LABORATORY MANUAL

PHYSICS

SUBJECT CODE :3110011

B.E. 1ST YEAR

NAME: ____

ENROLLMENT NO: ______________________________________

BATCH NO: ____

YEAR: ____

Amiraj College of Engineering andTechnology,

Nr. Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

Amiraj College of Engineering andTechnology,
Nr. Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

CERTIFICATE

This is to certify that Mr./Ms.-

____ ***Enrolment No.***

________________ ***of*** _______________ ***Semester Degree course in***

____________________ ***Engineering has Satisfactorily completed his/her term work in the subject of Physics and submitted on*** ________________.

( ) ( )

Faculty Name and Signature Head of Department

AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

B.E. 1ST YEAR

SUBJECT: PHYSICS

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List of Experiments

Sr. No.	Title	Date of Performance	Date of Submission	Sign	Remark

EXPERIMENT 1

FUNDAMENTAL QUANTITIES IN BASIC PHYSICS

OBJECTIVE

To study various important measurement quantities used in basic Physics.

QUANTITIES

Mass: Mass is a fundamental concept in Physics, roughly corresponding to the intuitive idea of how much matter there is in an object.

Length: Length is the long dimension of any object. The length of a thing is the distance between its ends, its linear extend as measured from end to end.

Area: Area is a quantity expressing the two dimensional size of a define part of a surface, typically a region bounded by a closed curve. The term surface area refers to the total area of the exposed surface of a 3-dimensional solid, such as the some of the areas of the exposed sides of a polyhedron.

Volume: The volume of any solid, plasma, vacuum or theoretical object is how much 3-dimensional space it occupies, often quantified numerically. One dimensional figures(such as lines) and two dimensional shapes (such as squares) are assigned zero volume in the 3-dimenstional space.

Density: The density of material is defined as its mass per unit volume. Different materials usually have different density, so density is an important concept regarding buoyancy, metal purity and packaging.

Time: Time is a component of a majoring system used to sequence events, to compare the duration of events and the intervals between them, and to quantify the motion of object.

Frequency: Frequency is a major of the number of occurrences of a repeating event per unit time.

Velocity: In Physics, velocity is defined as the rate of change of position. It is a vector physical quantity; both speed and direction are required to define it.

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Acceleration: In kinematics, acceleration is defined as the first derivative of velocity with respect to time (that is, the rate of change of velocity), or equivalent as the second derivative of position.

Force: In Physics, a force is whatever can cause an object with mass to accelerate. Force has both magnitude and direction, making it a vector quantity.

Energy: In Physics and other sciences, energy is a scalar physical quantity, an attribute of objects and system that is conserved in nature. In Physics text books energy is often define as the ability to do work.

Resistivity: Electrical resistivity (also known as specific electrical resistance) is a major of how strongly a material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electrical charge.

Conductivity: Conductivity may refer to: Electrical, a major of a material's ability to conduct an electric current, thermal conductivity, the intensive of a material that indicates it ability to conduct heat.

Viscosity: Viscosity is a major of the resistance of a fluid which is being deformed by either shear stress or extensional stress. In general terms it is the resistance of a liquid to flow, or its "thickness". Viscosity describes a fluid's internal resistance to flow and may be thought of as a major of fluid friction.

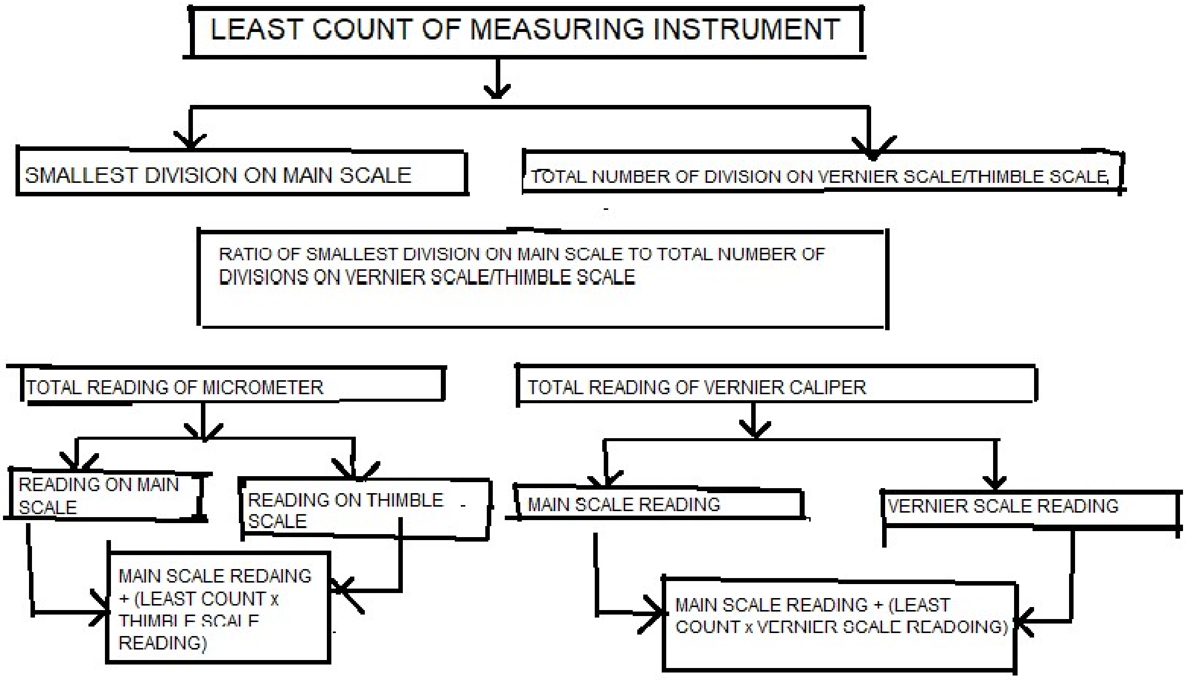
EXPERIMENT 2

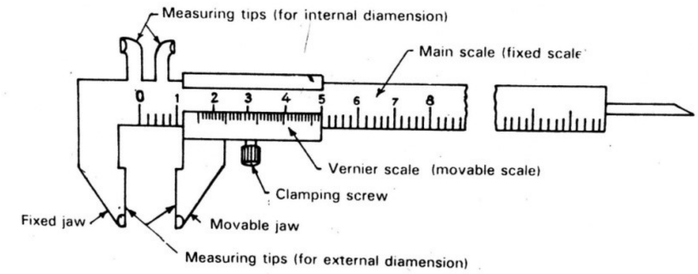
VERNIER CALIPER AND MICROMETER TO MEASURE DIMENSIONS OF GIVEN OBJECTS.

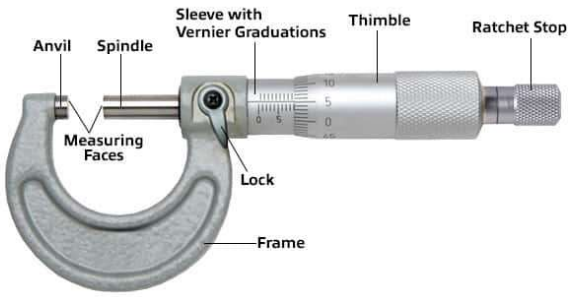
OBJECTIVE

To determine the dimensions of the given jobs

CONCEPT







PROCEDURE

Clean the work piece and instruments.

Check the vernier caliper & micrometer for errors.

If any error is presenet, correct it.

Calculate the least count of the instruments.

Hold the work piece in the measuring jaws/anvils.

Note down the readings on main scale & vernier/thimble scale.

Take the measurements for at least 3 com[ponents by vernier caliper and micrometer.

Calculate the total reading of vernier caliper and micrometer.

Complete the observation table.

OBSERVATION TABLE

Measurement using Vernier

Serial number	Dimension to be measure	Reading on main scale (MSR)	Reading on vernier scale (VSR) n X LCM	Dimension reading = MSR + VSR	Corrected reading = Dimension reading ± Correction

Measurement using Micrometer

Serial number	Dimension to be measure	Reading on main scale (MSR)	Reading on vernier scale (VSR) n X LCM	Dimension reading = MSR + VSR	Corrected reading = Dimension reading ± Correction

CONCLUSION

EXPERIMENT 3

MELDE'S STRING EXPERIMENT

OBJECTIVE

To determine the frequency of an electrically maintained tuning fork by,

1. Transverse mode of vibration

2. Longitudinal mode of vibration

EQUIPMENT

Electrically maintained tuning fork, fine thread, scale pan, weights and meter scale.

THEORY

Speed of waves in a stretched string: A string means a wire or a fiber which has a uniform diameter and is perfectly flexible. The speed of a wave in a flexible stretched string depends upon the tension in the string and mass per unit length of the string.

$$v = \sqrt{\frac{T}{\mu}} \qquad (1)$$

Where the tension T in the string equal to Mg.
M - Mass suspended and g is acceleration due to gravity.

μ - linear density or mass per unit length of the string.

$$\mu = \frac{m}{L} \qquad (2)$$

Where m is the mass of the string and L is the total length of the string.

Vibrations of a stretched string: When the wire is clamped to a rigid support, the transverse progressive waves travel towards each end of the wire. By the superposition of incident and reflected waves, transverse stationary waves are set up in the wire. Since ends of the wire are clamped, there is node N at each end and anti node A in the middle as shown in Fig: 1.

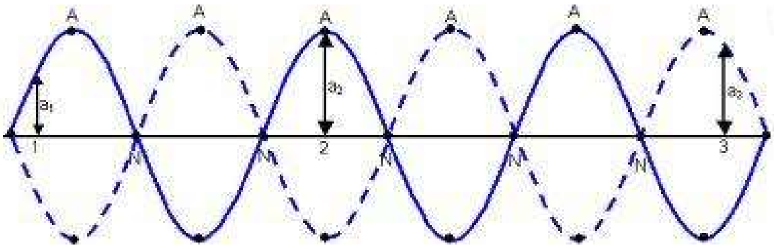


Fig:1

The points of the medium which have no displacements called ***nodes*** and there are some points which vibrate with maximum amplitude called ***antinodes.***

The distance between two consecutive nodes is λ/2, (λ - wavelength). Because l is half a wavelength in the equations,

$$l = \frac{\lambda}{2} \qquad (3)$$

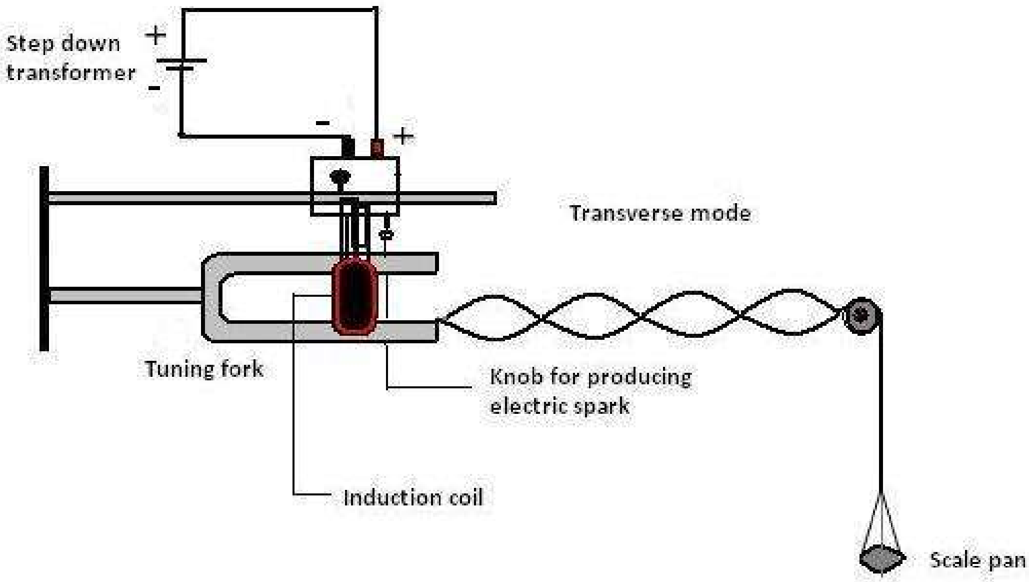
If 'f' be the frequency of vibration the wire,

$$f = \frac{v}{\lambda} = \frac{v}{2l} \qquad (4)$$

Substituting the value of ' v ' in equation (4)

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} \qquad (5)$$

Transverse drive mode : In this arrangement the vibrations of the prongs of the tuning fork are in the direction perpendicular to the length of the string.



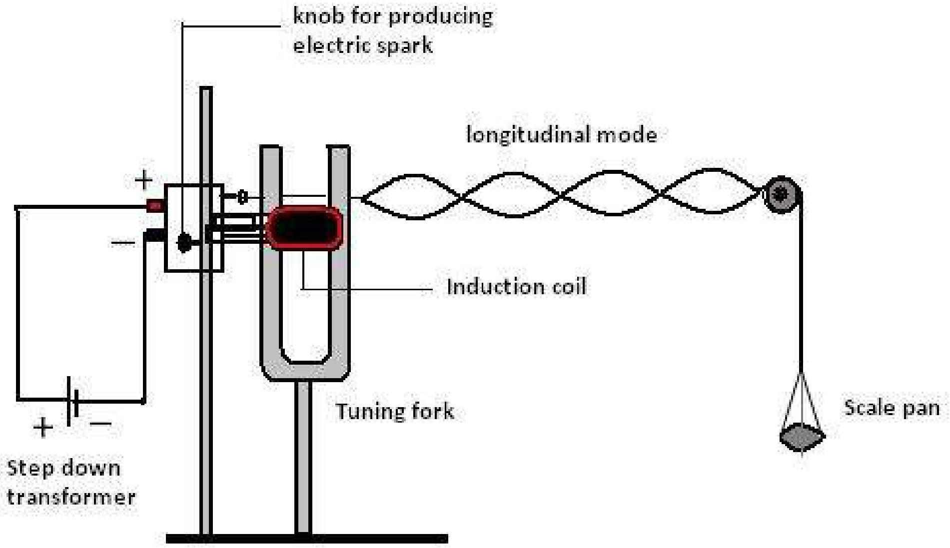
The time, during which the tuning fork completes one vibration, the string also completes one vibration. In this mode, frequency of the string is equal to the frequency of the tuning fork.

Therefore from equation (5),

Frequency $f = \sqrt{\dfrac{gM}{4\mu l^2}}$ (6)

Where
The total mass M is equal to the mass M' of the weight in the scale pan plus the mass M0 of the scale pane, $M = M' + M_0$.

Longitudinal drive mode: In this arrangement the tuning fork is set in such a manner that the vibrations of the prongs are parallel to the length of the string.



The time, during which the tuning fork completes one vibration, the string completes half of its vibration. In this mode, frequency of the fork is twice the frequency of the string.

Frequency $f = \sqrt{\dfrac{gM}{\mu l^2}}$ (7)

Using equation (6) and (7) we can calculate the frequency of electrically maintained tuning fork in two different modes of vibration.
In transverse drive mode the string follows the motion of the tuning fork, up and down, once up and once down per cycle of tuning fork vibration.
However, one cycle of up and down vibration for transverse waves on the string is two cycles of string tension increase and decrease. The tension is maximum both at the loops' maximum up position and again at maximum down position. Therefore, in longitudinal drive mode, since the string tension increases and decreases once per tuning fork vibration, it takes one tuning fork

vibration to move the string loop to maximum up position and one to move it to maximum down position. This is two tuning fork vibrations for one up and down string vibration, so the tuning fork frequency is half the string frequency.

Applications

1. Tuning of instruments like guitar.

2. Standing waves in air coloumn, soprano saxophone etc.

3. Human speech analysis.

PROCEDURE

Transverse mode of vibration of the string

The apparatus is arranged with the length of the string is parallel to the prong of the tuning fork on which one end of the string is attached. The other end of the string carrying a scale pan is passed over a pulley fixed at one end of the table. When the tuning fork is excited, it vibrates perpendicular to the length of the string.
The scale pan is detached from the string and its mass and length is determined using common balance and meterscale. Hence linear density is calculated.
The scale pan is again suspended at the end of the string and mass is added in the scale pan. The circuit is closed and tuning fork is set into vibration. The string vibrates transversely producing stationary waves. The length of the string is so adjusted to get well defined loops. Keeping two long knitting needle at two nodes, length of N loops is measured and average length is calculated. Using equation, frequency of the tuning fork is calculated.

Longitudinal mode of vibration of the string

The apparatus is arranged with length of the string is perpendicular to the prong of the fork. In this case, when the tuning is vibrated parallel to the length of the string. The experiment is performed exactly as in the previous case.

Observations and Calculations

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Trial No:	Total Mass (Kg)	No: of loops n	Length of n loops L (m)_	Length of one loop l= L/n (m)	M/l^2
1					
2					
3					
4					

Here, M is the total mass- mass of the scale pan + mass suspended.
Mass of the scale pan - 0 .5g.

Transverse mode

$$f = \sqrt{\frac{gM}{4\mu l^2}}$$ ....Hz

f - frequncy of tuning fork in Hz
μ - linear density in kg/m - mass of the string / length of the string.
Here, mass - 350mg and length - 3m and μ - 1.17×10^{-4} kgm^{-1}.
l - length of one loop in m

Longitudinal mode

$$f = \sqrt{\frac{gM}{\mu l^2}}$$ ....Hz

RESULTS

1. The frequncy of electrically maintained tuning fork at longitudianal mode of vibration = ... Hz

2. The frequncy of electrically maintained tuning fork at transverse mode of vibration = ... Hz

EXPERIMENT 4

ACOUSTIC GRATING METHOD SET UP FOR MEASUREMENT OF VELOCITY OF ULTRASONIC WAVES IN LIQUID

OBJECTIVE

To calculate the velocity of ultrasonic sound through different liquid media.
To calculate the adiabatic compressibility of the given liquid.

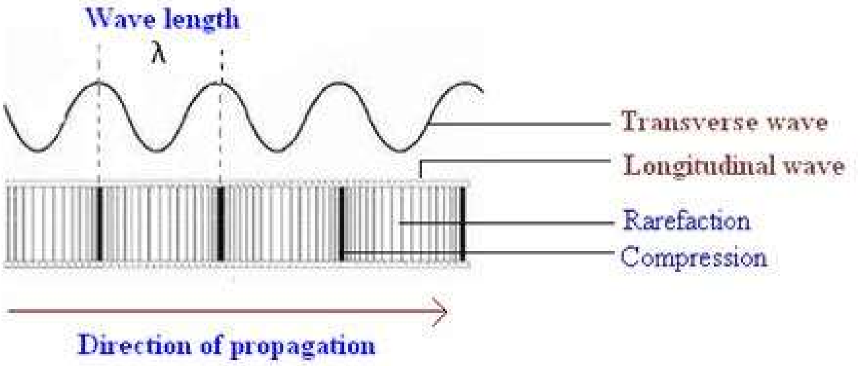
EQUIPMENT

Ultrasonic interferometer, sample liquids, high frequency generator etc.

THEORY

Ultrasonic interferometer is a simple device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium.

Ultrasonics:



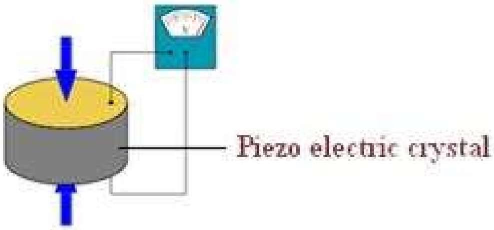
Ultrasonic sound refers to sound pressure with a frequency greater than the human audible range (20Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over very short distance in a direction parallel to the longitudinal wave. During this vibration, momentum is transferred among molecules. This causes the wave to pass through the medium.

Generation of ultrasound:

Ultrasonic can be produced by different methods. The most common methods include:

Mechanical method: In this, ultrasonic frequencies up to 100 KHz are produced. But this method is rarely used due to its limited frequency range.

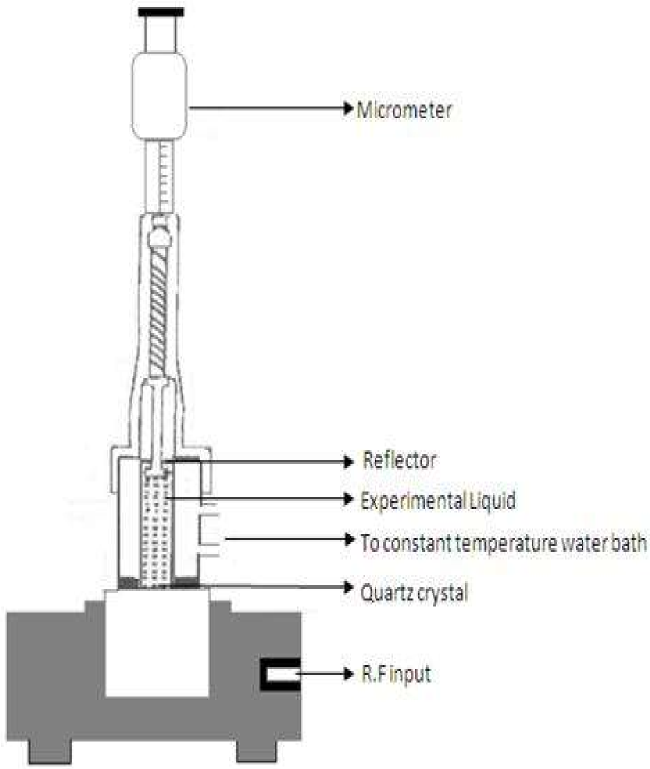
Piezoelectric generator: This is the most common method used for the production of ultrasound. When mechanical pressure is applied to opposite faces of certain crystals which are cut suitably, electric fields are produced. Similarly, when subjected to an electric field, these crystals contract or expand, depending on the direction of the field. Thus a properly 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 longitudinal wave, *i.e.*, a sound wave.



Magnetostriction generator: In this method, the magnetostriction method is used for the production of ultrasonic. Frequencies ranging from 8000 Hz to 20,000Hz can be produced by this method.

Ultrasonic Interferometer:

The schematic diagram of an ultrasonic interferometer is shown in the figure.



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

The micrometer scale is marked in units of 0.01mm and has an overall length of 25mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half-wavelengths 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 piezoelectric generator.

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

$$d = \frac{\lambda}{2}$$

We have, the velocity ($\boldsymbol{v}$) of a wave is related to its wavelength ($\boldsymbol{\lambda}$) by the relation,

$$v = \lambda f$$

, where $\boldsymbol{f}$ is the frequency of the wave.

Then,

$$v = \lambda f = 2df$$

The velocity of ultrasound is determined principally by the compressibility of the material of the medium. For a medium with high compressibility, the velocity will be less. Adiabatic compressibility of a fluid is a measure of the relative volume change of the fluid as a response to a pressure change. Compressibility is the reciprocal of bulk modulus, and is usually denoted by the Greek word beta (β).The adiabatic compressibility of the material of the sample can be calculated using the equation,

$$\beta = \frac{1}{\rho v^2},$$

Where ρ is the density of the material of the medium and v is the velocity of the sound wave through that medium.

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 instrument.
- Unscrew the knurled cap of the cell and 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 the sensitivity of the instrument.
- Increase the micrometer setting till the anode current in the ammeter shows a maximum.
- Note down the micrometer reading.
- Continue to increase the micrometer setting, noting the reading at each maximum. Count any number of maxima and call it as *n*. Subtract the reading at the first maximum from the reading at the last maximum. This will make the measurement accurate and we can say, d= D/(n-1).
- Note down this value as,

$$D = \frac{(n-1)\lambda}{2}$$

- Then calculate the velocity of wave through the medium as,

$$v = \lambda f = \frac{2Df}{(n-1)}$$

- Knowing the density of the medium, the adiabatic compressibility can be calculated using the equation,

$$\beta = \frac{1}{\rho v^2}$$

OBSERVATIONS

No:	Micrometer Reading (mm)	Anode Current (μA)

Least count of the micrometer: …………..mm

Frequency of the ultrasound used (f): …………….Hz

n = ... , D =...........mm.

v = ... ms^{-1}.

RESULT

The velocity of the ultrasonic wave through the given liquid medium = ... ms^{-1}.

The adiabatic compressibility of the given liquid medium = ... m^2N^{-1}.

EXPERIMENT 5

DETERMINATION OF WAVELENGTH OF LASER LIGHT USING DIFFRACTION GRATING

OBJECTIVE

To determine the wavelength of the laser light using diffraction grating.

EQUIPMENT

Diffraction grating, He-Ne laser or Semiconductor laser, optical bench and screen or scale arrangement.

FORMULA

$$\boldsymbol{Wavelength\ of\ laser\ light, \lambda = sin\theta\ /nN\ m}$$

where $\theta = \tan^{-1}(x_n / l)$ is the angle of diffraction

N is the number of lines per metre in the grating in lines/m

x_n is the distance of the spot from the central maximum in m

l is the perpendicular distance between grating and the scale in m

n is the order of the spectrum

PROCEDURE

The laser is mounted on its saddle on the optical bench. The grating is mounted on an upright next to laser. The screen or scale arrangement is placed next to the grating as shown in Fig .1. The laser is switched on. The relative orientation of laser with respect to grating is adjusted such that spectral

spots are observed on the scale. The scale is moved towards and away from the grating till at least three (for 6500 lines/inch) spots are clearly seen on the scale on the either side of the central spot. The central maximum and other maxima corresponding to different orders of the spectrum on either side of the central maximum are identified. The scale is again adjusted in such a way that the central spot coincides with the zero in the scale. Now the distances (x_n) of the spots corresponding to first order, second order etc on either side of central maximum are noted. The distance between the grating and the scale (/) is measured. The readings are tabulated.

How to find out Laser wavelength using the Diffraction Grating

The experiment is repeated for at least three P values (15cm, 20cm &25cm). The value of x_n is calculated for each case using the formula $\theta = \tan^{-1}(x_n / l)$.

Knowing the values of θ, n & N, the wavelength of laser light can be calculated using the formula $\lambda = \sin\theta / nN$

T o f ind λ

S. No.	**Order n**	**l (cm)**	**x_n (cm)**			**$\theta = \tan^{-1}(x_n/ l)$**	**Sin θ**	**λ (m)**
			LHS	**RHS**	**Mean**			

Mean value of λ = m.

CALCULATION

Distance of the spot from the central maximum (x_n) = m

Perpendicular distance between grating & the scale (l) = m

Number of lines per metre in the grating (N) = lines/m

Angle of diffraction, $\theta = \tan^{-1}(x_n / l)$ = Wavelength of laser light, $\lambda = \sin\theta / nN$

RESULT

Wavelength of laser light, λ =

EXPERIMENT 6

STUDY OF DAMPED SIMPLE HARMONIC MOTION

OBJECTIVE

To understand the relationships between force, acceleration, velocity, position, and period of a mass undergoing simple harmonic motion and to determine the effect of damping on these relationships.

THEORY

When a spring is stretched a distance x from its equilibrium position, according to Hooke's law it exerts a restoring force $F = - kx$ where the constant k is called the spring constant. If the spring is attached to a mass m, then by Newton's second law, $-kx = m\ x\ ..$, where x.. is the second derivative of x with respect to time. This differential equation has the familiar solution for oscillatory (simple harmonic) motion: $x = A\cos(\omega t + \varphi)$, (1)

where A and φ are constants determined by the initial conditions and $\omega = k / m$ is the angular frequency. The period is $T = 2\pi\ m\ k$. By differentiating Eq.(1) we determine the velocity

$$v = -A\omega\sin(\omega t + \varphi),$$

which can be rewritten as $v = A\omega\cos(\omega t + \pi\ 2 + \varphi)$. (2)

By differentiating again we obtain the acceleration

$$a = -A\omega^2\cos(\omega t + \varphi),$$

which can be rewritten as

$a = A\omega^2 \cos(\omega t + \pi + \varphi)$. (3)

From the acceleration we find the force, $F = mA\omega^2 \cos(\omega t + \pi + \varphi)$. (4)

From these four equations we see that the velocity leads the displacement in phase by $\pi/2$ while the force and acceleration lead by π.

For actual oscillating masses the motion is frequently not quite this simple since frictional forces act to retard the motion. To treat friction we will assume that the retarding force is proportional to the speed of the mass so that Newton's second law becomes

$m\, x\,.. = -kx - Rx\,.\,.$ (5)

We assume a solution $x = e^{\lambda t}$ which we substitute into Eq.(5) to obtain

$$e^{\lambda t}(\lambda^2 + R\lambda/m + \omega^2) = 0$$

This equation has two roots

$\lambda = -\gamma \pm \sqrt{(\gamma^2 - \omega^2)}$

where $\gamma = R/2m$.

The general solution to Eq.(5) can then be written as $x = e^{-\gamma t}(Ae^{\omega^* t} + Be^{-\omega^* t})$ (6)

where $\omega^* = \sqrt{(\gamma^2 - \omega^{2)}}$. We are here only interested in the case were the frictional forces are fairly small and $\gamma < \omega$ which is described as "underdamping". Then ω^* can be rewritten as $\omega^* = i\sqrt{(\omega^2 - \gamma^2)} = i\omega_1$, where ω_1 is a real quantity. Using Euler's identity,[$2\cos x = e^{ix} + e^{-ix}$], Eq.(6) can be written as

$$x = Ce^{-\gamma t}\cos(\omega_1 t + \varphi) \qquad (7)$$

where C and φ are constants determined by the initial conditions. The interpretation of this result is very easy. The motion is oscillatory with an angular frequency, $\omega_1 = \sqrt{(\omega^2 - \gamma^2)}$, slightly smaller than it would be if there were no damping. This shift will be too small to detect for the small value of γ we will be using in the experiment. In addition the amplitude of the oscillation decreases exponentially with a damping coefficient $\gamma = R/ 2m$

EXPERIMENT 7

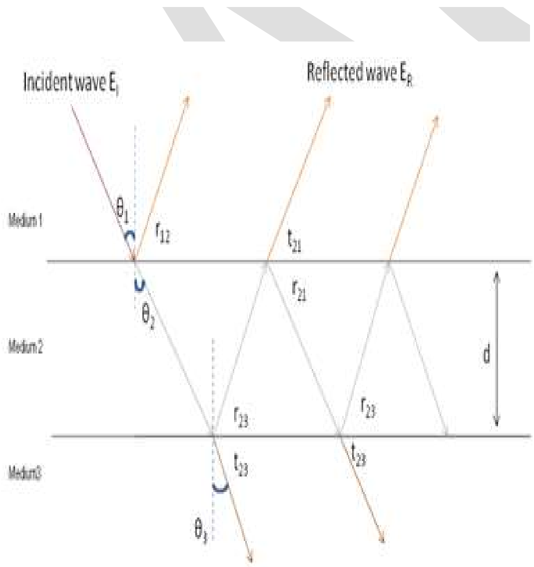
NEWTON'S RINGS

OBJECTIVE

1. To revise the concept of interference of light waves in general and thin-film interference in particular.
2. To set up and observe Newton's rings.
3. To determine the wavelength of the given source.

Thin film interference:

A film is said to be thin when its thickness is about the order of one wavelength of visible light which is taken to be 550 nm. When light is incident on such a film, a small portion gets reflected from the upper surface and a major portion is transmitted into the film. Again a small part of the transmitted component is reflected back into the film by the lower surface and the rest of it emerges out of the film. These reflected beams reunite to produce interference. Also the transmitted beams too interfere. This type of interference that takes place in thin films is called interference by division of amplitude.



$\boldsymbol{\Theta_1}$ angle of incidence at medium 1 to medium 2 boundary.
$\boldsymbol{\Theta_2}$ angle of refraction at medium 1 to medium 2 boundary.
$\boldsymbol{\Theta_3}$ angle of refraction at medium 2 to medium 3 boundary.
$\boldsymbol{r_{12}}$ reflected light from medium 1 to medium 2 boundary.
$\boldsymbol{r_{23}}$ reflected light from medium 2 to medium 1 boundary.
$\boldsymbol{r_{21}}$ reflected light from medium 2 to medium 3 boundary.
$\boldsymbol{t_{21}}$ transmitted light from medium 2 to medium 1 boundary.
$\boldsymbol{t_{23}}$ transmitted light from medium 2 to medium 3 boundary.
d thickness of the film.

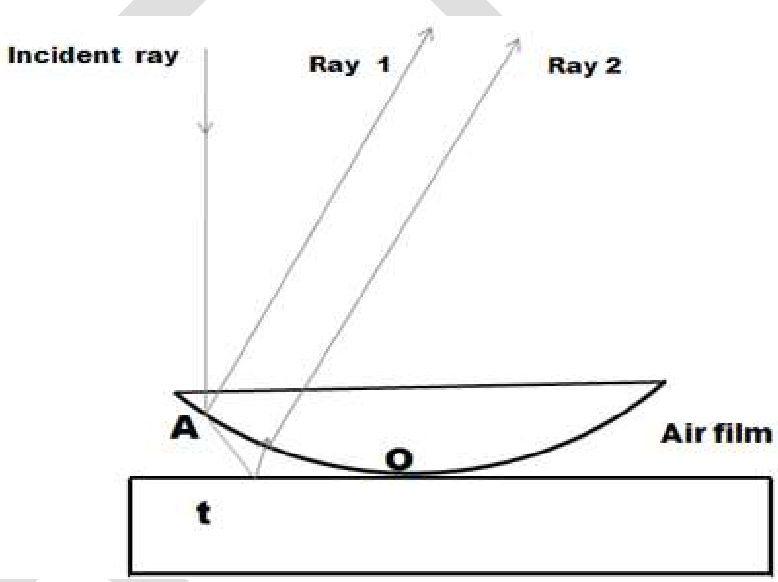
In the above figure the rays r_{12} and t_{21} interfere and results in a constructive or destructive interference depending on their path differences, given as,

$$2\mu_2 d\cos r_{12} = (2m+1)\frac{\lambda}{2}$$ **constructive interference**

$$2\mu_2 d\cos r_{12} = m\lambda$$ **destructive interference**

Where, $\mu_2 \rightarrow$ refractive index of the medium 2 and $m = 0, 1, 2, \ldots \rightarrow$ the order of interference.
The transmitted light from t_{23} can also interfere and result in constructive or destructive interference.

Thin film interference with films of varying thickness (Newton's rings):



Rings are fringes of equal thickness. They are observed when light is reflected from a plano-convex lens of a long focal length placed in contact with a plane glass plate. A thin air film is formed between the plate and the lens. The thickness of the air film varies from zero at the point of contact to some value t. If the lens plate system is illuminated with monochromatic light falling on it normally, concentric bright and dark interference rings are observed in reflected light. These circular fringes were discovered by Newton and are called Newton's rings.

A ray AB incident normally on the system gets partially reflected at the bottom curved surface of the lens (Ray 1) and part of the transmitted ray is partially reflected (Ray 2) from the top surface of the plane glass plate. The rays 1 and 2 are derived from the same incident ray by division of amplitude and therefore are coherent. Ray 2 undergoes a phase change of p upon reflection since it is reflected from air-to-glass boundary.

The condition for constructive and destructive interferences are given as; for normal incidence **cos r = 1** and for air film **μ = 1.**

$$2t = (2m+1)\frac{\lambda}{2}$$ **constructive interference**

$$2t = m\lambda$$ **destructive interference**

1. **Central dark spot:** At the point of contact of the lens with the glass plate the thickness of the air film is very small compared to the wavelength of light therefore the path difference introduced between the interfering waves is zero. Consequently, the interfering waves at the centre are opposite in phase and interfere destructively. Thus a dark spot is produced.

2. **Circular fringes with equal thickness:** Each maximum or minimum is a locus of constant film thickness. Since the locus of points having the same thickness fall on a circle having its centre at the point of contact, the fringes are circular.

3. **Fringes are localized:** Though the system is illuminated with a parallel beam of light, the reflected rays are not parallel. They interfere nearer to the top surface of the air film and appear to diverge from there when viewed from the top. The fringes are seen near the upper surface of the film and hence are said to be localized in the film.

4. **Radii of the mth dark rings:** $r_m = \sqrt{m\lambda R}$.

5. **Radii of the mth bright ring:** $r_m = \sqrt{(2m+1)R\frac{\lambda}{2}}$.

6. The radius of a dark ring is proportional to the radius of curvature of the lens by the relation, $r_m \; \alpha \; \sqrt{R}$.

7. Rings get closer as the order increases (m increases) since the diameter does not increase in the same proportion.

8. In transmitted light the ring system is exactly complementary to the reflected ring system so that the centre spot is bright.

9. Under white light we get coloured fringes.

10. The wavelength of monochromatic light can be determined as, $\lambda = \frac{D_{m+p}^2 - D_m^2}{4\,p\,R}$. Where, D_{m+p} is the diameter of the (m+p)th dark ring and D_m is the diameter of the mth dark ring.

PROCEDURE

After experimental arrangement, the glass plate is inclined at an angle 45° to the horizontal.This glass plate reflects light from the source vertically downloads and falls normally on the convex lens. Newton's rings are seen using a long focus microscope, focussed on the air fil. The cross-wire of the microscope is made tangential to the 20^{th} ring on the left side of the centre. The readings of the main scale and vernier scale of the microscope are noted. The cross wire is adjusted to be tangential to the 18^{th}, 16^{th}, 14^{th}, etc on the left and 2nd, 4th, 6th, etc on the right and readings are taken each time. From this the diameter of the ring is found out which is the difference between the readings on the left and right sides. The square of the diameter and hence Dn^2 and D^2n+m are found out. Then wavelength is calulated using equation.

OBSERVATIONS

To find Least Count

One main scale division = ... cm

Number of divisions on Vernier = ...

L.C = One main scale division/ Number of division on vernier=.................................

Order of ring	Microscopic Reading (cm)		Diameter D(cm)	$D^2(cm^2)$	$D^2_{m+p} - D^2_m$ (cm^2)
	Left	Right			

CALCULATION

Mean value of D^2_{m+p} - D^2_m=.......cm^2

Wavelength of light λ = $(D^2_{m+p} - D^2_m)/4pR$

=.............................nm

RESULT

Wavelength of light from the given source is found to be = ...nm

__EXPERIMENT 8__

STUDY OF LLOYD'S MIRROR

OBJECTIVE

To study of Lloyd's mirror

THEORY

Lloyd's mirror is a classic optics experiment that was first described in 1834 by Humphrey Lloyd in the Transactions of the Royal Irish Academy. Its original goal was to provide further evidence for the wave nature of light, beyond those provided by Young and Fresnel. In the experiment, light from a monochromatic slit source reflects from a glass surface at a small angle and appears to come from a virtual source as a result. The reflected light interferes with the direct light from the source, forming interference fringes. It is the optical wave analogue to a sea interferometer.

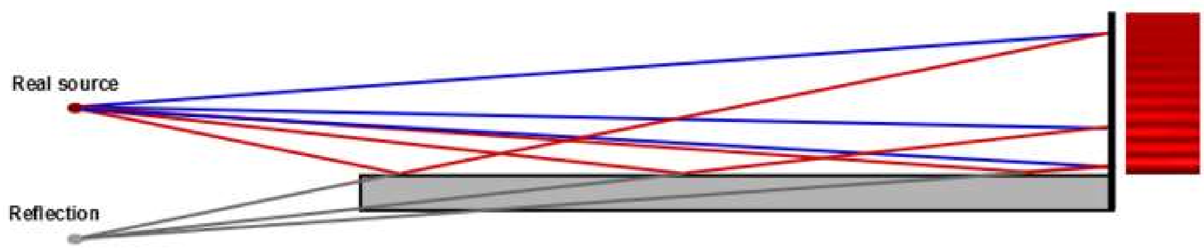


Fig.1 Lloyd's Mirror

Lloyd's Mirror is used to produce two-source interference patterns that have important differences from the interference patterns seen inYoung's experiment.

In a modern implementation of Lloyd's mirror, a diverging laser beam strikes a front-surface mirror at a grazing angle, so that some of the light travels directly to the screen and some of the light reflects off the mirror to the screen . The reflected light forms a virtual second source that interferes with the direct light.

In Young's experiment, the individual slits display a diffraction pattern on top of which is overlaid interference fringes from the two slits (Fig. 2). In contrast, the Lloyd's mirror experiment does not use slits and displays two-source interference without the complications of an overlaid single-slit diffraction pattern.

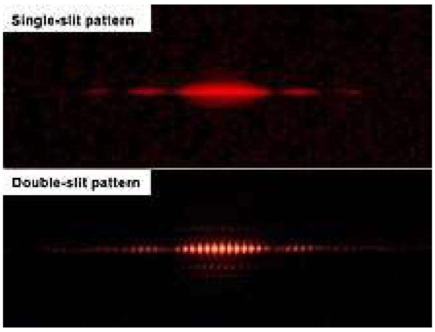


Figure 2. Young's two-slit experiment displays a single-slit diffraction pattern on top of the two-slit interference fringes.

In Young's experiment, the central fringe representing equal path length is bright because of constructive interference. In contrast, in Lloyd's mirror, the fringe nearest the mirror representing equal path length is dark rather than bright. This is because the light reflecting off the mirror undergoes a 180° phase shift, and so causes destructive interference when the path lengths are equal or when they differ by an integer number of wavelengths.

Applications

Interference lithography

The most common application of Lloyd's mirror is in UV photolithography and nanopatterning. Lloyd's mirror has important advantages over double-slit interferometers. If one wishes to create a series of closely spaced interference fringes using a double-slit interferometer, the spacing *d* between the slits must be increased. Increasing the slit spacing, however, requires that the input beam be broadened to cover both slits. This results in a large loss of power. In contrast, increasing *d* in the Lloyd's mirror technique does not result in power loss, since the second "slit" is just the reflected virtual image of the source. Hence, Lloyd's mirror enables the generation of finely detailed interference patterns of sufficient brightness for applications such as photolithography.

Typical uses of Lloyd's mirror photolithography would include fabrication of diffraction gratings for surface encoder and patterning the surfaces of medical implants for improved biofunctionality.

Test pattern generation

High visibility $\cos^2$-modulated fringes of constant spatial frequency can be generated in a Lloyd's mirror arrangement using parallel collimated monochromatic light rather than a point or slit source. The uniform fringes generated by this arrangement can be used to measure the modulation transfer functions of optical detectors such as CCD arrays to characterize their performance as a function of spatial frequency, wavelength, intensity, and so forth.

Optical measurement

The output of a Lloyd's mirror was analyzed with a CCD photodiode array to produce a compact, broad range, high accuracy Fourier transform wavemeter that could be used to analyze the spectral output of pulsed lasers.

Radio astronomy

Main article: Sea interferometry

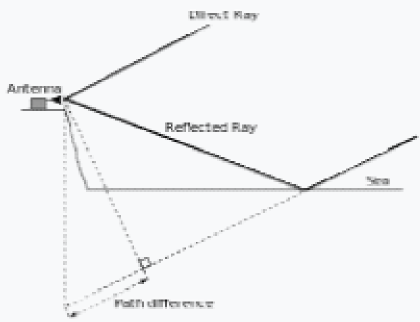


Figure 3. Determining the position of galactic radio sources using Lloyd's mirror

In the late 1940s and early 1950s, CSIRO scientists used a technique based on Lloyd's mirror to make accurate measurements of the position of various galactic radio sources from coastal sites in New Zealand and Australia. As illustrated in Fig. 3, the technique was to observe the sources combining direct and reflected rays from high cliffs overlooking the sea. After correcting for atmospheric refraction, these observations allowed the paths of the sources above the horizon to be plotted and their celestial coordinates to be determined.

Underwater acoustics

An acoustic source just below the water surface generates constructive and destructive interference between the direct path and reflected paths. This can have a major impact on sonar operations.

The Lloyd mirror effect has been implicated as having an important role in explaining why marine animals such as manatees and whales have been repeatedly hit by boats and ships. Interference due to Lloyd's mirror results in low frequency propeller sounds not being discernible near the surface, where most accidents occur. This is because at the surface, sound reflections are nearly 180 degrees out of phase with the incident waves. Combined with spreading and acoustic shadowing effects, the result is that the marine animal is unable to hear an approaching vessel before it has been run over or entrapped by the hydrodynamic forces of the vessel's passage.