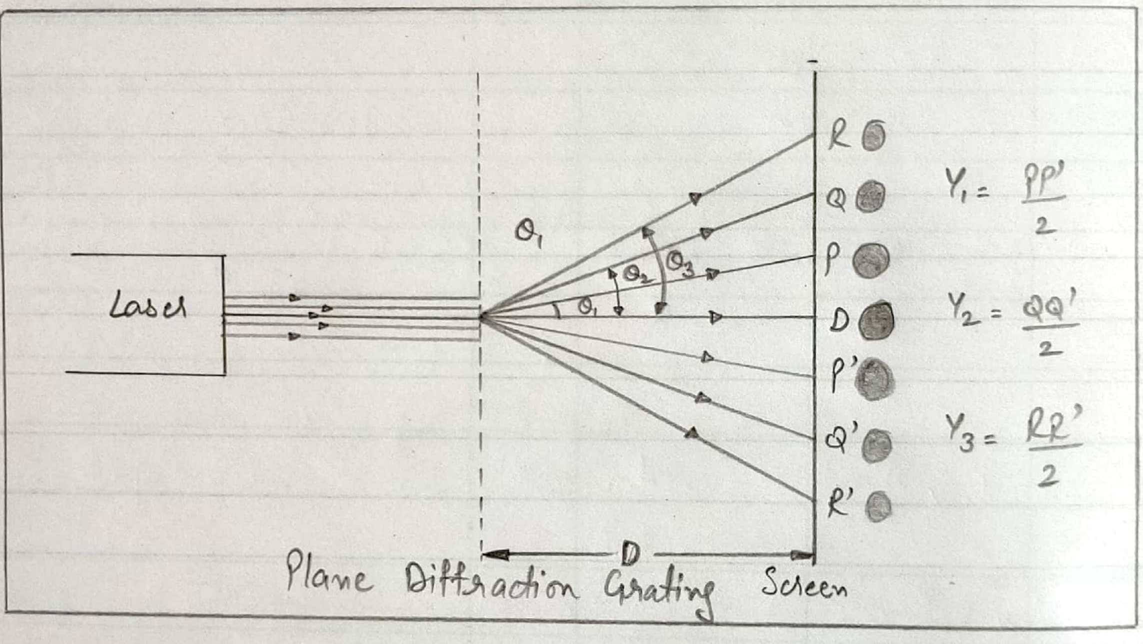
Experiment ⇒ 1

Aim ⇒ To study diffraction using laser beam and thus to determine grating element

Apparatus ⇒ A He-Ne laser, transmission grating, measuring tape or steel scale screen graph paper.



Observations ⇒

Sr. No.	Order of diffraction (n)	Seperation b/w corresponding maxima on either side of central maximum	Passition of nth maximum	θ_n	d
1.	1	PP' = 3	Y_1 = 1.5	θ_1 = 3.621	100.20×10^{-5}
2.	2	QQ' = 5.9	Y_2 = 2.45	θ_2 = 7.0911	102.52×10^{-5}
3.	3	RR' = 8.8	Y_3 = 4.4	θ_3 = 10.51	104.03×10^{-5}

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Experiment => 1

Aim => To study Diffraction using laser Beam and thus to determine grating element

Apparatus Required -> A He-Ne laser, transmission grating, measuring tape or steel scale, Screen, graph paper.

Theory => A diffraction grating is extremely useful device to study diffraction. It consists a large number of slits placed side by side. All these slits lie in a single plane. Due to this it is also called plane diffraction grating. These slits are separated from each other by opaque spaces. When a wavefront is incident on a grating surface, light is transmitted through transparent portion and obstructed by opaque parts of grating. This causes diffraction of light and hence bright and dark fringes are obtained on screen. The intensity of bright fringes goes on decreasing in higher orders.

Formula used :- d = grating element
θ_n = angle of diffraction
n = order of diffraction
λ = wavelength of laser beam

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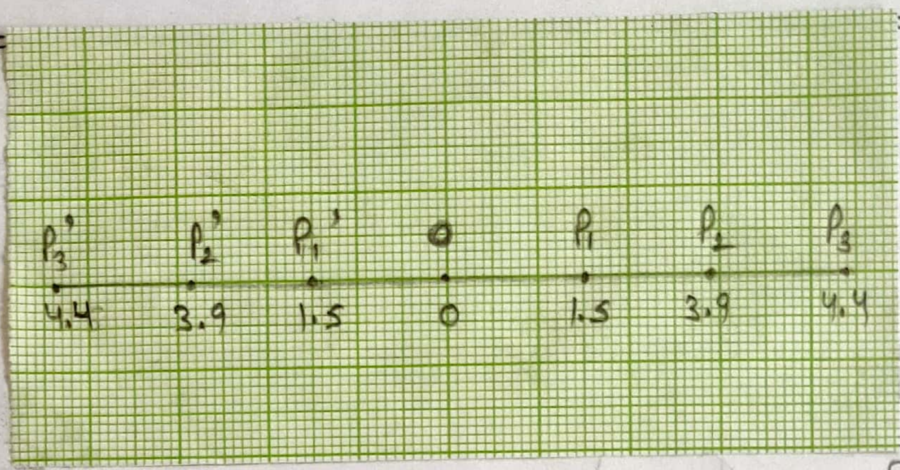

Calculations ⇒ $d \sin\theta_n = n\lambda$ $[\lambda = 6.328 \times 10^{-5}\ cm]$

$$\tan\theta_n = \frac{Y_n}{D}$$

$\theta_1 = 3.621$, $\theta_2 = 7.0911$, $\theta_3 = 10.5144$

$\sin\theta_1 = 0.06315$ $d_1 = 100.20 \times 10^{-5}$ cm

$\sin\theta_2 = 0.12344$ $d_2 = 102.52 \times 10^{-5}$ cm

$\sin\theta_3 = 0.18248$ $d_3 = 104.03 \times 10^{-5}$ cm

Result Obtained ⇒ $d = 102.25 \times 10^{-5}$ cm

Actual value ⇒ $d = 100 \times 10^{-5}$ cm

Percentage Error ⇒ $\frac{\text{Observation} - \text{Actual}}{\text{Actual}} \times 100$

$$= \frac{102.25 \times 10^{-5} - 100 \times 10^{-5}}{100 \times 10^{-5}} \times 100$$

$$= 2.25\%$$

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(i) $d = \dfrac{n\lambda}{\sin\theta_n}$ (ii) $\theta_n = \tan^{-1}\left(\dfrac{y_n}{D}\right)$

where y_n = mean distance between n^{th} maxima and contral maximum

D = distance between diffraction grating and screen.

Source of Error ⇒ (i) Distance between spots ~~should be~~ was not measured accurately.

(ii) There can be some calculation error.

(iii) All the distance cannot be taken in same unit.

Precautions ⇒ (i) Experiment must be perform in dark room.

(ii) Laser light should not fall on eyes of observer directly.

(iii) Distance between spots should be measured accurately.

(iv) Light should fall normally on diffraction grating and screen should be placed normally to the path of incident laser beam.

Result ⇒ Grating element of given diffraction grating is $d = \ldots$ cm

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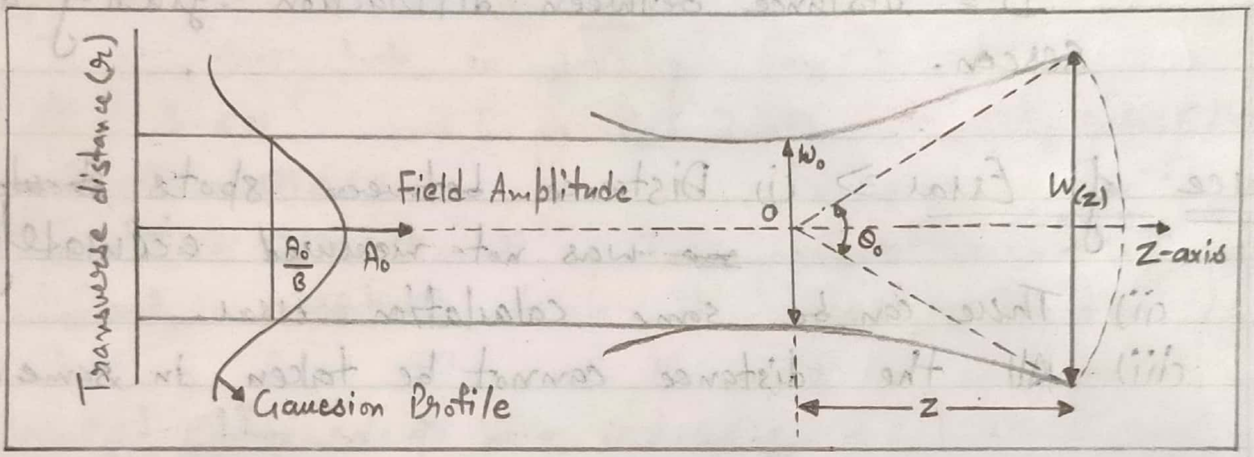
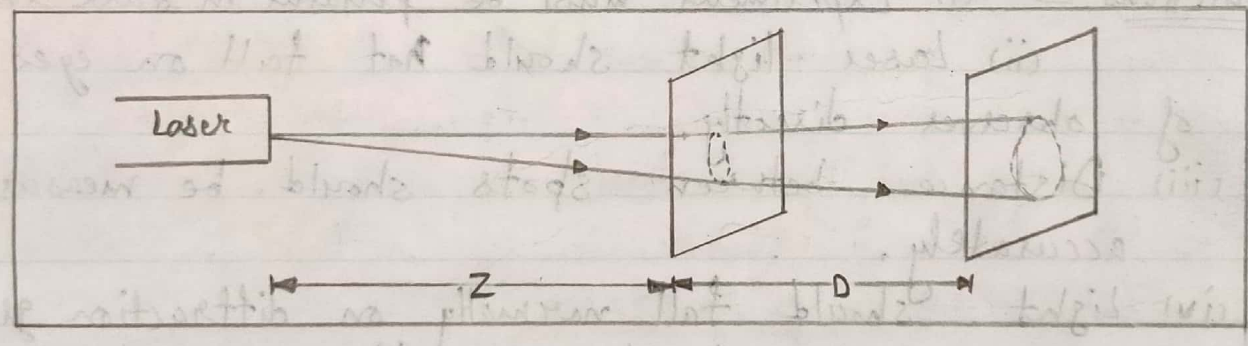
Experiment => 2

Aim => To measure the divergence of the laser beam.

Apparatus => He-Ne laser, stand, screen, measuring tape, graph paper etc.





Observation => D = 2m , Z = 2m

Sr. No.	Distance	Spot Size
1.	Z = 2m	4mm
2.	Z+D = 4m	7mm
3.	Z+2D = 6m	10.5mm

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Experiment - 2

Aim ⇒ To measure the divergence of the laser beam

Apparatus ⇒ He-Ne laser, stand, screen, measuring tape, graph paper etc.

Theory ⇒ Divergence is defined as the spread of laser beam ie. How much angle is subtended by laser spot at the point of origin. It is measured in radian. In an optical resonator if single-passgain is more than cavity loss than TEM_{00} mode is developed whose intensity distribution has a Guassian shape in a direction transverse to the direction of propagation of beam. A guassian beam has following property if a beam has guassian transverse profile at one location, then it will have gaussian transverse profile at all locations else where. Such a gaussian beam can be characterized completely at any spatial location by defining both its 'beam waist' and radius of curvature of wave front at specific location of beam. Moreover an unaltered gaussian beam always has a minimum waist size W_0 at on location in space.

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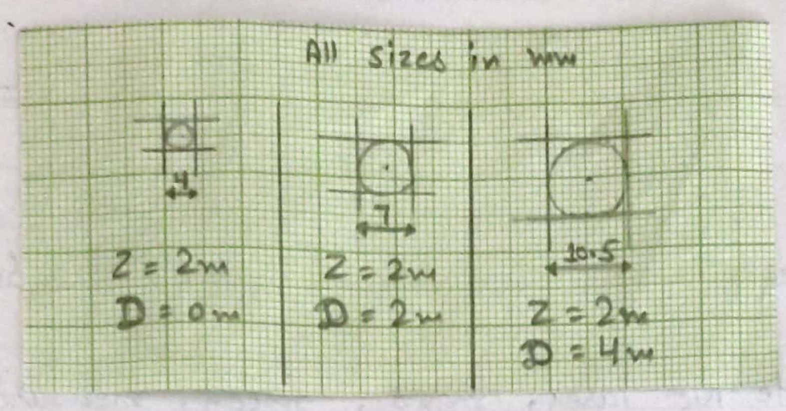

Calculations =>

$$\theta_0 = \frac{1}{2000}\sqrt{\frac{(4)^2 - 2(7)^2 + (10.5)^2}{2}}$$

$$= \frac{1}{2000}\sqrt{\frac{28.25}{2}}$$

$$= 0.00188 \text{ radian}$$

$$= 1.9 \times 10^{-3} \text{ radian}$$

Actual value => $\theta_0 = 1 \times 10^{-3}$ rad

Result obtained => $\theta_0 = 1.9 \times 10^{-3}$ rad

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Formula used ⇒ Let D = displacement of screen w_1, w_2 and w_3 are spot size at distance z, $z+D$, $z+2D$ from laser.

Angular divergence was given by

$$\theta_0 = \frac{1}{D}\sqrt{\frac{w_1^2 - 2w_2^2 + w_3^2}{2}}$$

Source of error ⇒ 1) The distance between laser and screen was not measured accurately.

2) The size of laser beam was not measured correctly.

3) There can be some calculation mistake.

Precaution ⇒ 1) Experiment should be performed in dark room.

2) Spot size should be measured accurately.

3) Screen should be placed normally to path of laser beam.

4) Laser should not fall directly on eyes of ~~obs~~ observer.

5) Spot size and other distances must be recorded in same units.

Result ⇒ The angle of divergence of He-Ne laser is given by, θ_0 = 0.00188 radian

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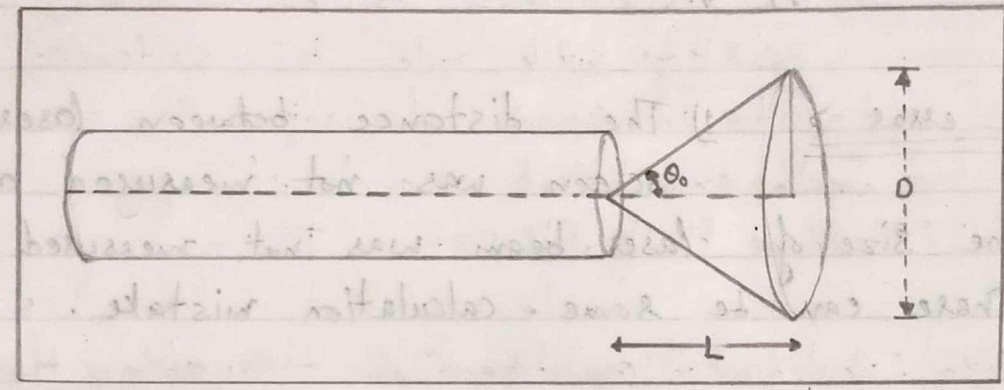
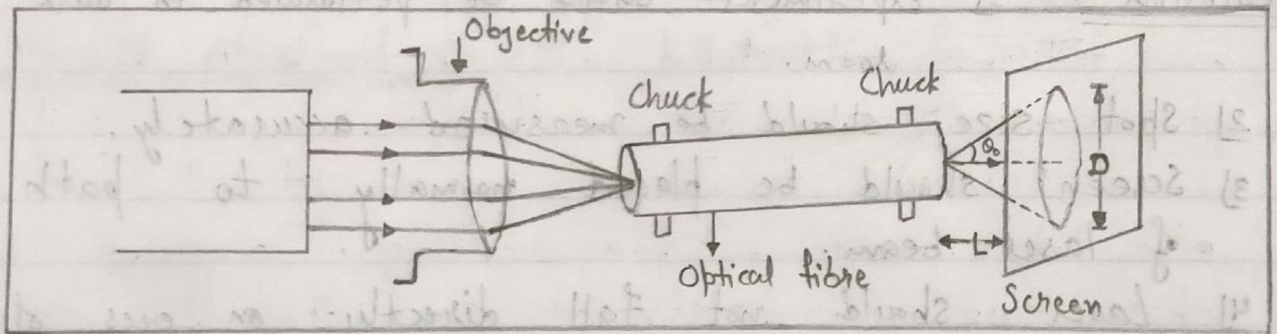
Experiment → 3

Aim ⇒ To determine Numerical Aperture of an optical fibre.

Apparatus ⇒ He-Ne laser, 20X microscopic objective, fibre optic chuck, optical fibre, screen, graph paper, measuring tape etc.





Observation ⇒

Sr. No.	Distance between screen & output end of fibre L (cm)	Diameter of spot D (cm)	Angle of acceptance $\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$	Numerical Aperture $NA = \sin\theta_0$
1	0.7	0.675	25.738	0.434

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Experiment → 3

Aim ⇒ To determine Numerical Aperture of an Optical fibre

Apparatus ⇒ He-Ne laser, 20x Microscopic objective, fibre optic chuck, optical fibre, screen, graph paper, measuring tape etc.

Theory ⇒ Numerical aperture is a basic descriptive characteristic of specific fibres. It can be thought of as representing the size or degree of openness of the input acceptance cone. Mathematically, numerical aperture is defined as the sine of angle of acceptance. The light gathering power of flux carrying capacity of a fibre is numerically equal to the sequence light gathering power or flux carrying capacity of a fibre is numerically equal to the sequence of the aperture, which is the ratio between the area of of a unit sphere with acceptance cone area of the hemisphere (2π solid angle).

formula used ⇒ (i) $\theta_0 = \tan^{-1}\left(\frac{D}{2L}\right)$

(ii) $NA = \sin\theta_0$

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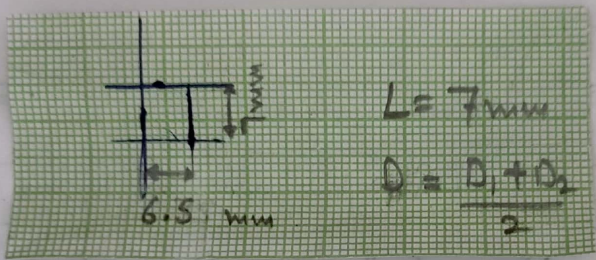

Result ⇒ Numerical aperture of optical fibre is 0.434

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where, D = diameter of spot
L = distance between screen and output end of optical fibre.

Precautions ⇒ i) Spot formed on graph paper should be sharply defined.
(ii) Experiment should be performed in a dark room.
(iii) Coupling of light to optical fibre should be adequate.
(iv) Diameter of spot and distance between screen and output end of optical fibre should be measured carefully.

Result ⇒ Numerical aperture of optical fibre is 0.434

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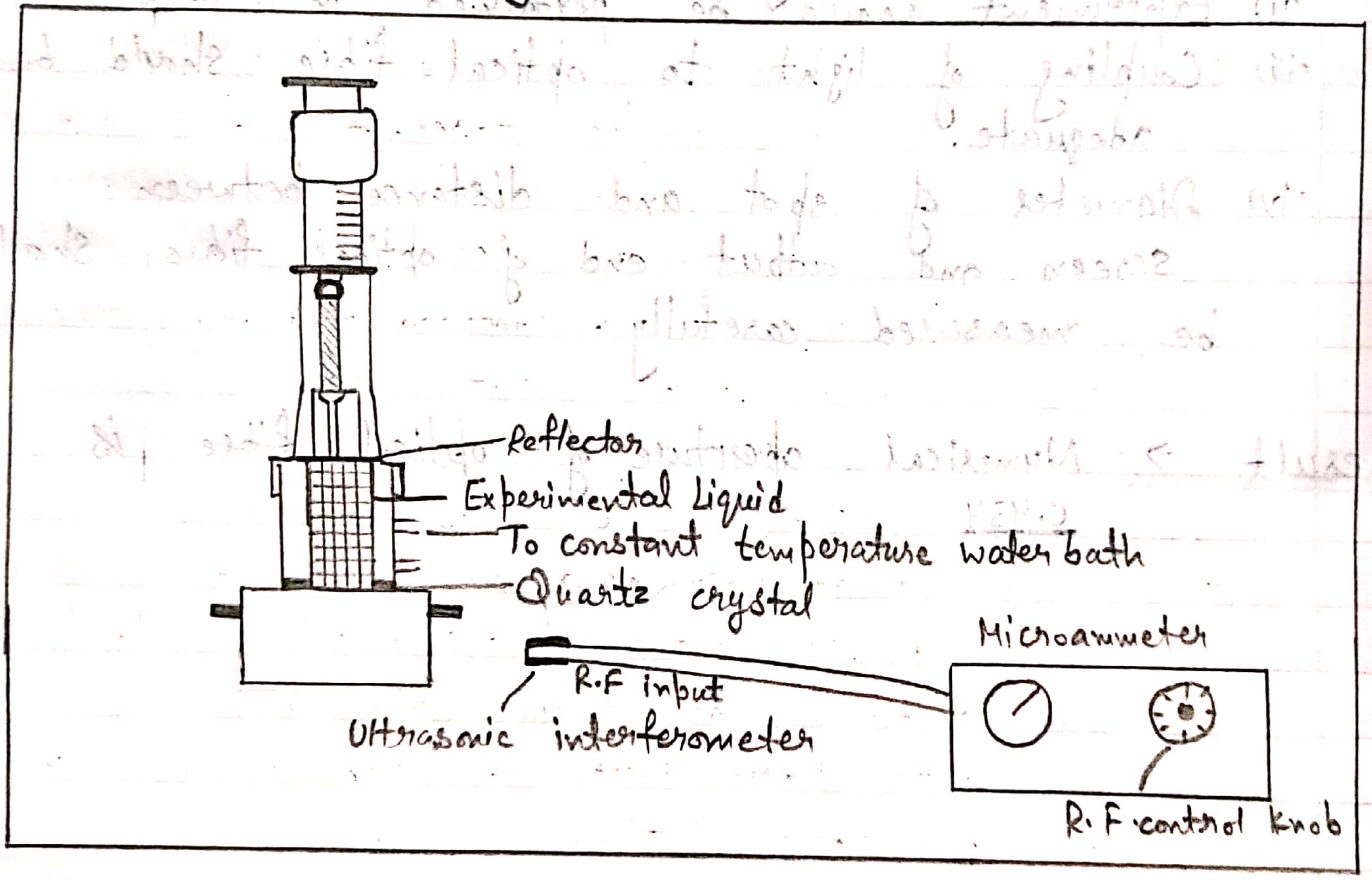
Experiment → 4

Aim → To find the velocity of ultrasound in a given liquid using ultrasound interferometer

Apparatus → Ultrasonic interferometer, sample liquid, high frequency generator.



Observations →

Sr. No.	Position of Screw at one maximum (d_1)	Position of Screw at next consecutive maximum (d_2)	Distance moved $d = [d_1 - d_2]$
1	5.31	5.67	0.36
2.	5.67	6.06	0.39
3	6.06	6.43	0.37

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Experiment → 4

Aim ⇒ To find the velocity of ultrasound in a given liquid using ultrasound interferometer

Apparatus ⇒ Ultrasonic interferometer, sample liquid, high frequency generator.

Formula used ⇒ If λ is wavelength of ultrasonic waves in a given liquid and is distance between two consecutive current maxima, then velocity of ultrasonic waves in the liquid is given by

$$V = 2df$$

Theory ⇒ In the interferometer, ultrasonic waves are produced using piezoelectric method. The apparatus consists of an ultrasonic cell, which is a double walled brass cell with chromium plated surfaces and has a capacity to contain liquid upto 10ml volume. The least count of micrometer screw is 0.001 cm and pitch scale has length 25mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. This crystal produces ultrasonic waves which travel through the liquid filled in the cell. ~~This crystal~~ These waves are reflected from a movable metallic plate attached to micrometer screw. These reflected waves come

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Mean separation between two consecutive maxima, $d = 0.37$

frequency of ultrasonic used $\Rightarrow f = 2\,MHz$

Velocity of Ultrasonic waves in given liquid, $V = 2df$

$V = 1480\ ms^{-1}$

Result $\Rightarrow$ The velocity of Ultrasonic in a given liquid is $= 1480\ ms^{-1}$

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toward quartz crystal. Thus waves generated by quartz crystal and reflected ~~waves~~ by metallic wave super impose on each other. If the separation between quartz plate and reflected plate is exactly equal to whole number multiple of wavelength of ultrasonic, then standing waves are produced in the liquid medium.

Precautions and Source of Error

1) The least count of screw gauze must be carefully noted.
2) Screw must be rotated in one direction to avoid backlash.
3) Ultrasonic cell should not be overfilled with the liquid.
4) There should not be any air gap between the quartz plate and reflecting plate.

Result => The velocity of ultrasonics in a given liquid is = $1480\ ms^{-1}$

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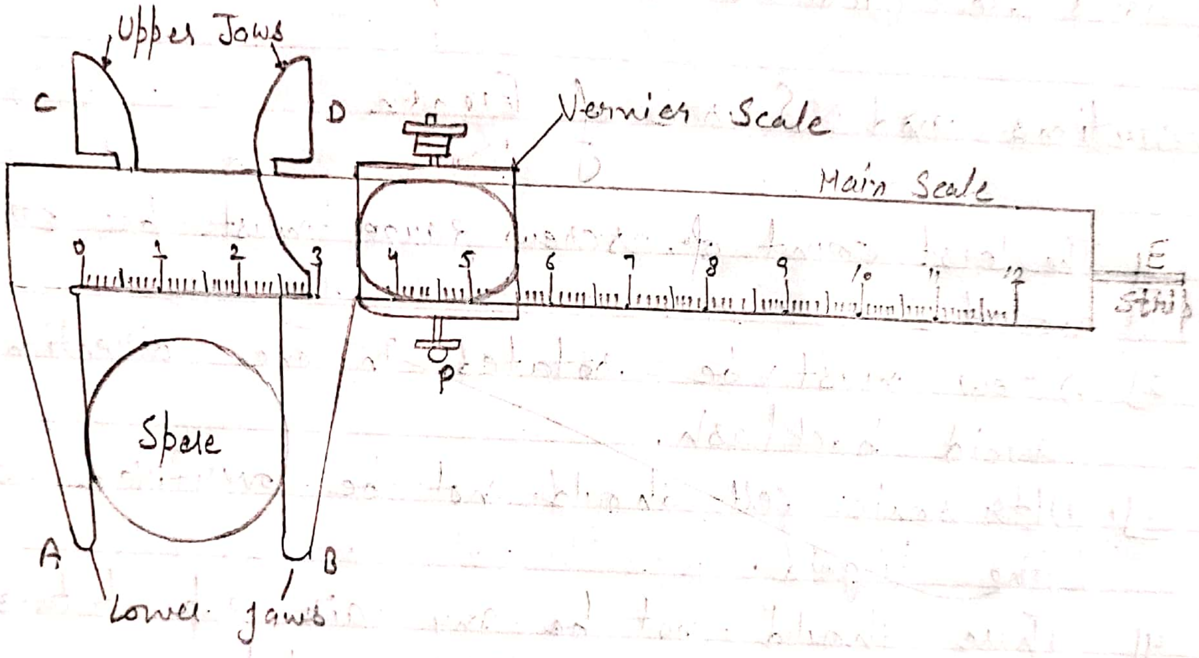
Experiment → 5



Vernier Calliper

Experiment ⇒ 5

Principle of vernier calliper ⇒ If we wand to measure the length of an object to a greater accuracy (upto 0.1 mm), then each mm on the scale has to be further divided into equal parts (say 10). It was difficult with normal scale because the division marks may be too close to be seen separately, So, pierre vernier, a Belgian Mathematician invented a device called vernier calliper.

A Vernier calliper of a main scale, against which another calliper scale called Vernier scale can slide. A division of the vernier scale is smaller than the size of a division of main scale. Usually 10 divisions of the scale coincide with 9 divisions of the main scale.

Vernier constant ⇒ The vernier constant of a vernier is difference between the value 1 main scale division (M.S.D) and 1 vernier division (1 V.D)

Vernier constant is the smallest length that can be measured by the vernier. It is also called least count of the instrument.

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Let us find the vernier constant of a vernier in which n division of the Vernier scale coincide with (n-1) divisions of the main scale, it implies that

$$n(V.D) = (n-1)\ M.S.D$$

$$1(V.D) = \frac{(n-1)}{n}\ M.S.D$$

$$\text{Vernier constant} = 1\ M.S.D - 1(V.D)$$

$$= 1\ M.S.D - \frac{(n-1)}{n}\ M.S.D$$

$$\text{Vernier constant} = \frac{1\ M.S.D}{n}$$

$$\text{Vernier constant} = \frac{\text{Value of } 1\ M.S.D}{\text{Total no. of divisions of the vernier scale}}$$

As we know

$$10\ V.D = 9\ M.S.D$$

$$1\ V.D = \frac{9}{10}\ M.S.D$$

$$\text{Vernier constant} = 1.\ M.S.D - 1(V.D)$$

$$= M.S.D\left(\frac{10-9}{10}\right) \quad [\because M.S.D = 1\,mm]$$

$$\text{Vernier constant} = 0.1\ mm$$

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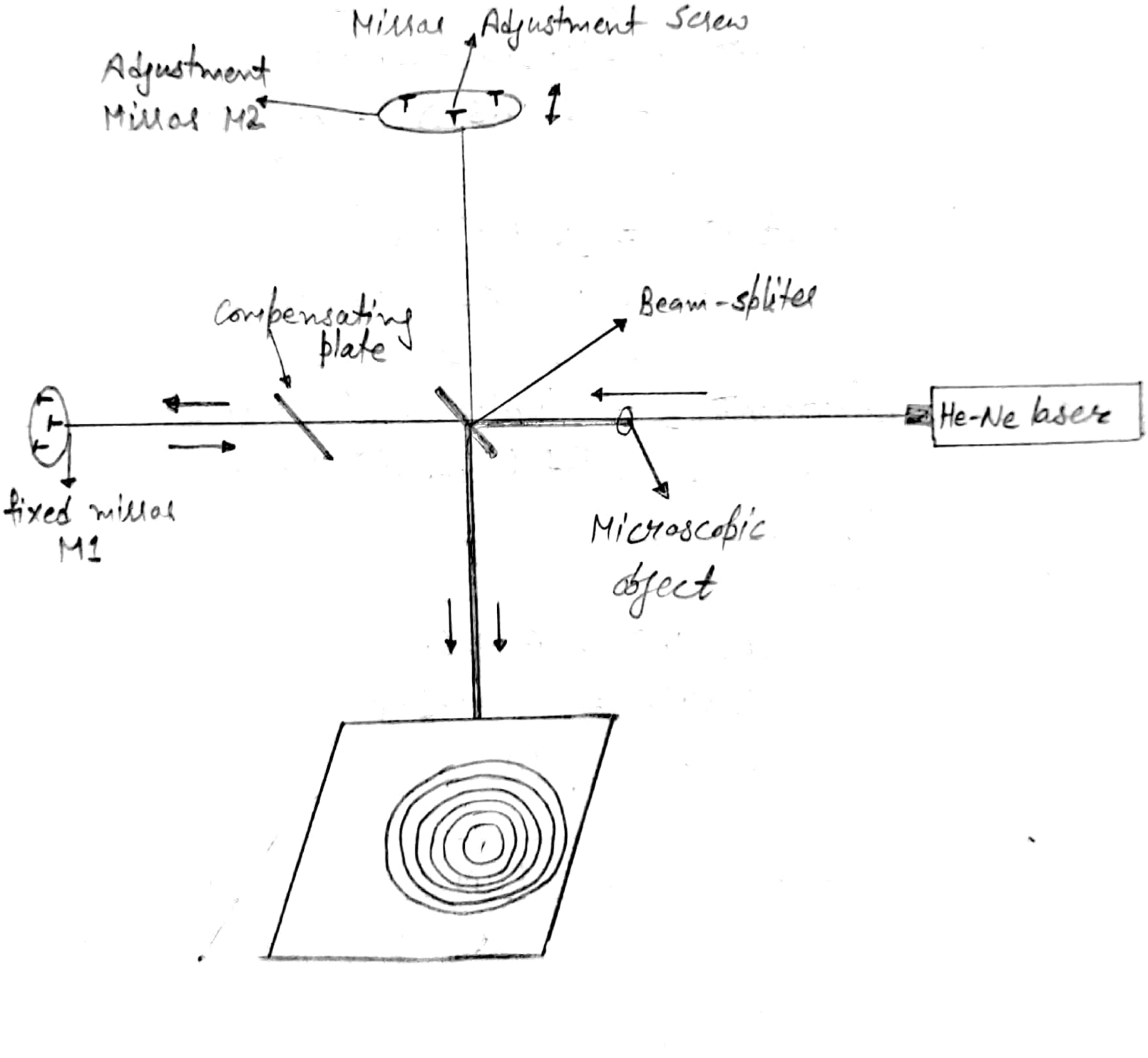
Experiment → 6

Aim → To determine the wavelength of monochromatic light source i.e. He-Ne laser source using michelson interferometer.

Apparatus → Michelson interferometer, He-Ne laser, stand.



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Experiment ⇒ 6

Aim ⇒ To determine the wavelength of Monochromatic light source i.e. He-Ne laser source using michelson interferometer

Apparatus ⇒ Michelson interferometer, He-Ne laser, stand.

Formula used ⇒ Wavelength of monochromatic light is calculated by the relation $\lambda = \frac{2d}{m}$

where, d is the distance moved by the sliding mirror for the shift of 'm' number of fringes.

Theory ⇒ The Michelson interferometer is a device that produces interference between two beams of light.

Light from a light source is split into two parts. One part of the light travels a different path length than the other. After transversing these different path lengths, the two parts of the light are brought together to interfere with each other. The interference pattern can be seen on a screen.

Light ~~from~~ source strikes the beam splitter (BS). The beam splitter allows 50% of the radiation to be transmitted to the fixed mirror M1.

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Observations

Sr. No.	Initial Reading 'L1' cm	No. of fringes shifted 'm'	final Reading 'L2' cm	Distance moved (d = L2 - L1)	$\lambda = 2d/m$ (cm)
1.	0	10	31	31	6.2
2.	31	10	66	35	7
3.	30	10	68	38	7.6

Calculations =>

Average λ = 6.93 cm

λ = 6930 Å

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The other 50% of the radiation is reflected to the translatable mirror M2. The compensator plate C is introduced along this path to make each path have the same optical path length when M1 and M2 are the same distance from the beam splitter. After returning from M1, 50% of the light is reflected toward to the glass screen. At the screen. Likewise, 50% of the light returning from M2 is transmitted to the glass screen. At the screen, the two beams are superposed and one can observe the interference between them.

Source of Error ⇒ 1) Mirror movement → The amount of adjustable mirror M2 movement per fine adjustment knob is constant to with 1%. Most of error occurs at extreme end of the mirror's total possible movements.

2) Movement of fine adjustment knob ⇒ The rotation of fine adjustment knob should be either clock-wise or anti-clock-wise during the experiment to reduce any distortion on the fringes.

3) Backlash ⇒ The effect of backlash should be

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practically eliminated by using proper technique when counting fringes.

4) The fixed mirror M1 should be exactly perpendicular to movable mirror M2 and nearly equal distance so that the fringes will be formed in circular pattern.

5) Distance of M1 and M2 from the back surface of beam splitter (BS) must not be exactly equal so as to get circular fringes.

6) The fine adjustment knob should be moved in one direction.

Result ⇒ The wavelength of monochromatic light source = 6930 Å

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