Experiment (5)

Determination of the refractive index of a liquid by a liquid lens method

Objective:-

Determine the refractive index of a liquid.

Apparatus:-

Convex lens, liquid, plane mirror, retort stand with clamp and pin, spherometer, meter rule.

Theory:-

A spherometer: is an instrument for the precise measurement of the radius of a sphere. This experiment is one of the most important experiments to find the refractive index for all the liquids. As we know that the light pass in vacuum with constant speed which is equal 3×10^8 M/Sec (300000 Km/Sec) and the light pass also in different material which is transparent like (Air, water, glass) because the atoms of this material has ability to absorb the light and retransmission and dispersion it, for this reason the light pass through different materials in different speeds less than its speed in vacuum.

The speed of light depend on the nature of material, for that reason when the light pass from one medium to another, a change in speed will occur and change in direction happened, this phenomena called refraction, and controlled by "Snell's law of refraction "and to explain the change in light speed when it pass from vacuum to certain medium, we used a physical quantity called refractive index or index of refraction of material (n) is the ratio of the light speed in vacuum to its speed in a material .

Below are the materials having the values of refraction index are more than one because the speed of light in vacuum is large than its speed in materials:

Refraction index	**Material**
1.501	C_6H_6
1.461	CCL_4
1.362	CH_3OH
1.333	H_2O

Let the focal length of the convex (glass) lens be f1 and the focal length of the combination of this lens and the Plano concave liquid lens be f. then:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \quad \ldots\ldots\ldots.. \quad (1)$$

Since f_1 and f are known, the value of (f_2) can be calculated from (1).

Now $\frac{1}{f_2} = (n_\ell - 1)(\frac{1}{r} + \frac{1}{\infty}) = \frac{n_\ell - 1}{r}$ (where f_2 and r are both negative)

i.e. $$n_\ell = 1 + \frac{r}{f_2} \quad \ldots\ldots\ldots.. \quad (2)$$

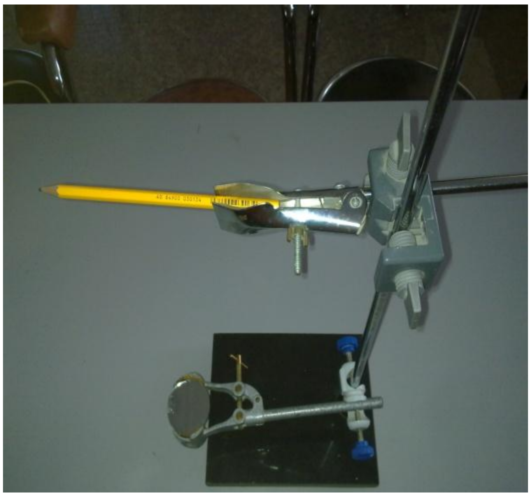


Figure (1): The experimental setup

Procedure:-

1:- The plane mirror is placed on the base of the stand with the pin held horizontally by the clamp above see figure (1 and 2).

2:-The convex lens is then placed on the mirror, and its focus is found by locating the position of the pin where it coincides with its own image. By measuring from this point to the lens, its focal length (f_1) is found.

3:- The lens is now removed, and a few drops of liquid are placed on the mirror. On placing the convex lens on the liquid, a combination of a convex (glass) and a Plano-concave (liquid) lens results.

4:- The focal length (f) of the combination is found as above, and the focal length (f_2) of the liquid lens calculated from f and f_1 (equ. (1)).

5:- The radius of curvature (r) of the lens surface in contact with the liquid is now obtained by a spherometer , or by boys' method.

6:- Calculate the refractive index of liquid from equation (2).

7:- Find the percentage error of (n):

$$\mathbf{p.e=((n_{th}-n_{exp})/n_{th})\times 100\%}$$

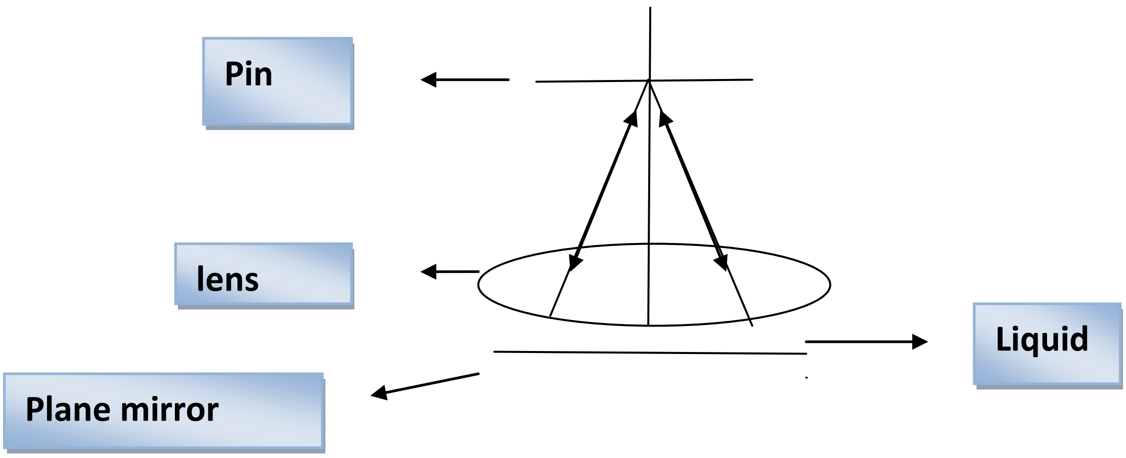


Figure (2): Schematic diagram of the experimental.

Discussion:-

Q1:- Discuss the results in the experiment?

Q2:-What is the reason of using the Spherometer in experiment?

Q3:-What is the effect of the convex lens in this experiment?

Q4:-If you use a concave lens instead of convex lens, what the result would be?

Experiment (3)

Determine the Refractive Index of Glass

Objective:-

Calculate the refractive index of glass by using Michelson Interferometer.

Apparatus:-

Bread board, Diode laser with power supply, beam splitter, mirrors with mount (M_1, M_2), rotation stage with slide of glass, Screen.

Theory:-

The principle works of a Michelson interferometer are shown in figure (1). M_1 and M_2 are two plane mirrors silvered on the front surfaces. The Beam splitter, is a planar glass plate partially slivered (50%-50%) on one side. It is mounted vertically at an angle 45 degree to the incident light.

A ray of light from monochromatic source A strikes the beam splitter C, Which divided the beam into two paths. Part of light (ray1) passes through the silvered surface (beam splitter C) and the glass plate D and is reflected from mirror M_1 .It then returns through D and is reflected from the silvered surface of C to the observer. The remained of the light (ray 2) is reflected from the silvered surface at point P to the mirror M_2 and back through C to the observer's eye.

The position of mirror M_2 can be adjusted with a very accurate micrometer screw. If the distance L_1 and L_2 are exactly equal and the mirrors M_1 and M_2 are exactly at right angles, the virtual image of M_1 formed by reflection at the silvered surface of plate C coincides with mirror M_2.If $L_1$and L_2 are not exactly equal, the image of M_1 makes a slight angle with M_2.

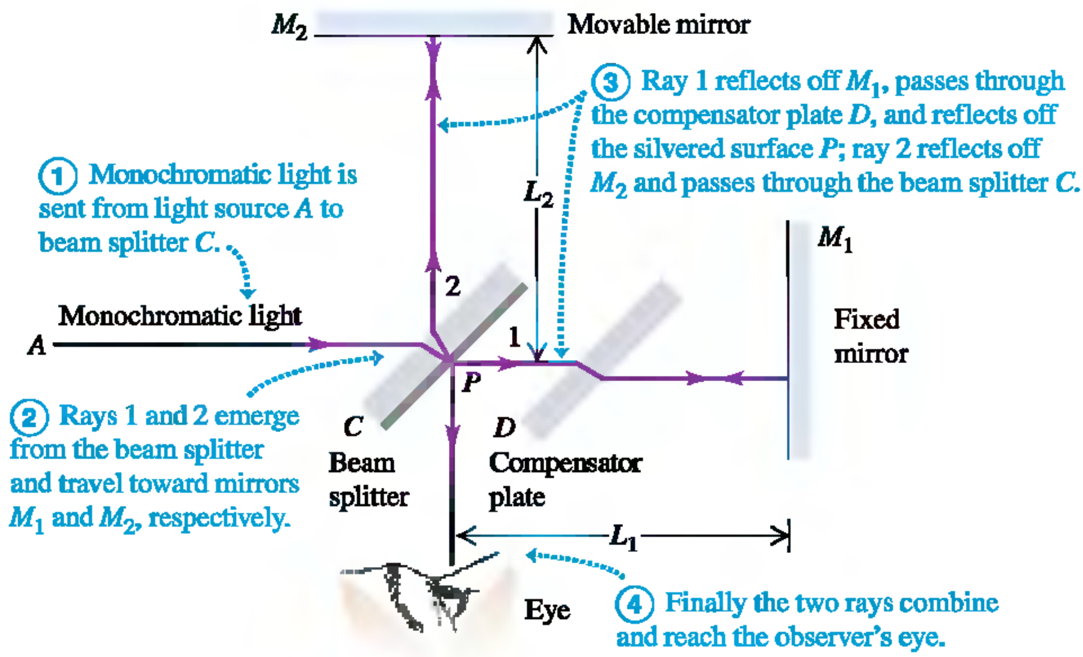


Figure (1) :Michelson interferometer

Procedure:-

1. Align the laser and interferometer in the Michelson mode.
2. Place the rotation stage between the beam splitter and movable mirror, perpendicular to the optical path.
3. Mount the glass plate on the rotation stage.

4. Position the stage and glass such that glass slide is perpendicular to the optical path.
5. When glass plate is introduced in the optical path of Michelson interferometer, the fringe will be shifted and will blur. To make the fringe sharing again, move mount to and fro till the clear set of fringes is achieved on the viewing screen.
6. Slowly rotate the rotation stage. Count the number of fringe translations that occur as you rotate the table to an angle θ (at least 20 degree).
7. Before taking the readings, observe the movement of fringe.
8. Calculate the refractive index of glass by using the relation below:

$$n = \frac{(2t - N\lambda)(1 - COS\Theta)}{2t(1 - cos\theta) - N\lambda}$$

Where:

n=the refractive index of glass slide.

N=number of the fringes counted.

ϴ=angle of rotation.

λ=wavelength of laser beam.

t=the thickness of the glass slide

Discussion:-

Q1:- Explain the principles work of Michelson interferometer.

Q2:- Define the refractive index.

Q3:- What is the function of beam splitter.

Q4:- Discuss the source of error in your experiment.

Experiment (1)

Laser beam divergence angle

Objective:-

This work is used to determined and reduce the divergence angle of He-Ne laser with and without beam expander.

Apparatus:-

He-Ne laser, Beam expander, screen

Theory:-

The laser (light amplification by stimulated emission of radiation) is a device that produces a strong beam of coherent photons by stimulated emission. A laser beam is coherent, very narrow and intense.

The directionality of the leaser beam is expressed in term of the full angle beam divergence, which is twice the angle that the outer edge of the beam makes with the center of the beam as shown in Fig. (1), the divergence tells us how rapidly the beam separates when it is emitted from the laser. Although the divergence angel can be measure in fractions of degrees or radian, the relation between degree and rad is 2π = 360 degree and 1 rad = 57.3 degree, 1 mrad = 0.057 degree.

Consider a monochromatic beam of light of “infinite” extent, which passes through a circular aperture of diameter D. The beam, will now diverge by an amount dependent on the size of D.

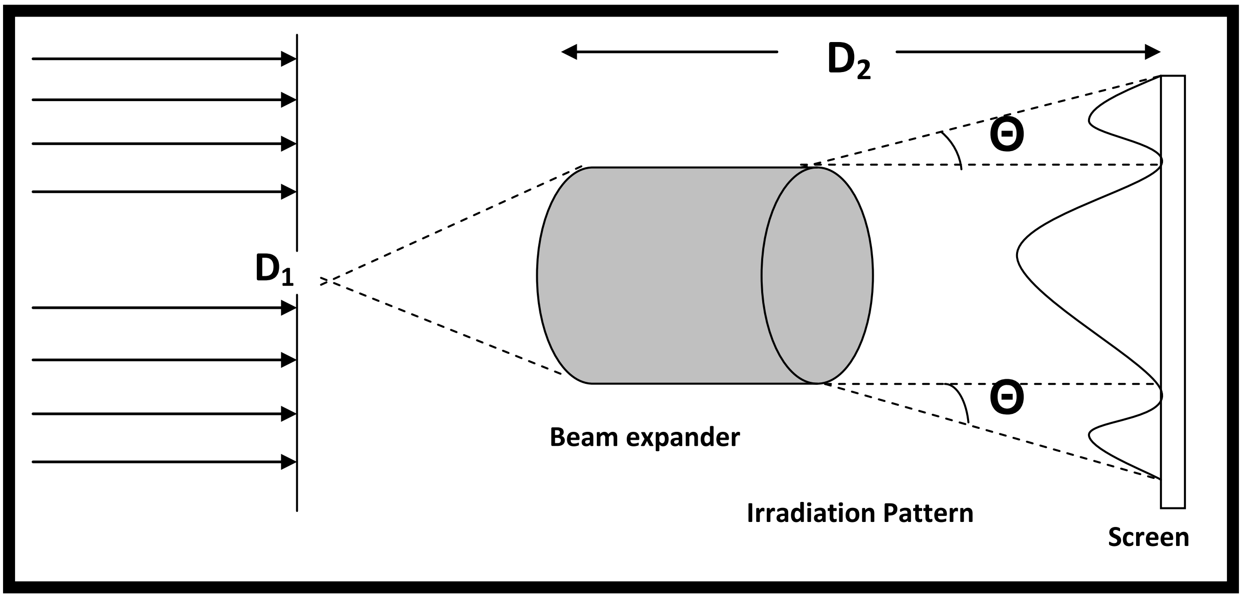


Fig (1):- Beam divergence from a circular aperture.

Procedure:-**Part A:- Without beam expander:**

1. Determined (D1) which represented the diameter aperture of He-Ne laser.
2. Place the He-Ne laser at distance of about (S=500 mm) from the screen as in Fig. (2)
3. Determined the diameter of beam on screen (D2).

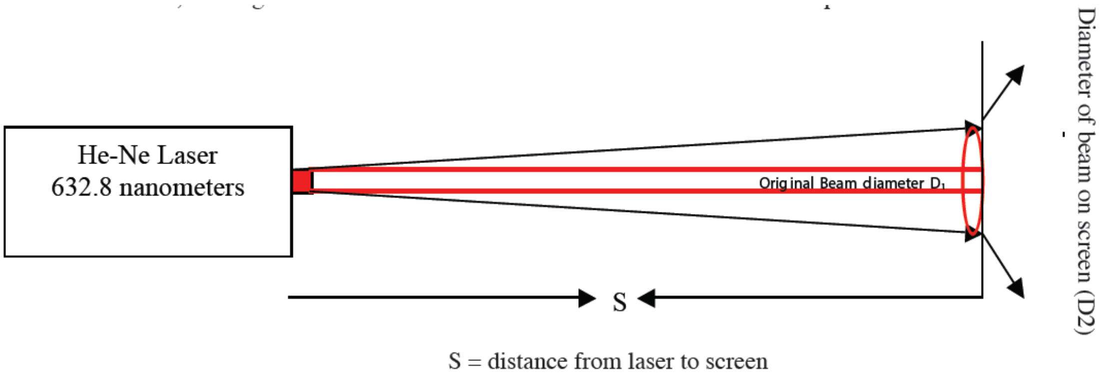


Fig.(2):- The setup without beam expander.

4.Increase the distance (S) from (500 to 3000)mm and arrange your results as in table below:

S (mm)	D1(mm)	D2 (mm)	D3=D2-D1
500 ⋮ 3000			

5. Plot a graph between D3 as a function of S to find the slope.
6. Slope = tan θ

Where:

λ: Wave length of He-Ne laser=632.8nm

θ: Divergence angle.

<u>Part B:-With beam expander.</u>

Repeat all the steps in Part A but S is the distance between beam expander and the screen. See fig.(1).

Discussion:-

Q1:-What is the reason for laser beam divergence?

Q2:- What is the mean property of He-Ne laser?

Q3:- A laser has a divergence of 0.2 mill radians (mrad):

(i)If the beam cross section is circular, what is the solid angle of the beam?

(ii)If the power of the beam is 5 mW, what is the intensity of a point at 2 m distance from the laser?

Q4:- The divergence of laser beam after sending through a telescope is 10^{-6} red .What is the diameter of the spot formed on the moon's surface if the laser is directed towards the earth? (The distance from earth to the moon is $3.8*10^{5}$ km).

Experiment (5)

Lenses

Objective:-

This work is used to find the focal length of the convex lens by using two methods:

A. Direct method (auto-collimation method).

B. Graphical method (displacement method).

Apparatus:-

Bromine tungsten lamp, Convex lens (L), Illuminated object (P), Optical bench, Two axis tilt holder, Flat mirror (M).

Theory:-

A lens is a piece of glass or other transparent material shaped so that it can produce an image by refracting light that comes from an object.

Lenses are used for many purposes (in eye classes to improve vision, in cameras to record senses).

Lenses are of two kinds, converging and diverging, a converging lens is thicker in the middle than at it is; a diverging lens is thinner in the middle as shown in Fig. (1(a,b)),a converging lens brings a parallel beam of light to a single focal point (F),here F is called a real focal point because the light rays pass through it and the distance from the lens to (F) is called the focal length of the lens.

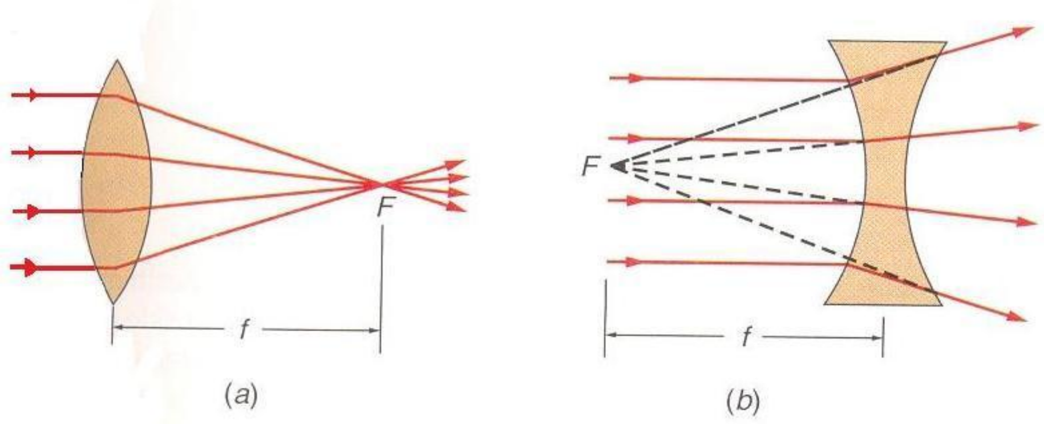


Fig. 1:- a) Convex Lens, b) Concave Lens.

Also any ray from the object is refracted by the lens would change in to a parallel ray, once reflected by the plane mirror and again refracted by the lens Shown in Fig. (2).

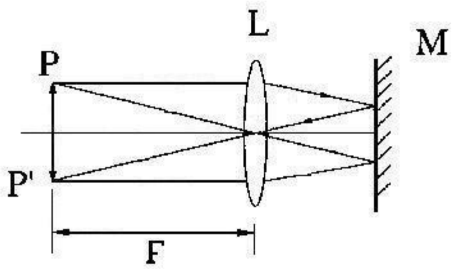


Fig.(2)

Procedure:-

A. Auto –collimation method:

To find the focal length (f) for the convex lens align all components in same height as shown in Fig. (3,4).

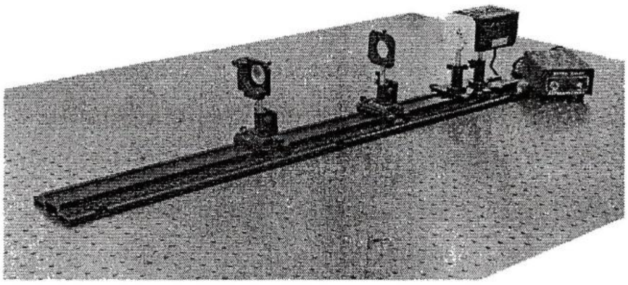


Figure 3

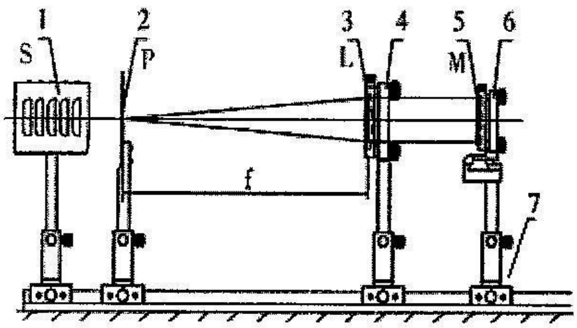


Figure 4

1. Move lens (L) back and forth till a clear image of the object on (P) is observed on the back surface of (P).
2. Adjust axis of mirror (M) and finely move (L) till the image is clearest and is the same size as the object.
3. Write down the locations of (P) and (L) as (S_1) and (S_2).
4. calculate the focal length:

$$f = S_2 - S_1$$

B: - Graphical method:-

1. To find the focal length (f) for the convex lens align all components in same height as shown in Fig. (5,6).

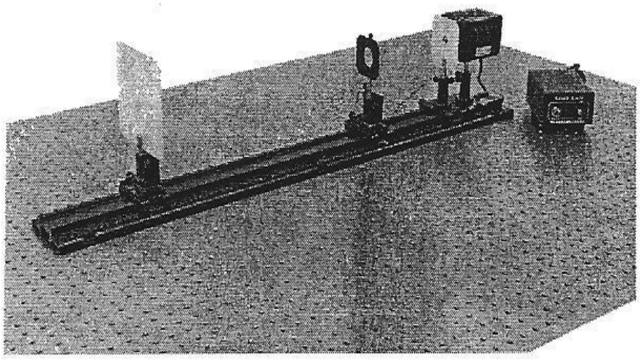


Figure 5

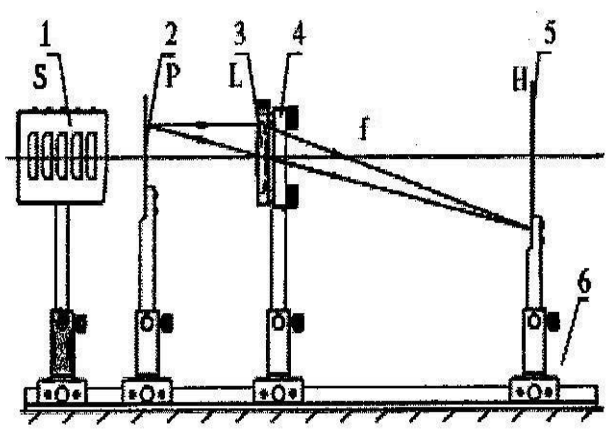


Figure 6

2. Move lens (L) back and forth till a clear image of the object on (P) is observed on the screen (H).
3. Measure the distance between the object and leans also the distance between the lens and screen (u and v respectively).
4. Move the lens to obtain another clear image and record the results.
5. Repeat step (4) for three times.
6. Arrange you results as shown in table below:

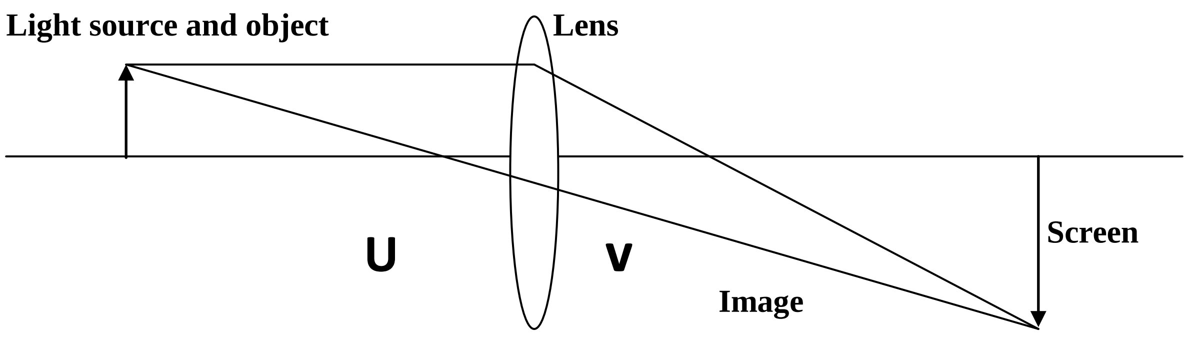
u	v	1/u	1/v	1/u+1/v=1/f

Where:

u: is the distance between the object and the lens.

v: is the distance between the image and the lens.

f: is the focal length of lens.



7. Plot a graph of 1/v as a function of 1/u. then find focal length (f).

Discussion:-

Q1:-which method you prefer to find the focal length? And why?

Q2:-What is the function of the convex lens in optical system.

Q3:-Explain the six cases for producing an image by convex lens.

Q4:-The near point of a certain eye is (100cm) in front the eye, what kind of lens should be used to see an object (25cm) in front of the eye?

Experiment (2)

Measuring the Wavelength of Laser with a Simple Ruler

Objective:-

To calculate the wavelength of Laser using a simple ruler as a diffraction grating.

Apparatus:-

He-Ne Laser, metallic ruler, Screen,

Theory:-

Diffraction is the bending of light around the edge of an object. The amount of bending is quite small but depends on the size of the opening relative to the wavelength of the light.

In this experiment, we will use a steel ruler to measure the wavelength of light emitted by a laser. The laser produces a narrow intense beam of monochromatic (i.e., single wavelength) light. The ruler has a shiny, metallic finish. Consequently, if you reflect the laser light off the surface of the ruler, it behaves like a mirror with the angle of reflection equal to the angle of incidence.

Light from a laser has such a high degree of spatial and temporal coherence (what do these terms mean?) that if it is aimed at a steel ruler, the ruler markings can act as a diffraction grating which producing a series of bright spots on the vertical board. The positions of the diffracted beams then enable the wavelength of the laser light to be simply determined.

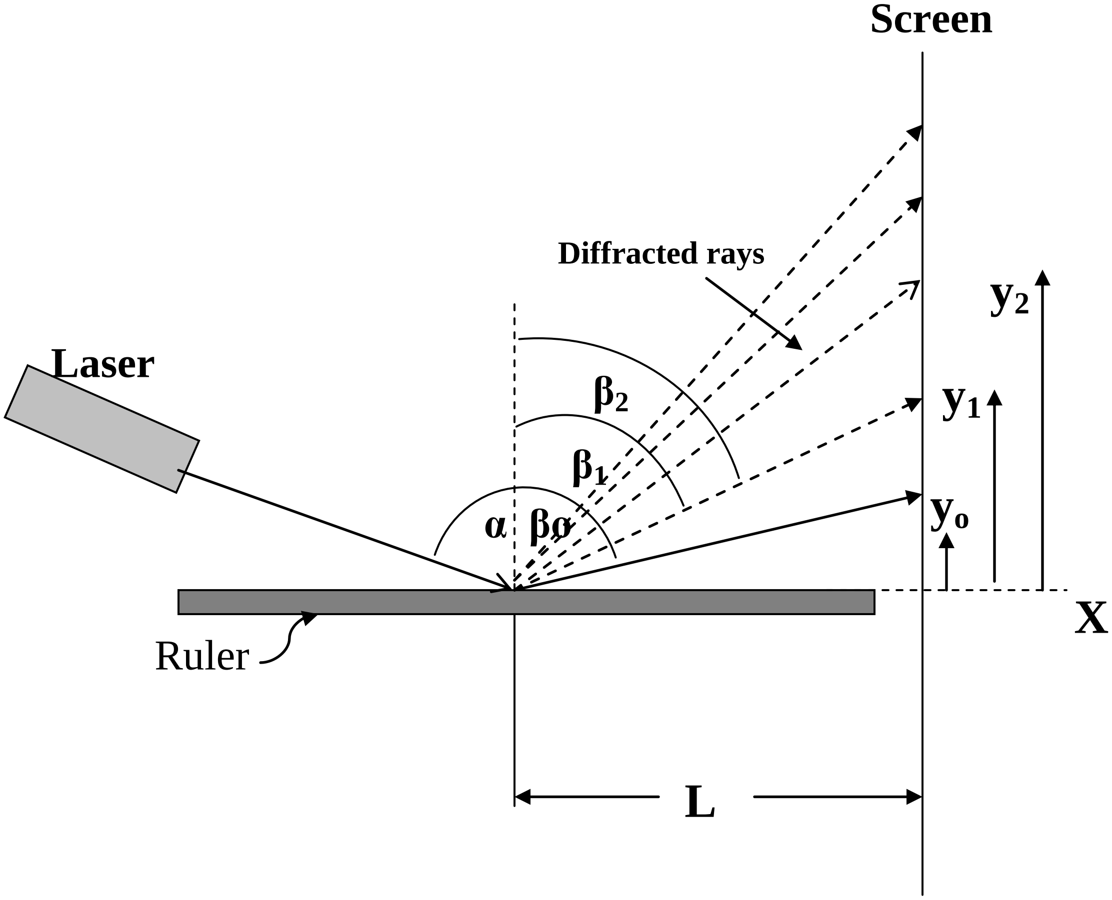


Figure (1): The experimental setup

In this case, the waves are not incident normal to the surface but instead are incident at a small angle and the waves reflect from between the rulings. It is possible for interference to occur.

There will be constructive interference for all pairs of angles **α** and **β** that satisfy the grating equation:

$$n\,\lambda = d\,(\sin\alpha - \sin\beta) \quad \ldots\ldots(1)$$

where **d** is the grating spacing, **n** the diffraction order (n=1,2,3,…) and **λ** the wavelength of the laser light.

Now, from simple geometry

$$\beta_n = \frac{x}{\sqrt{x^2 + y_n^2}} \qquad \ldots\ldots\ldots (2)$$

Where $\mathbf{y_n}$ is the height of the $\mathbf{n^{th}}$ diffracted spot.

Provided the spot heights are small compared to the distance to the vertical board, i.e. $y_n \ll x$, Equ. (2) may be approximated by :

$$\sin\beta_n \approx 1 - \frac{y_n^2}{2x^2} \qquad \ldots\ldots\ldots (3)$$

Therefore, from Equ. (1), and the fact that $\boldsymbol{\alpha = \beta_0}$, we finally have:

$$n\lambda \approx \frac{d}{2}\left(\frac{y_{n}^{2} - y_{0}^{2}}{x^2}\right) \text{ or } y_{n}^{2} = y_0^2 + \left(\frac{2\lambda x^2}{d}\right)n \quad \textbf{.........\ (4)}$$

Procedure:-

1.Assemble the set up according to figure (l).

2.Mount the laser on the magnetic mount in such a way that the beam will make a small angle with the ruler.

3.Record the distance (L) which represent the distance between ruler (where the light striks it) and screen.

4.Record the distance (d) : the smallest distance between neighboring marks on the ruler.

5. Mark on the screen the hight of the spots of light (Y_o ,Y_1 , Y_2 ,….) as shown in figure (l).

6. Plot a graph of Y^2_n against the order of diffraction n.

7.Determined the gradient which equals to $2\lambda L^2/d$ from this you can calculate the wavelenght of laser λ.

Discussion:-

Q1:- Define Diffraction and Explain the Diffraction phenomenon.

Q2:- What are the types of Diffraction.

Experiment (4)

Mirrors

Objective:-

1:-To find the focal length of a concave mirror by two methods:-

A:-Direct method.

B:-Graphical method.

Apparatus:-

Light source, concave mirror, convex mirror, object and screen.

Theory:-

The reflection can occur at an interface between two transparent materials or at a highly polished surface of an opaque material such as a metal, in which case the surface is usually called a mirror.

We have three types of mirrors:-

1. Concave mirror.
2. Convex mirror.
3. Plane mirror.

A spherical reflection has image-forming properties similar to those of a thin lens, you can see a spherical mirror of radius of curvature (r) in Fig. (1).

In this case the focal length of spherical mirror can see in equation (1):

$$f = \frac{1}{2} r \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where:

f: focal length

r: is the radius

But in graphical method you can find the focal length by using equation (2):

$$1/u+1/v=1/f \qquad (2)$$

Where:

u: Distance between object and mirror.

v: Distance between mirror and screen.

f: Focal length.

Procedure:-

A:-Direct method:

1. To find the focal length place the concave mirror facing the object and screen with object in the same level as shown in Fig.(1):

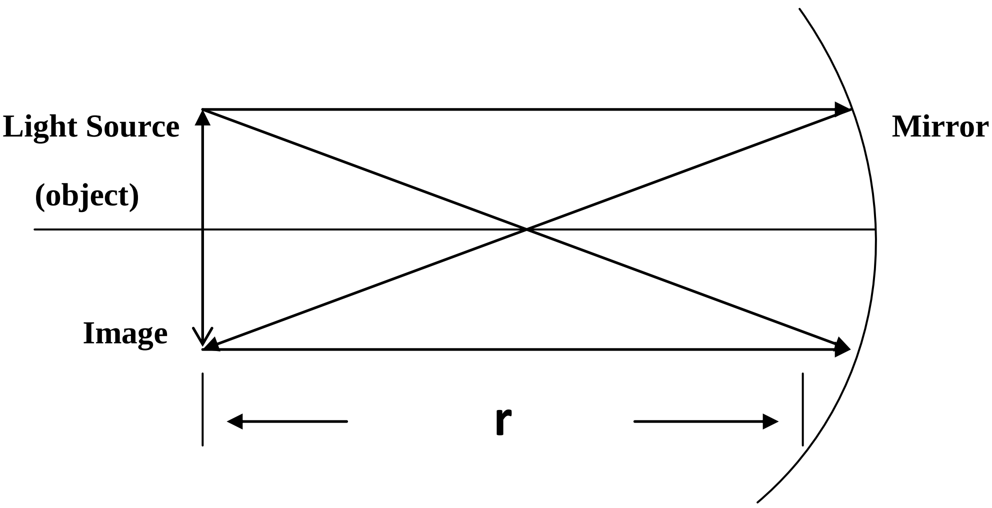


Fig. (1):- The setup of Direct Method.

2. Adjust the position of mirror until a sharp and screen image coincides with the object.
3. Measure the distance between the bottom of the mirror and the object.
4. Find the focal length (f) of the mirror by applying equation (1).
5. Find the percentage error (p.e) of the focal length.

p.e= $((f_{th}-f_{exp})/f_{th}) \times 100\%$

B:-Graphical method:

1. Place the object at a distance u from the concave mirror.
2. Fix the concave mirror and move the screen as shown in Fig. (2).

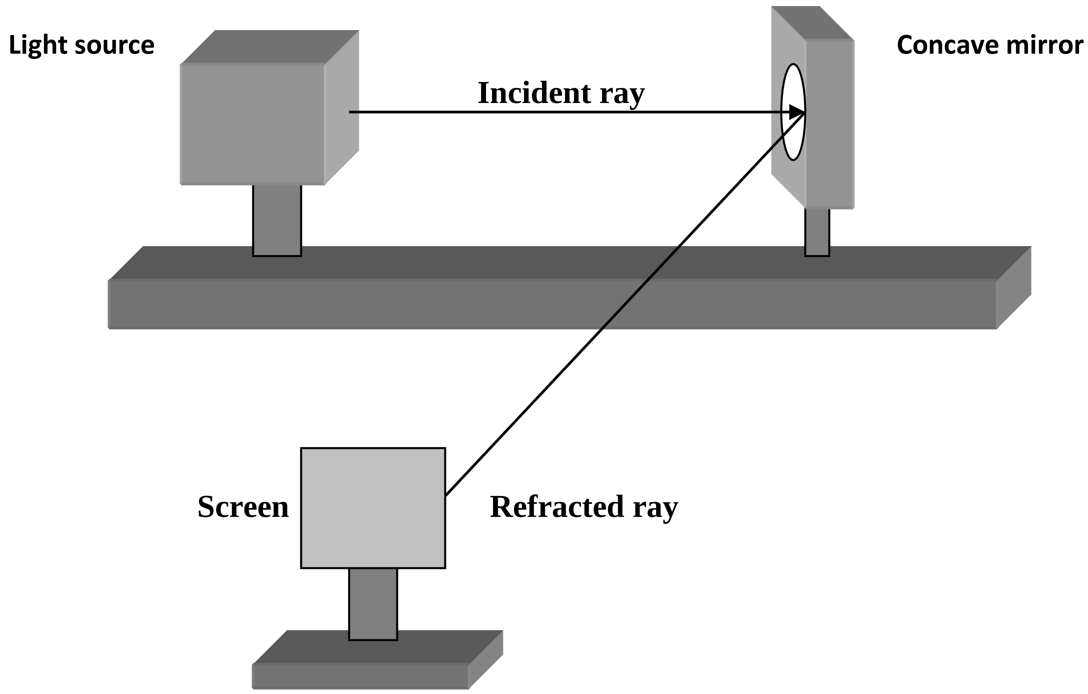


Fig. (2):- The setup of Graphical Method.

3. Take six reading for u and the corresponding v.

u	v	1/u	1/v

u: Distance between object and mirror.

v: Distance between mirror and screen.

f: Focal length.

4. Plot a graph of 1/v as a function of 1/u# to find focal length (f).

5. Find the percentage error (p.e) of the focal length.

$$\mathbf{p.e = ((f_{th} - f_{exp})/f_{th}) \times 100\%}$$

Discussion:-

Q1:-Which method you prefer to find the focal length? And why?

Q2:-What type of mirror is required to form an image on a wall (0.6 m) from the mirror, of the filament of a head light lamp 20 cm in front of the mirror?

Q3:-Explain the six cases for producing image formed by concave mirror.

Q4:-Prove that f=r/2.

Experiment (1)

Speed of Light in Glass

Objective:-

This experiment is used to determine the speed of propagation of light waves in glass.

Apparatus:-

Prism, spectrometer, Halogen lamp source.

Theory:-

Light travels with the speed c = 2.998 $*10^8$ m s^{-1} in vacuum. In a material medium its speed (ν) depend on the refractive index of material. As a result, light waves undergo refraction at the interface of two media. In this experiment, we take the material of the medium in the form of a glass prism. A parallel stream of waves traveling from a medium 1 (here air) is incident on the interface air and glass (the prism), at the angle incidence θ_1.The angle of refraction is θ_2 Snell' s law connects the two by the relation,

$$n_1 * \sin\theta_1 = n_2 * \sin\theta_2 \qquad \text{.........} (1)$$

$$\nu = c/n \qquad \text{.........} (2)$$

Where (n_1) and (n_2) are the refractive indices of the two media 1 and 2 respectively.

By using equation (1) and sub situation equation (2) we get equation (3) Since the medium 1 here is air ($n_1 \cong 1.000$), the speed of light in the second medium given by

$$\nu = c\,(\sin\theta_2 / \sin\theta_1) \quad \ldots\ldots\ldots (3)$$

We know that for a certain direction of incidence, the ray travels parallel to the base of the prism and the angular displacement of the final ray that emerges from the second interface of the prism has the lowest possible value. For this minimum angular deviation, δ_m, and the corresponding incidence angle θ_1 the geometry of symmetric propagation inside the medium leads to the equation for ν.

$$\nu = c \, \frac{\sin(\alpha/2)}{\sin(\alpha+\delta_m)/2} \quad \ldots\ldots\ldots\ldots (4)$$

Where (α) is the apex angle of the prism. Thus, from a measurement of the angle of the prism and the value of the minimum angular displacement (δ_m), the speed of light in the material can be determined.

<u>Procedure:-</u>

1:- In the experiment, we need to produce a parallel beam of rays to be incident on the prism. This is done with the help of a collimator. The collimator has an adjustable rectangular slit at one end and a convex lens at the other end. When the illuminated slit is located at the focus of the lens (see Fig.1), a parallel beam of rays emerges from the collimator. We can test this point, with the help of a telescope adjusted to receive parallel rays.

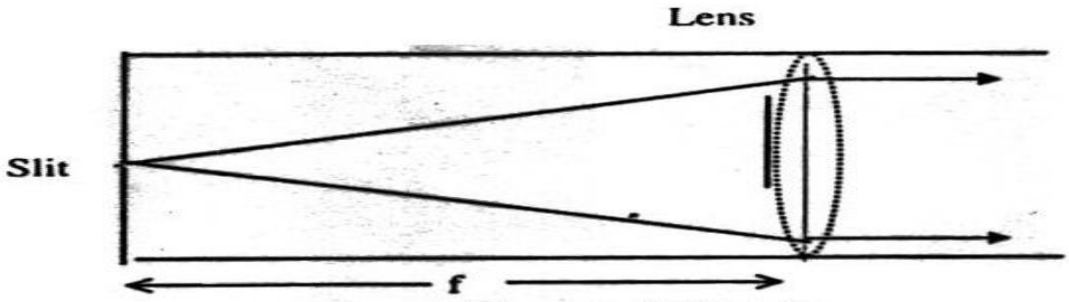


Fig : 1. Collimator

2:- Put the prism on the table with one apex of the prism at the center and the direction of the apex angle towards the collimator.

3:- Slightly adjust the prism so that the beam of the light from the collimators falls on the two reflecting faces symmetrically (Fig. 2).

4:- Fix the prism and turn the telescope to one side as to receive the reflected image repeat this procedure for the other side. Measure the apex angle of the prism (α).

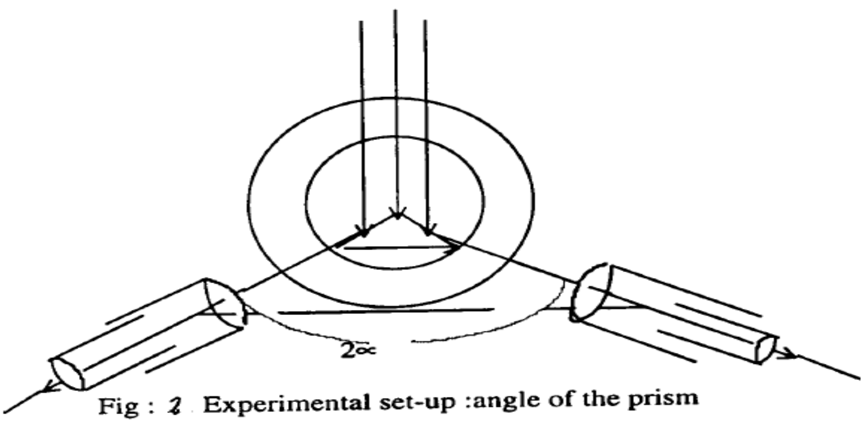


Fig : 2 Experimental set-up :angle of the prism

5:- Turn the prism table for the measurement of the angle of minimum deviation (δ_m) Locate the image of the slit after refraction through the prism as shown in (Fig.3).

6:- When you turn the telescope you can see the spectrum of light, take the reading and calculate the angle of the minimum angular deviation, (δ_m).

7:- Use equ. (4) to calculate the experimental value of the speed of light in the glass medium.

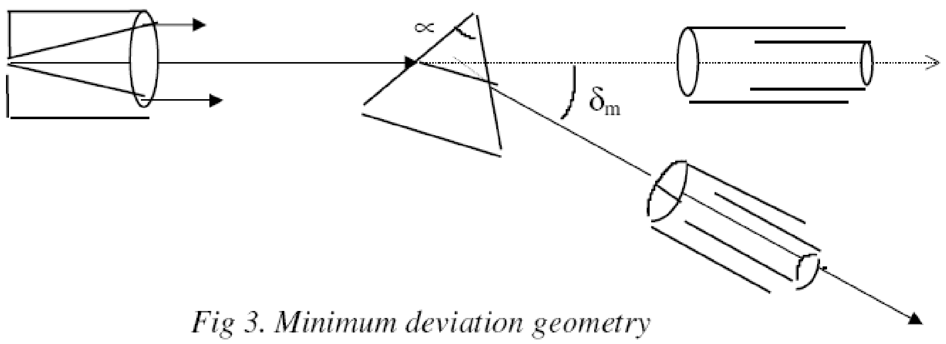


Fig 3. Minimum deviation geometry

8:- Use equ. (2) to calculate the theoretical value of the speed of light in the glass medium.

9:- Find the percentage error of (v):

$$\mathbf{p.e = ((v_{th} - v_{exp})/v_{th}) \times 100\%}$$

Discussion:-

Q1:- Define the prism and the angle of deviation.

Q2:- What are the main parts of the spectrometer?

Q3:- Explain the dispersion of light by using the prism?

Q4:- Define the telescope and describe the types of the telescope.

Q5:- Discuss the source of error in your experiment.

Experiment (6)

Speed Sound in Air (Resonance Tube Method)

Objective:-

To calculate the speed sound in air by using tuning fork.

Apparatus:-

Resonance-Tube, tuning fork, rubber hammer, meter stick, clamp and stand.

Theory:-

Sound is a longitudinal wave that is created by a vibrating such as a guitar string, the human vocal cords other diaphragm of a loudspeaker. Moreover sound can be created or transmitted only in a medium such as a gas, liquid, or solid. Sound travels through gases, liquids and solids at considerably different speeds. In general sound travels slowest in gases faster in liquid fastest in solid for example the speed in Oxygen is (316 m/sec) in Ethanol (1162 m/sec) and in Copper (5010 m/sec).

When a tuning fork is vibrating near the open end of air column at the other end, a strong reinforcement called a resonance can be heard. This reinforcement occurs because the ways reflected from the closed bottom of the tube return in phase with the direct wave made by the tuning fork, the direct and reflected waves combine producing a Standing wave.

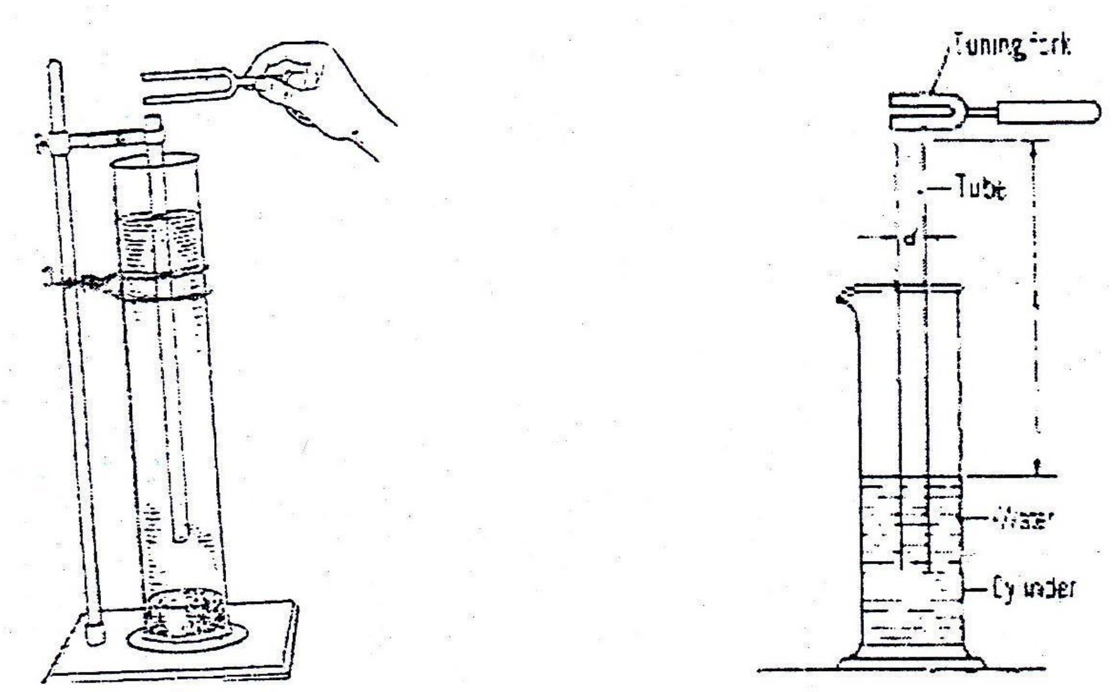


Fig. (1): The setup of the resonance tube method

In fig.(2) show an air column closed at one end with the diameter small compared to its length, a strong resonance will occur when the length of the resonant air column is one-quarter of a wavelength (λ/4) of the sound waves made by the tuning fork.

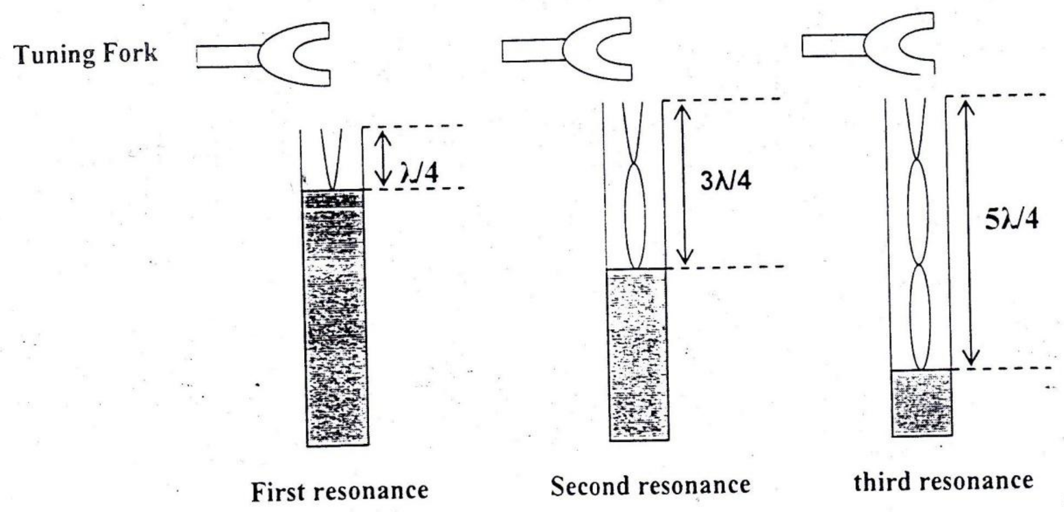


Fig. (2): The cases of resonance

Procedure:-

1:- Fill the reservoir about (42 cm) on the resonance tube.

2:- Using a rubber mallet, or the heal of your hand to strike the tuning fork, hold the vibration tuning fork horizontally as close to the open end of the tube. Move the tube and fork up and down until the sound is best reinforced and hold the tube in the position of the best sound reinforced.

3:- Measure and record the frequency of the tuning fork and the length of air column that is the distance from the top of tube to the top of the water.

4:- Arrange your results in the table below.

F(Hz)	**L(cm)**	**1/F (Hz^{-1})**

Where:

F= frequency of the tuning fork in (Hz), L= distance from the top of the tube to the top of the water.

5:- Plot a graph between1/F (Hz^{-1}) and L (cm) then find the slope.

6:- To Find the speed sound in air (ν) : we have the relation between the wavelength (λ) and the length of tube (L)

$$L=\lambda/4 \longrightarrow \lambda=4L \quad \text{........ (1)}$$

$$\nu=F * \lambda \quad \text{............ (2)}$$

λ=wavelength of sound in meters, ν=velocity of sound in m/sec.

Replace equation (1) in (2) we get: $\nu = 4 * L * F$

Discussion:-

Q1:- Why it is necessary to avoid striking the tuning fork too hard?

Q2:- What is the major cause for error?

Q3:- Explain why travels sound faster in warm air than in cool air. Suppose the room temperature (in degree Celsius) were 10% higher, how would your resonance lengths changes?

Q4:- Define the sound wave and what are the types?

Experiment (2)

The law of Reflection

Objective:-

This work is used to prove the law of reflection

Apparatus:

Plane mirror, He-Ne laser, stand for path tracing.

Theory:-

Many familiar optical phenomena involved the behavior of the wave that strikes an interface between two optical materials such as air and glass or water and glass. When the interface is smooth, i.e. when it is irregularities are small compeered with the wave length, the wave is in general partly reflected and partly transmitted in to the second medium as shown in Fig.(1).

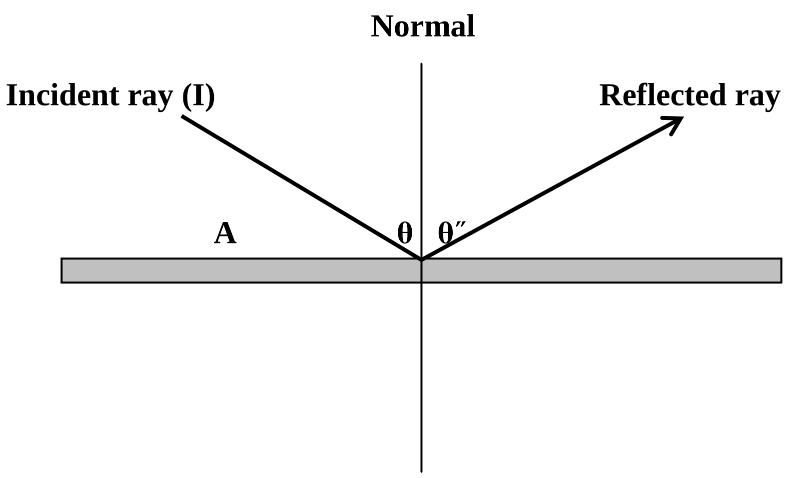


Figure (1): Reflection at ray boundary

In figure(1) let (IA) represent the incident ray and let it make the angle (θ) with (NA) the normal to the surface at (A) and it called the angle of incident and the plan defined by (IA) and (NA) is called the plan of incident.

Therefore the law of reflection may now state that:

The reflected ray lies in the plan of incidence and the angle of reflection equal the angle of incidence.

Procedure:-

1. Arrange the experimental set up as shown in Fig. (1).
2. Put the laser light and check the ray make a 90 with the plane mirror.
3. Turn the light left with (10-80) in step of 10 angle with the perpendicular to the surface of the mirror.
4. Make a table and record the results which represent the angle of reflection.

Angle of incident	Angle of reflection
10	
20	
30	
40	
50	
60	
70	
80	

Discussion:-

Q1:-What is the source of error in your experiment?

Q2:-Define: The angle of reflection and the angle of incidence?

Q3:-What is the nature of light that explained the concept of reflection?

Q4:- A ray of light is intended on a plane surface separating two transparent substances of indices 1.60 and 1.40. The angle of incidence is 45^o and the ray originates in the medium of higher index. Compute the angle of reflection?

Q5:- what is the meaning of regular reflection and irregular reflection?

Experiment (3)

The Law of Refraction

Objective:-

This work is used to prove the law of refraction.

Apparatus:-

Piece of glass, He-Ne laser, stands for path tracing.

Theory:-

When a ray of light strike any boundary between two transparent substance in which the velocity of the light it's appreciably difference it is in general divided into a reflected ray and refracted ray.

For monochromatic light and for given a pair of substances a and b on opposite sides of the surface of separation the ratio of the sine of the angle (θ_a) between the ray in substance a and the normal and the sin of the angle (θ_b) between the ray in substance b and the normal is constant thus:

$$\mathbf{Sin\ \theta_a / Sin\ \theta_b = constant} \quad \ldots\ldots..(1)$$

When the incident and refracted rays and the normal to the surface all lie in the same plane is known as the low of refraction as shown in fig. (1).

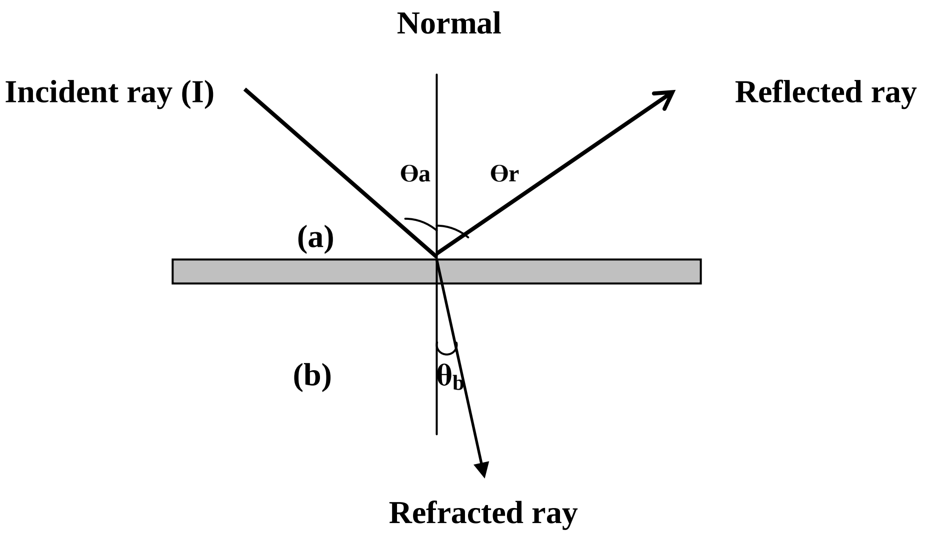


Fig.(1): Refraction at ray boundary

The discovery of the low is usually credited to Willebrord Snell; it is called Snell's low:

$$n_a * \sin\theta_a = n_b * \sin\theta_b \quad \ldots\ldots\ldots\ldots\ldots(2)$$

Procedure:-

1:-Arrange the experimental set up shown in Fig. (1).

2:-Put the laser light and check the ray make a 90 with the plane mirror.

3:-Turn the light left with (10-80) in step of 10 angle with the perpendicular to the surface glass piece.

4. Make table and record the result which represent the angle of refraction.

Incident angle(θ_a)	Refraction angle(θ_b)	Refractive index(n_b)
10		
20		
30		
40		
50		
60		
70		
80		

5. Find the refractive index in (n_b) by applying equation (2).

6. Find the percentage error of (n):

$$\mathbf{p.e= ((n_{th}-n_{exp})/n_{th})\times 100\%}$$

Where:

n_{exp}: experimental value

n_{th}: theoretical value of refractive index of glass (1.5).

<u>Discussion:-</u>

Q1:-Discuss the source of error in your experiment.

Q2:-Define the refraction angle and refractive index?

Q3:-What is nature of light that explain the concept of refraction?

Q4:- Let material A be water and material B a glass with index of refraction 1.5 if the incident ray makes an angle of (45^o) with the normal, find the reflective and refractive angle.

Experiment (4)

The Photoelectric Effect

Objective:-

This work is used to measure the plank's constant and work function.

Apparatus:-

Use the system with its accessories as shown in Fig.(1) below.

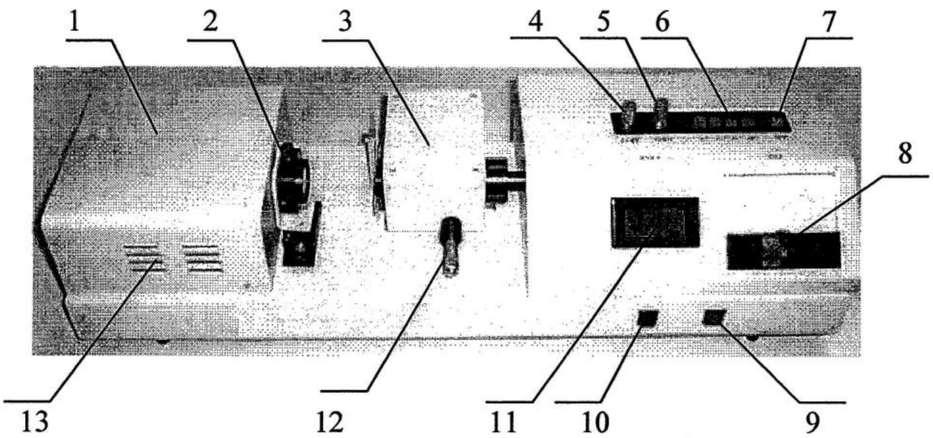


Fig. 1

1. Tungsten-halogen lamp box.
2. Condenser lens.
3. Monochromator.
4. Zeroing adjustment.
5. Voltage adjustment.
6. Current amplification range switches.
7. Voltage polarity switch.
8. Microampere meter.
9. Measurement switch.
10. Lamp switch.
11. DC voltage digital display.
12. Wave length adjuster.
13. Traverse stage of condencer.

Theory:-

In Fig. (2) Shown a schematic diagram of the basic apparatus for studding the photoelectric effect. When the light incident on a clean metal surface (Cathode(C)) electron are emitted sum of these electrons strike the second metal plates (Anode(A)) constituting an electric current between the plates. The maximum energy of the emitted electrons can be measured.

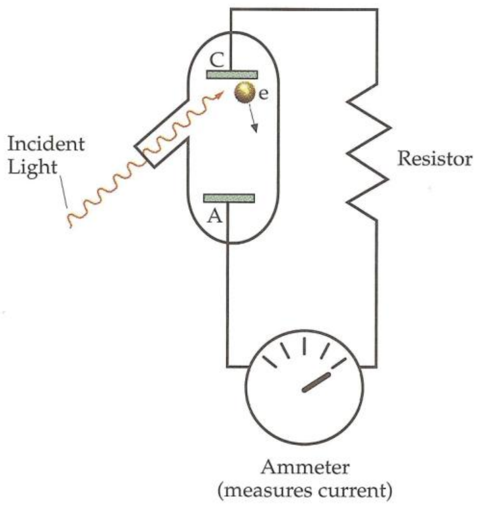


Fig. (2) Schematic diagram of a photoelectric effect.

Einstein suggested that this experimental result can be explained if light energy is quantized in small bundles called "photons". The energy of each photon is given by:

$$E = h\nu \text{ ……….. (1)}$$

Where:

h: is the Plank' s constant

ν: is the incident light frequency

When incident light frequency is below the threshold frequency (or cut-off frequency) in photoelectric effects there is no photoelectron emitted.

The maximum kinetic energy of the electrons emitted is given by:

$$\mathbf{(1/2\ mv^2)_{max} = h\nu - \Phi \ \ldots\ldots.(2)}$$

Where:

m: mass of electron ($9.109X10^{-31}$ Kg)

v: initial speed of photoelectron emitting from metal surface

The quantity Φ called the work function which is the minimum energy necessary to remove an electron from a metal surface so:

$$\mathbf{E = h\nu - \Phi \ \ldots\ldots.. (3)}$$

In the case of zero potential difference between anode and cathode photoelectrons still transmit to the anode to form a photocurrent due to some photoelectrons having maximum kinetic energy. But when the potential difference is at a negative value (U_s), then no electrons transmit to the anode and hence the photocurrent is zero.

$$\mathbf{e\ U_s - 1/2\ mv^2 = 0 \ \ldots\ldots..(4)}$$

Replace equation (4) in to equation (2) we have:

$$\mathbf{e\ U_s = h\nu - \Phi \ \ldots\ldots.(5)}$$

Where:

U_s: cut-off potential of the photoelectric effect or (cut-off voltage)

Procedure:-

A: measuring the Plank' s constant:

1. Turn on the tungsten-halogen lamp.
2. Loosen condenser locking screw, move condenser backwards and forwards to focus the light on to the surface of the entrance slide the lock it.
3. Use the horizontal adjustment screw to make the focused spot in to the entrance slit.
4. Turn on the measure switch and allow a warm up for around 25 -30 min. Block the entrance slit of the monochromeator by turning a plate in front of it.
5. Adjust the voltage meter to zero volt and then make fine adjustment On the zeroing to set the ampere meter to zero.

Note: Once the zero point of the ampere meter is set never turn zeroing knob again during measurement.

6. Set voltage polarity switch to ‘’-‘’.
7. Select the wave length between 500nm and 700nm.
8. Select the amplification range switch in 10^{-5} µA.

9. Apply DC voltage at different intervals biased on current changes at various stages and read the corresponding current values.
10. Make some experiments at different wavelengths with suitable intervals.
11. Record data in the following table:

λ_1		λ_2		λ_3	
V(v)	**I(μA)**	**V(v)**	**I(μA)**	**V(v)**	**I(μA)**

12. Plot between I-V characteristic curves and find the cut-off voltage from the graph.
13. find the cut-off voltage U_s at selected wavelengths and fill in the following table:

Wavelength(nm)			
Frequency(ν)X10^{14} (Hz)			
Cut-off voltage U_s (v)			

14. Plot a graph between U_s and ν based on the data on the above table. Designate the x-axis to be frequency and y-axis to be cut-off

voltage.

15. Find the slop = K= ($\Delta U_s/\Delta \nu$).
16. Find the Plank's constant from slop =K= h/e:

    So h=K*e

Where:

e: an electron charge (1.602 X10^{-19} C)

B: measuring the work function:

17. Determine the work function (Φ) of the material from equation (5).
18. Determine cut-off frequency of the cathode material:

$$h\nu_o = \Phi$$

Where:

ν_o: threshold frequency

Discussion:-

Q1:-Discuss the source of error in your experment.

Q2:- what is the meaning of Planck's constant, work fuction, cut-off frequency.