on sodium light and wait till it attains its characteristic yellow colour. Allow sodium light to fall on assembly of plane glass plate and plano-convex lens. Then the latter is so set the Newton's rings become visible in the field of view of the microscope and the point of intersection of the cross-wires coincides with the center of the centeral spot. Newton's rings can be made distinct, using the rack and pinion arrangement attached to the microscope.

Next the prependicular cross wire is moved to 15th bright ring (say) on any side of the bright s ring. then brought back to the 9th bright ring without taking reading at the 15th ring to avoid backlash error, if any. The cross-wire is then set at the middle of the 9th, 6th and the 3rd bright rings on the side in the succesion and corresponding observations are recorded. Then move the cross-wire to the other side and record observations for the same bright rings starting with 3rd ring and moving to the 9th ring. Determine diameters of these rings taking diffrences of the readings of the corresponding rings on either side of the centeral spot.

Make a suitable table of observations and determine the wavelength of sodium light.

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Results :

The mean wavelength of Na light : 697.4317 nm

Standard mean wavelength = 589.0 nm

Percentage Error = 18.91 %

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Precautions :

- The lens should be of large radius of curvature.
- The source of light used should be an extended one.
- Before measuring the diameter of the rings, the range of the microscope should be properly adjusted.
- Crosswire should be focused on a bright ring ~~tent~~ tangentially.

Results :

The mean wavelength of Na light = 697.4317 nm

Standard mean wavelength = 589.0 nm

Percentage Error = $\cancel{\approx}$ 18.91 %

Teacher's Signature :

Experiment - 8

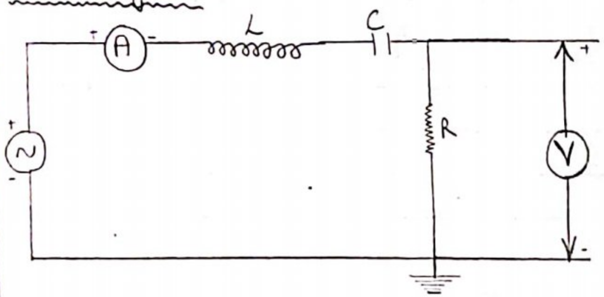
Aim of the Experiment :

To determine resonance in series and parallel RLC circuit.

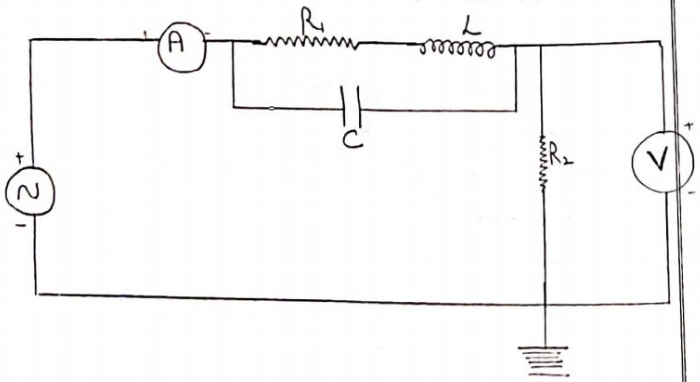
Apparatus Required :

Sine wave Generator [Signal Generator]
AC ammeter
AC voltmeter

Circuit Diagram :



Series LCR circuit



Parallel LCR circuit

Experiment - 8

Aim of the Experiment:

To determine the resonance in series and parallel RLC ckt.

Apparatus Required :

Sine wave Generator (Signal Generator)
AC ammeter
AC Voltmeter

Theory:

Series LCR circuit :

When the resistor R, inductor L, and capacitor C are connected in a series with a source of emf V, the circuit is called as the series LCR. This is an acceptor circuit, that means it allows maximum current to flow through it at a particular (resonant frequency) and at all other frequencies it allows less current. In AC circuit voltage and current are usually out of phase. Across the inductor, the current lags behind the voltage by an ~~voltag~~ angle of $\pi/2$ whereas across the capacitor, the current leads the voltage by $90°$. But across the resistor the voltage & current both are in phase. Under certain conditions, the voltage and current are in phase, even through the circuit consists of a L, C and R

Observation Table :

Circuit in Series		Circuit in Parallel	
Frequency (Hz)	Voltage (mV)	Frequency (Hz)	Voltage (mV)
100	30	100	168
200	53	200	158
300	75	300	145
400	101	400	135
500	128	500	127
600	153	600	115
700	165	700	105
800	175	800	100
900	180	900	110
1000	176	1000	120
1100	166	1100	135
1200	154	1200	145
1300	140	1300	156
1400	124	1400	160
1500	110	1500	165
1600	100	1600	169
1700	84		
1800	66		
1900	45		
2000	35		

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the circuit behaves as a pure resistor. This phenomenon is called Resonance. This occurs at a single frequency known as a resonant frequency. At this frequency the capacitive reactance ($X_C = 1/\omega C$) and the inductive reactance ($X_L = \omega L$) are equal. So they cancel each other and only resistances acts. The impedence of the circuit is given by.

$$Z = R + j(\omega L - 1/\omega C)$$

at resonance

$$X_L = X_C \Rightarrow \omega L = 1/\omega C \Rightarrow \omega L - 1/\omega C = 0$$

$\therefore$ impedence $Z = R$

The current is maximum $I = V/R$

So $\omega L = 1/\omega C$

$$\omega_0 = \omega = 2\pi f_0 = 1/\sqrt{LC}$$

At this frequency the current is maximum and this frequency f_0 is called resonant frequency. The circuit has selective properties. To compare selectivity or sharpness of resonance, a band of frequencies is choosen at which the current falls to $1/\sqrt{2}$ times (half power points) of its maximum value. The frequency difference ($f_2 - f_1$) between the half power points is called a bandwidth.

Parallel LCR circuit :

Parallel resonant circuit is one in which one branch consists of an inductor L with associated resistor R and the other branch consists of a capacitor C. This is a rejector circuit

Teacher's Signature :

Observations :-

Series LCR circuit

Peak voltage = 180 mV

Resonance Frequency = 900 Hz

Half Power freq (lower) = 500 Hz

Half Power freq (upper) = 1400 Hz

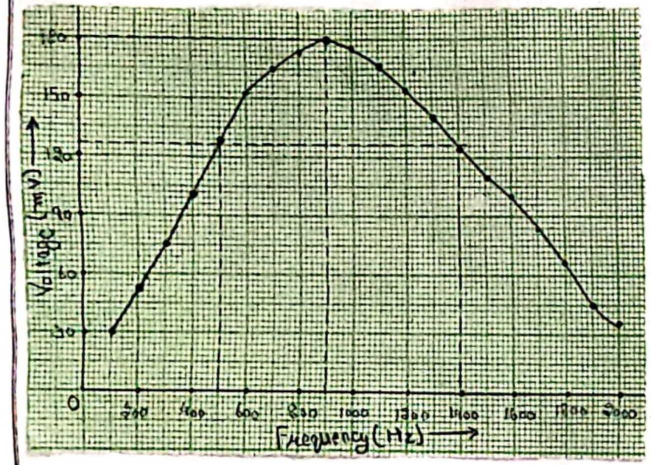
Parallel LCR circuit

Minimum voltage = 100 mV

Resonance Frequency = 800 Hz

Half Power freq (lower) = 320 Hz

Half Power freq (upper) = 1180 Hz

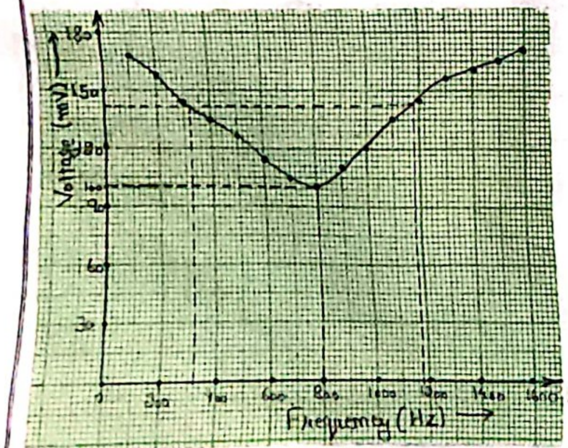


Series LCR circuit

$$\text{Bandwidth} = \frac{f_0}{|f_1 - f_2|}$$

$$\text{Bandwidth} = \frac{900}{|500 - 1400|}$$

Bandwidth = 1.0027



Parallel LCR circuit

$$\text{Bandwidth} = \frac{f_0}{|f_1 - f_2|}$$

$$\text{Bandwidth} = \frac{800}{|320 - 1180|}$$

Bandwidth = 0.9756

that means it rejects the current or allows minimum current to flow through it, at a particular (anti-resonant) frequency and it allows more current at all other frequencies. So the circuit is not selective. But it is highly selective when energized from a high impedence generator.

The impedence of the ckt is given by:

$$\frac{1}{Z} = \frac{1}{R + jL\omega} + \frac{1}{1/j\omega}$$

At resonance the impedence is maximum.

The impedence at resonance $Z = L/RC$

The anti resonant frequency $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$ Hz

If R is very small then $f = \frac{1}{2\pi\sqrt{LC}}$ Hz

Procedure :

For Series LCR circuit :

1. Connect the current meter in to the circuit across.
2. Adjust the output of Function Generator starting from 10 Hz frequency.
3. Increase the frequency of signal upto 10 KHz in small steps and note down the corresponding value of frequency & Voltage.

Results:

	Series LCR circuit	Parallel LCR circuit
Resonant frequency f_0	900 Hz	800 Hz
Half upper frequency f_2	1380 Hz	1180 Hz
Half lower frequency f_1	500 Hz	320 Hz
Bandwidth $\frac{f_0}{\lvert f_1 - f_2 \rvert}$	1.0027	0.9756

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For Parallel LCR circuit:

1. Connect the current meter in to the circuit across.
2. Adjust the output of the function Generator starting from 10 Hz frequency.
3. Increase the frequency of signal up to 10 KHz in small steps and note down the corresponding value of frequency and voltage.

Precautions:

1. All the connections should be tight.
2. Ammeter is always connected in series in the circuit while voltmeter is parallel to the conductor.
3. The electrical current should not flow the circuit for long time, otherwise its temprature will increase and the result will be affected.
4. Before the circuit connection it should be check out working condition of all the component.

Teacher's Signature :

Experiment - 9

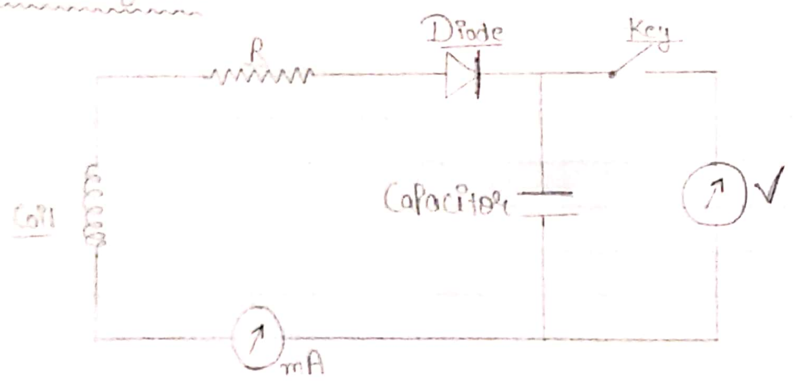
Aim of the Experiment:

To study the induced emf as a function of velocity of the magnet.

Apparatus Required:

- a permanent magnet
- a stop watch
- circuit arrangement for measuring the Peak Value of the induced emf.

Circuit Diagram:



Experiment - 9

Aim of the Experiment:

To study the induced emf as the function of velocity of the magnet.

Apparatus Required:

- a permanent magnet
- a stop watch
- circuit arrangement for measuring the peak value of induced emf.

Theory:

According to the Faraday's law, the change in magnetic flux (ϕ) through a coil gives rise to an induced emf (E) given by:

$$E = -\frac{d\phi}{dt} \quad \text{--- (1)}$$

Where magnetic flux $\phi = \bar{B} \cdot \bar{A}$

where B = magnetic induction

& A = area of cross-section

For an oscillating system, when magnet passing through coil is made to oscillate.

$$E = -\frac{d\phi}{dt} = -\frac{d}{dt}[B \cdot A]$$

$$E = -A \frac{d}{dt}[B(x,t)] \quad \text{--- (2)}$$

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OBSERVATION TABLE :

Amplitude = Variable , Time Period = Constant

Sr. No	Amplitude $A = R_0\theta_0$	Time for 5 oscillations (s)	Mean Time (T).	e_0	Linear Velocity $V = 2\pi/T\,(R_0\theta_0)$
1	15×30 = 450	8·22	1·644	0·275	1718·99
2	15×40 = 600	8·31	1·662	0·350	2269·14
3	15×50 = 750	8·34	1·668	0·450	2823·75
4	15×60 = 900	8·47	1·694	0·500	3336·45
5	15×70 = 1050	8·53	1·706	0·550	3865·18

Amplitude = Constant , Time Period = Variable.

Sr. No.	Amplitude $A = R_0\theta_0$	Time for 5 oscillations	Mean Time (T)	e_0	Linear Velocity $V = 2\pi/T\,(R_0\theta_0)$
1	30×20 = 600	8·38	1·676	0·325	2848·21
2	40×15 = 600	8·31	1·662	0·350	2267·14
3	50×12 = 600	8·00	1·600	0·400	2355·00
4	60×10 = 600	7·96	1·592	0·450	2366·83
5	70×8·57 = 600	8·18	1·636	0·500	2303·17

If I is the moment of inertia of oscillating system and ω is the angular velocity of the magnet, the kinetic energy of system is given by $\frac{1}{2} I\omega^2$ and the potential energy is given by : $mgR(1-\cos\theta)$

where θ is the angular displacement of the magnet.

If θ_0 is the angular amplitude and ω_{max} is the maximum value of angular velocity then

$$\frac{1}{2} I\omega_{max}^2 = mgR(1-\cos\theta_0)$$

$$\Rightarrow \omega_{max}^2 = \frac{2mgR}{I}(1-\cos\theta_0) \quad — (3)$$

The motion can be regarded as simple harmonic and its time period is given by :

$$T = 2\pi\sqrt{\frac{I}{mgR}} \quad (4a)$$

$$\Rightarrow \omega_{max} = \frac{4\pi}{T}\sin\frac{\theta_0}{2} \quad — (4b)$$

$$\Rightarrow V_{max} = \frac{4\pi R}{T}\sin\frac{\theta_0}{2} \quad — (4c)$$

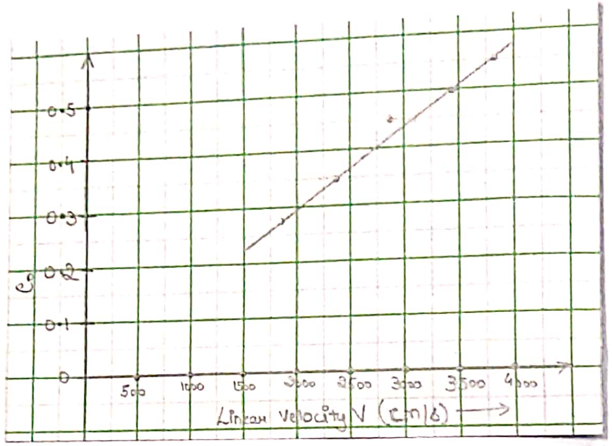
where R is the radius of frame

Induced emf, thus can be written as :

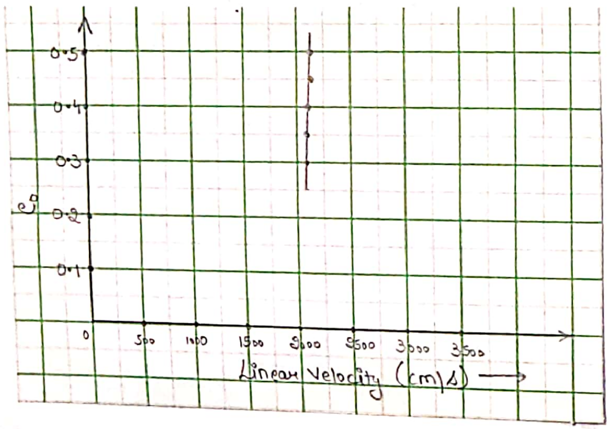
$$E = -\frac{d\phi}{dt} = -A\frac{dB(x,t)}{dt} = -A\frac{dB}{dx}\cdot\frac{dx}{dt}$$

Graph :

Graph between e_0 and V when amplitude is variable and time is constant



Graph between e_0 and V when amplitude is constant and time Period is variable.



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$$E = -A \frac{dB}{dr} \cdot V \quad -(5)$$

or $E_{max} \propto V_{max}$

Procedure :

1. Mount the small Permanent magnet at the middle Point of the semi-circular arc from its center so that the whole frame can oscillate freely through the coil. level, if necessary.
2. Adjust the Position of the two weights on the diameter of the arc to have minimum time Period.
3. Connect the terminals of the coil to the diode circuit to note the Peak voltage generated.
4. Take the magnet carrying arc to one side so that amplitude of vibrations is about 20cm and release the arm. Note the time. Note the time of 20 oscillations.
5. Repeat thrice keeping the amplitude same and find the time Period. Also note the Peak voltage after 20 oscillations.
6. Repeat the Process after changing the amplitude and take atleast 8 readings.
7. Now change the time Period by adjusting the Position of the weights on the diameter arm. Take atleast 3 readings for each Position keeping amplitude constant.
8. To Plot the graph between linear velocity V of the magnet and maximum induced emf e take along the x-axis and

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Results:

from the graph we see the maximum voltage across the Capacitor Varies linearly with velocity of the magnet.

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c along Y-axis for all the values of c and v in table A and B, the graph is a straight line.

This shows that the induced emf is proportional to the linear velocity of the magnet.

Precautions:

1. The semi circular frame should oscillations freely as a whole on the knife edge.
2. The magnet Should Pass freely through the coils C_1 and C_2.
3. The emf devloped in the coil should be measured with the help of an electronic - circuit.
4. The magnet should be small and should be mounted at the middle of the semicircular arc.

Results:

from the graph we can see the maximum voltage across the Capacitor varies linearly with velocity of the magnet.

Teacher's Signature :