University of Technology
Laser & Optoelectronics Engineering Department
Laser Eng Branch
Laser application Lab.

Experiment (1)

Study of the Effect of Laser Focuse on the Speed Penetration and Cutting

Aim of the work:

Measure the Speed Penetration and Cutting

Instruments:

Laser (He-Ne & Diode), Beam expander, Lens, Workspace.

Theory:

The divergence of a laser beam is of the order of 1mill-Radian.Thus,at 1000meter the beam diameter is 1meter. For some applications the beam divergence need to be reduced, and an optical element external to the optical cavity is used. The radiation emitted from a laser is described in fig(1)

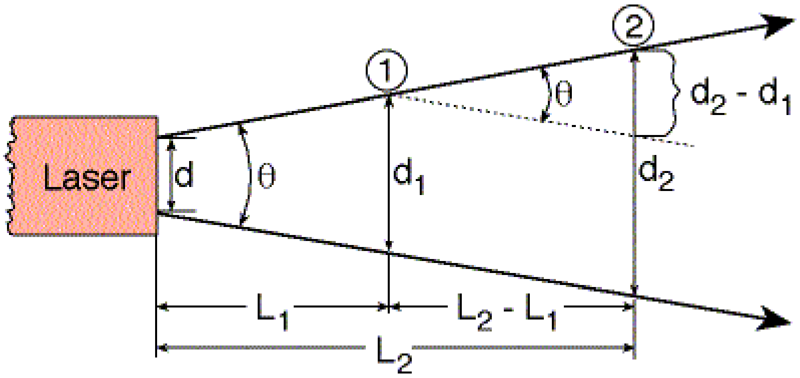


Fig (1) Divergence of Laser Beam (Beam Divergenceθ)

The straight lines that the edges of the beam create an angle called beam divergence are:

$$\theta = \frac{d_1 - d_2}{L_1 - L_2} \qquad (1)$$

θ=Beam divergence

d_1,d_2 = Beam diameters at points ‘1,2’.

L_1 , L_2 = Distances along the laser axis ,from the end of the laser to points’1,2’.

So in some applications we need to make focus the beam show fig (2)

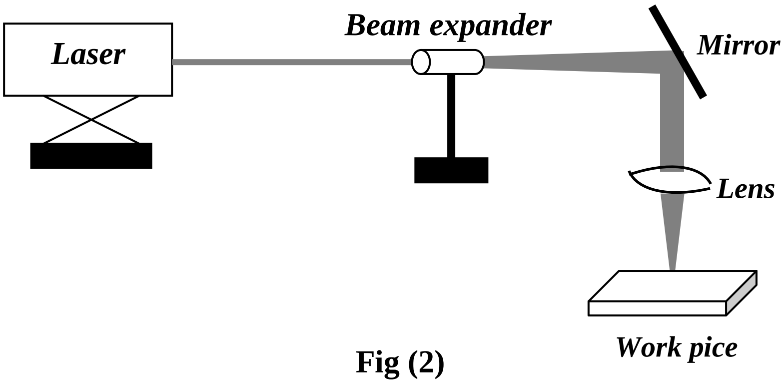


Fig (2)

Basically the beam is passed through abeam expander and then focused to a small spot on the work piece using lens, The reason for incorporating abeam expander in to the optical system is that enables a smaller final spot to be obtained. The focused spot size (W_o) is given by:

$$W_o = \frac{\lambda f}{\pi W_L} \text{...(2)}$$

Where:

Wo: radius (mm)

$W_{L:}$ the bean radius at the final focusing lens (mm)

F: The focal length of lens (mm)

λ: Wave length (nm)

To know the principle work of beam expander show fig (3).

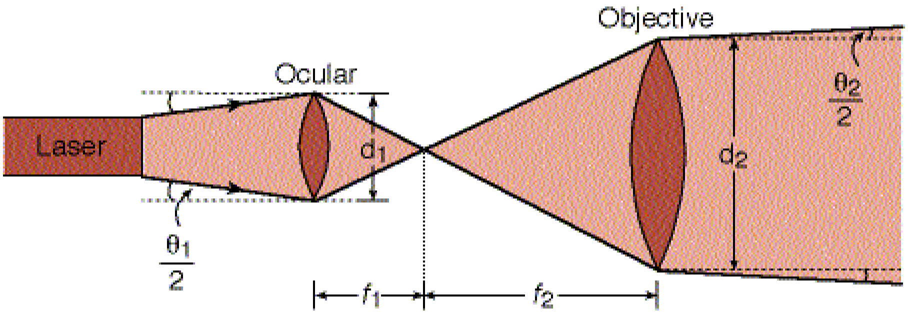


Fig (3)

The first positive lens has short focal length and small diameter while the second positive lens has long focal length and large diameter. The distance between the lenses is exactly equal to the same of the focal length of the two lenses. The laser beam enters the short focal length and is focused length and is focused to a real image serves as a point source for the other lens. At the out put of the second lens the beam has larger radius, and a smaller divergence.

The relation between the beam diameters and the beam divergence angle is :

$$\frac{f_1}{f_2} = \frac{d_1}{d_2} = \frac{\theta_2}{\theta_1} \text{..(3)}$$

f_1 = Focal length (cm) of the input lens-ocular.

f_2= Focal length (cm) of the output lens-objective.

d_1 =Diameter of the input beam.

d_2 =Diameter of the output beam.

θ_1 = Divergence angle (Rad) of the beam at the input to the beam expander.

θ_2= Divergence angle (Rad) of the beam at the output to the beam expander.

From the equation it is clear that the ratio between the beam diameters is directly related to the ratio of the focal lengths of the lenses. Another aspect of interest is the called Depth of Focus (Z) of the beam which is the distance we can move the workspace away from the minimum beam radius still have an acceptably small spot.

Procedure:

1. Array your devices as fig (2).

Calculations:

1. Experimantal part

A. Using Laser He-Ne

1. Calculate the divergence angle from applying this equation:

$$\theta = \frac{1.27\lambda}{d} \text{..(3)}$$

Where:

d= diameter of the laser beam show fig (5)

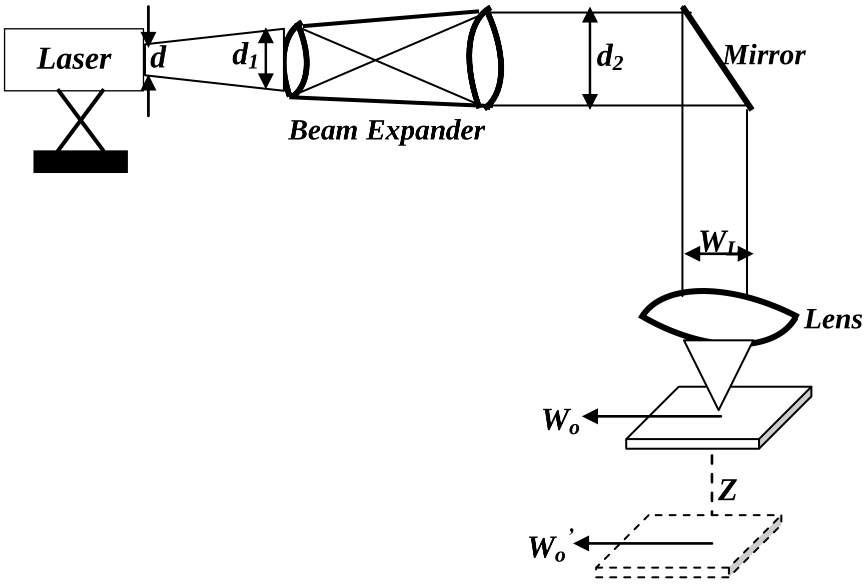


Fig (5)

2. Determine the diameter (d_1) of the beam before enters in the beam expander.

3. Determine the diameter (d_2) of the beam when it goes out the beam expander.

4. Calculate the redias of the beam before the focusing (W_L).

5. Determine the redias of the beam after the focusing (W_o).

7. Move the work pice to Z and measure the spot size.

<u>B. Using Laser diode:</u>

Repeat all these steps.

2. Theortical part:

1. From the parameters in the table(1), calculate the speed of penteration and cutting ***(V_p , V_c)***. use the vale of spot ***without*** beam expander and another ***with*** beam expander, If :

$$V_p = \frac{4P}{\pi w_o \rho (CT_v + L_v)} \text{..................................(5)}$$

$$V_c = \frac{4P}{\pi w_o Z \rho (CT_v + L_v)} \text{..............................(6)}$$

Where:

V_p = the speed of penteration.

V_c = The speed of cutting.

ρ : Density (Kg/m^3)

Z : penteration depth

L_v : latent heat of vaporization (J/Kg)

P : power

C : specific heat capasity (J/Kg.K)

Table (1)

Material	***Laser Source***		***Spacific heat capasity (J/Kg.K)***	***Density (Kg/m^3)***	***Boiling point (K)***	***Latent heat vaporzition (J/Kg) 10^6***	***Thickness (mm)***
	CO_2 KW	***Nd-YAG KW***					
Aluminum	***-***	***1***	***903***	***2710***	***2720***	***10.9***	***2.5***
Metal	***1***	***-***	***435***	***7870***	***316***	***6.8***	***2.5***

Note: Use the value of spot before and after use beam expander**.**

Discussions:

1. Why we need to focus the beam of the laser?
2. what is the effect of
    a. beam expander in the value of speed penetration and cutting?
    b. The thickness of sample on $V_{p\,\&}\,V_{c.}$
3. Give the applications that need to focusing process.
4. Compare the results when you change the laser?
5. What are happen if you change the lens to negative lens?
6. The diameter of a beam emitted from He-Ne laser is 1.4 mm and divergence angle is 1mRad. A Kapler beam expander is used made of 2 positive lenses with focal lengths of 2cm and 4cm.Calculate:
    1. The beam diameter at the output of the beam expander.
    2. The beam divergence angle.

Experiment (2)

Measurement the Distance by Using Triangulate.

Aim of experiment:

Measurement the distance for far bodies.

Instruments:-

Laser He-Ne, Optical table, Screen.

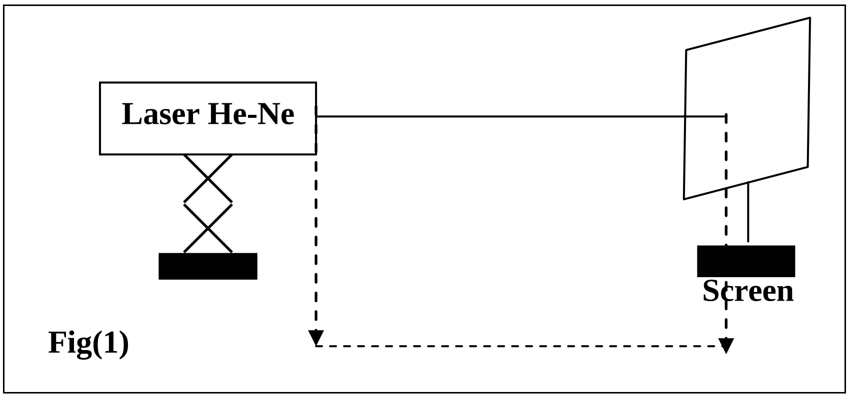
Theory:

There are many properties of laser beam help us to use it applied in the different applications like as:

1. ***Single wave length.***
2. ***Narrow band width.***
3. Can ***transmit in free space*** to far distance with ***small divergence***, and ***small attenuation.***

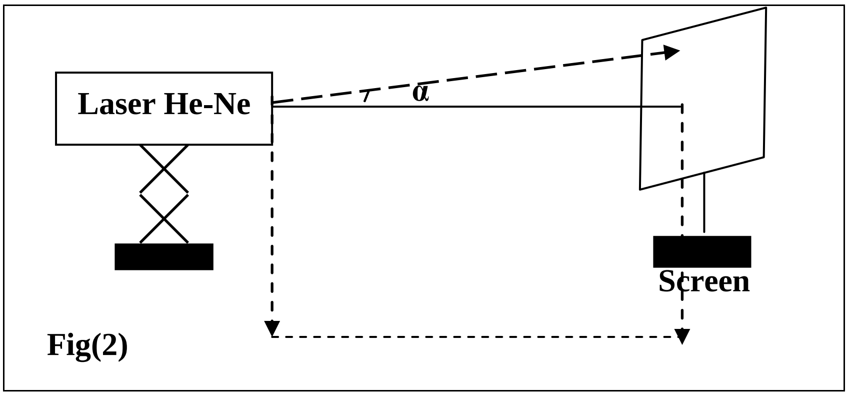
Procedure:

1. Array the devices like as fig (1).



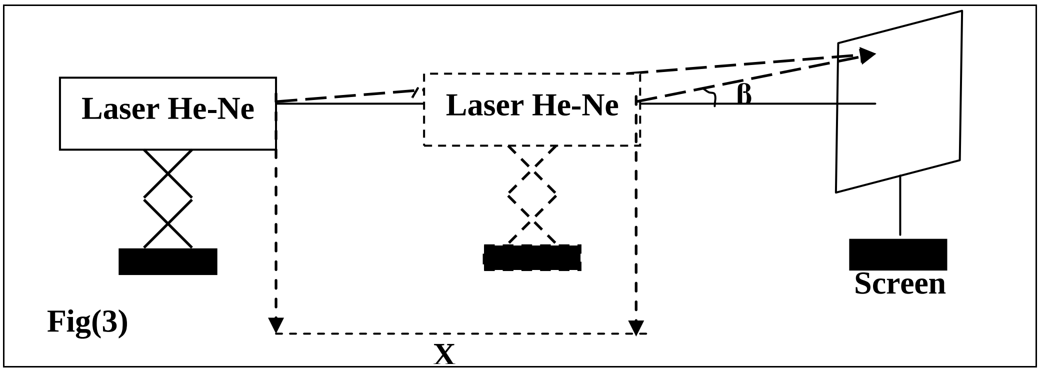
Fig(1)

2. Guide the laser at angle (α) on the screen and measure it as fig (2).



Fig(2)

Move the laser at distance (x), later guide the beam on the same point at point (2) as fig (3).



Fig(3)

3. Show the fig (4), you get the triangle (ABC) and from it, you can calculate the distance between the point on the screen & laser beam.

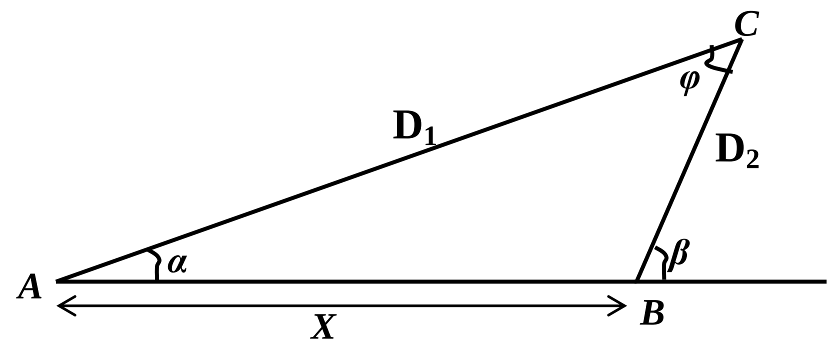


Fig (4)

Calculations:

1. Calculate D_1 by using this equation:

$$D_1 = X - [\sin(180 - \beta) / \sin(\beta - \alpha)]$$

2. Apply this equation to find the vale of D_2.

$$D_2 = X - [\sin(\alpha) / \sin(\beta - \alpha)]$$

Discussion:

1. Why we used the laser beam to calculate the distance?
2. Is there another method to measure the distance? Explain it.

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Experiment (9)

Measure the Distance Between Tracks of CD and DVD

The aim of work:

1-measure the distance between tracks of CD and DVD.

2-study the different between the CD & DVD.

Instruments:-

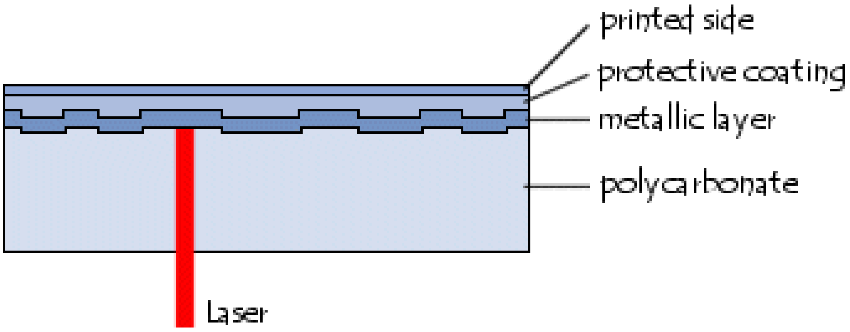
Laser He-Ne, CD & DVD, screen, ruler, holders

Theory:-

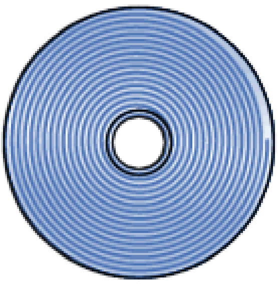
The **Compact Disc** was invented by *Sony* and *Philips* in 1981 in order to serve as a high-quality compact audio storage device which allowed for direct access to digital sound tracks. It was officially launched in October 1982. In 1984, the Compact Disc's specifications were extended (with the publication of the *Yellow Book*) so that it could store digital data.

A **CD** (**Compact Disc**) is an optical disc 12cm in diameter and 1.2mm thick (its thickness may vary from 1.1 to 1.5 mm) for storing digital information: up to 650 MB of computer data (equivalent to 300,000 typed pages) or 74 minutes of audio data. A circular hole 15mm in diameter is used to centre it on the CD player's surface.

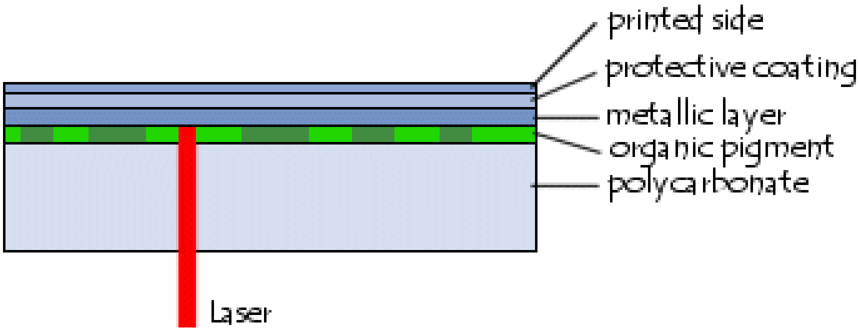
A CD is built from a plastic (polycarbonate) substrate and a fine, reflective metallic film (24-carat gold or a silver alloy). The reflective layer is then covered with an anti-UV acrylic finish, creating a protective surface for data. Finally, an additional layer may be added so that data can be written on the other side of the CD as well.



The reflective layer contains tiny bumps. When the laser passes over the polycarbonate substrate, light is reflected off the reflective surface, but when the laser reaches a bump, that's what allows it to encode information. This information is stored in 22188 tracks engraved in grooves (though it's actually just one track spiralling inward).



Commercially purchased CDs have already been pressed, meaning that the bumps have been created used plastic injected into a mold which contains the desired pattern in reverse. A metallic layer is then affixed onto the polycarbonate substrate, and this layer is itself covered with a protective coating. **Blank CDs** (**CD-R**), by contrast, have an additional layer (located between the substrate and metallic layer) made of a dye which can be marked (or "burned") by a high-powered laser (10 times as powerful as the one used for reading them). It is the dye layer which either absorbs or reflects the beam of light emitted by the laser.



The most commonly used dyes are:

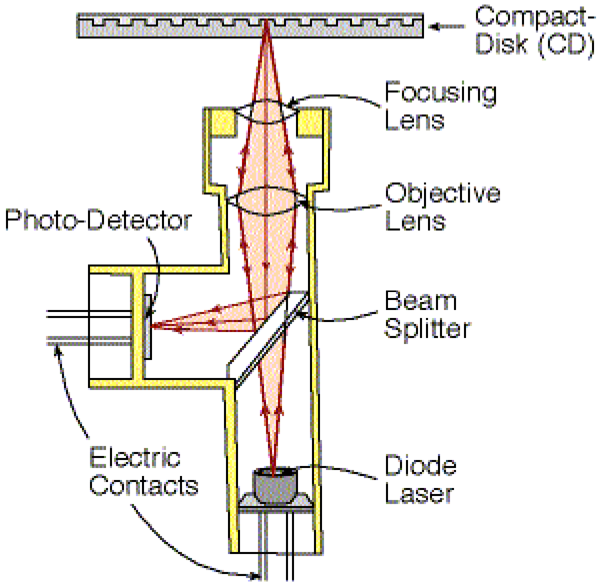
- Blue-coloured **cyanine**, which appears green when the metallic layer is made of gold
- Light-green-coloured **pthalocyanine**, which appears gold-coloured when the metallic layer is made of gold

- Dark-blue-coloured **azo**

As the information is not stored as pits but as coloured marks, a *pre-groove* is placed in the blank disc to help the burner follow the spiral path, so that precision engineering is not needed on CD burners. What's more, this pre-groove follows a sine wave called a *wobble*, with an amplitude of +/-0.03?m (30nm) and a frequency of 22.05kHz. The wobble lets the burner know what speed it needs to record at. This information is called *ATIP* (*Absolute Time in Pre-Groove*).

Operation

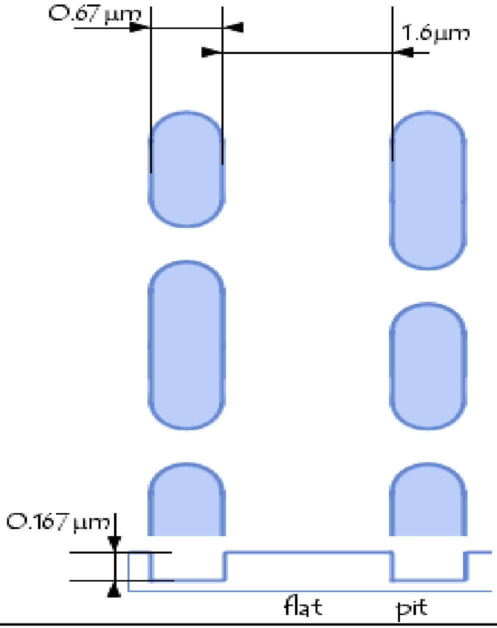
The read head is made of a laser (*Light Amplification by Stimulated Emission of Radiation*) which emits a beam of light, and a photoelectric cell which captures the reflected beam. CD players use an infrared laser (with a wavelength of 780 nm), as it is compact and inexpensive. A lens located near the CD focuses the laser beam onto the pits. A semi-reflective mirror allows the reflected light to strike the photoelectric cell, as shown in the following diagram:



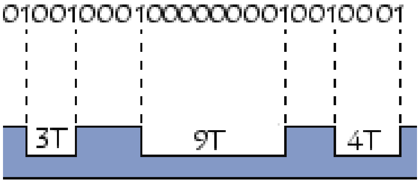
A "pickup" moves the mirror so that the read head can access the entire CD-ROM.
A CD has two basic operating modes:

Encoding information

The physical track is made up of bumps 0.168?m deep and 0.67?m wide, with variable length. The "rings" in the spiral are spread about 1.6?m apart from one another. *Pits* are the term for the depressions in the groove, and *lands* are the spaces between them.



The laser used for reading CDs has a wavelength of 780 nm when travelling through air. As the polycarbonate's refractive index is 1.55, the laser's wavelength in the polycarbonate is equal to 780/1.55 = 503nm = 0.5?m. Since the depth of the groove is one quarter the wavelength of the laser beam, a light wave reflected by a *pit* travels half again as long (125% as long to hit the disk and the same to return) as a wave reflects by a *land*. This way, whenever the laser strikes a pitted groove, the wave and its reflection are dephased by a half wavelength and cancel one another out (destructive interference), so it's as if no light was reflected at all. Moving from a pit to a land causes a drop in the signal, which represents **one bit**. The length of the groove is what stores the information. The size of a bit on a CD ("S") is standardized and corresponds to the distance travelled by the light beam in 231.4 nanoseconds, or *0.278?m* and the standard minimum velocity of 1.2 m/s. In the *EFM* standard (*Eight-to-Fourteen Modulation*), used for storing information on a CD, there must always be at least two bits set to 0 between two consecutive 1 bits, and there cannot be more than 10 consecutive zero bits between two 1 bits, in order to avoid errors. This is why the length of a groove (or a land) is greater than or equal to the length needed to store the value *OO1* (*3S*, or *0.833?m*) and less than or equal to the length of the value *00000000001* (*11S*, or *3.054?m*).



DVD Digital Versatile Disk

In 1995, new standard was established for DVD Digital Versatile Disk (called at first Digital Video Disk). They were first developed for storing a full digital movie. The DVD is a special disk that can store up to 4.7 GB information on a single layer on the disk. The new devices can store information on both sides, so the total amount of information is 9.4 GB.

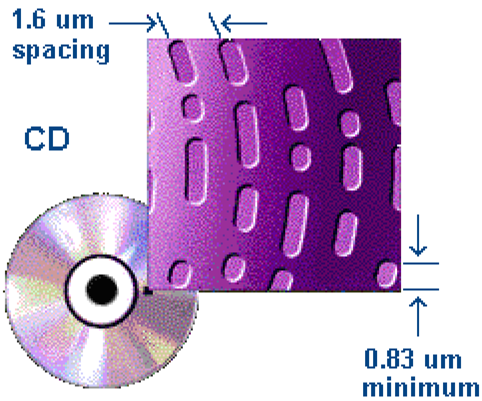
The size of the DVD is the same as CD, but because it use a shorter wavelength, the pits can be smaller (minimum size 0.4 µm) and so is the distance between tracks (0.74 µm).

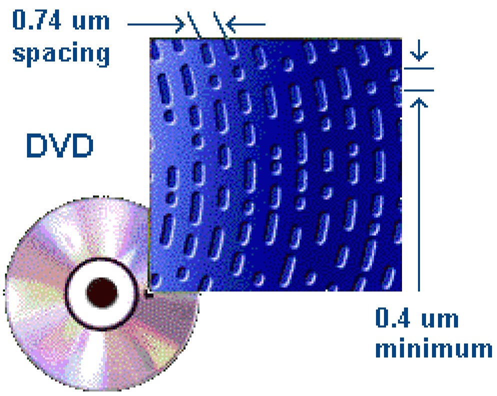
CD-ROMs are based on Diode laser with Infra-Red wavelength of 780 nm.

DVD devices are based on Diode laser with red wavelength of 650 nm. As we saw, the exact wavelength is a critical parameter in reading the information, since the process is based on the interference between the beams reflected from different depths inside the recording media.

In order for the new DVD machines to be able to read CD-ROM media, two separate optical pickups need to be inside. Each Optical pickup operates at its own specific wavelengths.

DVD increases its capacity by using higher resolution optics. DVD uses a shorter wavelength laser with red light around 650 nm compared to a CD with infrared light at 780 nm. In addition, better focusing optics allows closer tracks and smaller pits; as shown in the diagrams below





Procedure:

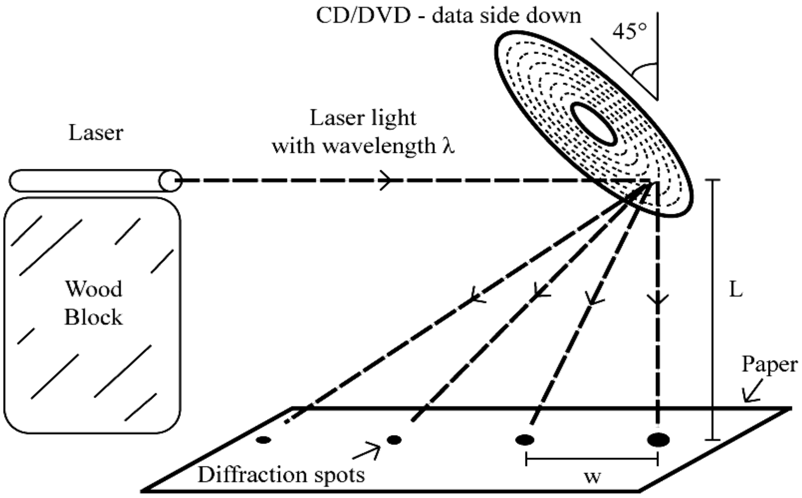
A. *First method :-determine the spacing between tracks by using the concept of diffraction*

1. Set up the laser, CD and a sheet of paper as shown.
2. Put the CD in a 45 degree angle.
3. you should see a bright spot on the paper directly underneath the CD along with other diffraction spots in line with the laser.
4. Determine the position of each spot on the paper.
5. Measure the

L = Distance of laser beam above paper
w = Distance between diffraction spots

A red laser light has a wavelength of about

λ = 650 nanometers (6.5 ×10-7 meters).



CD Track Spacing

L = ...(cm)
w = ...(cm)
d = Distance between CD Tracks
= L × λ ÷ w
= ....(m)
= ....(mm)
Number of CD Tracks per millimeter
= ....

DVD Track Spacing

L = ...(cm)
w = ...(cm)
d = Distance between DVD Tracks
= L × λ ÷ w
= ....(m)
= ....(mm)
Number of DVD Tracks per millimeter
= ....

A. second method:- determine the spacing between tracks Geometrically:-

1. Vertical Geometry:-

A. Put the CD or DVD vertically as shown in figure ,where the grating equation is

$$n\lambda = d(\sin\theta_n - \sin\theta_0)$$

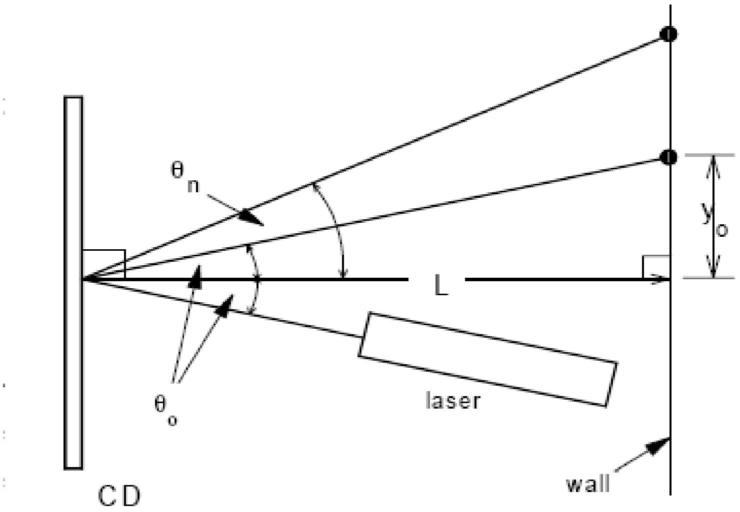


Fig. 1 Geometry for Eq. (1). The zeroth order diffraction (n=0) at θ_0 is basically a simple reflected beam. Note that the sketch assumes the CD is parallel to the wall.

B. If we let the distance from the grating to the wall be L and the distances of the zeroth and n the order diffraction spots from the horizontal plane to be Y_0 and Y_n respectively, then

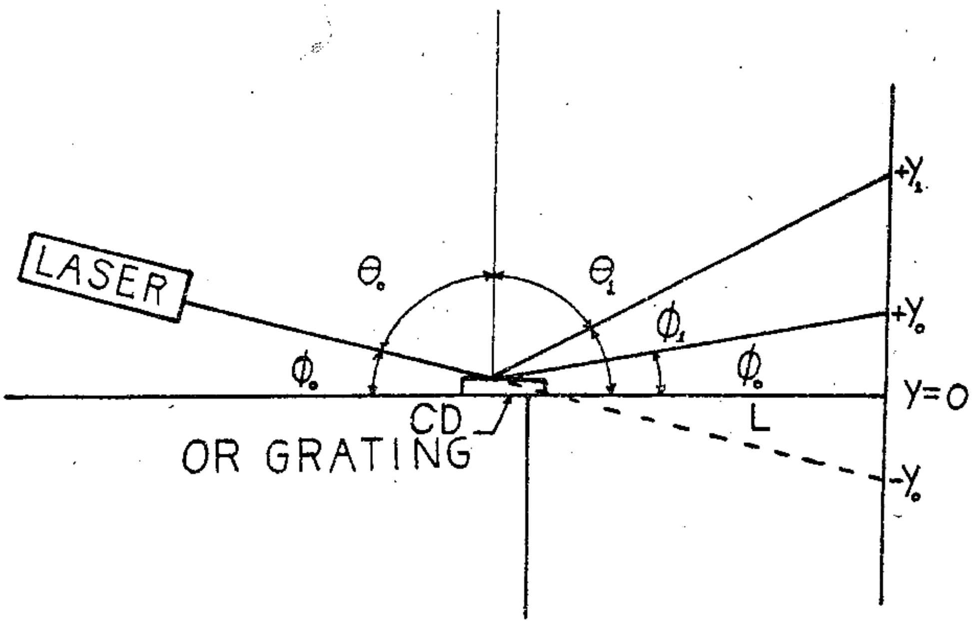
$$\sin\theta_o = \frac{Y_o}{\sqrt{Y_o^2 + L^2}} \quad \text{and} \quad \sin\theta_n = \frac{Y_n}{\sqrt{Y_n^2 + L^2}}. \qquad (2)$$

You could think about aligning the laser beam normal to the diffraction grating. Then oθ=0 and the grating equation simplifies to

$$n\lambda = d\sin\theta_n = \frac{dY_n}{\sqrt{Y_n^2 + L^2}}. \qquad (3)$$

2- Horizontal Geometry

The CD flat can be placed horizontally on the holder provided. This geometry is pictured in Fig. 1 of *The compact disk as a diffraction grating*. Be careful to label your angles correctly. In the grating equation, θ is the angle between the normal to the disk and the laser beam, but you will likely make your measurements relative to the plane of the disk, say φ, so that cosΦ=sinθ.



From Fig. 2 it is seen that $\cos \emptyset_0 = L/(L^2 + Y_0^2)^{1/2}$ and for n=1, $\cos \emptyset_1 = L/(L^2 + Y_1^2)^{1/2}$

Discussion:

1.from any material the CD & DVD manufactured ?

2.Why DVD-ROM can read CD & DVD ? and why CD-ROM read only CD?

3.What is the best method, diffraction or geometrical ?Why?

4.is the lens that found in CD or DVD –ROM moving or standing ?Why?

5.Explaine Blu-Ray technique ?

6. what is the advantage of beam splitter in CD-ROM or DVD-ROM?

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Experiment (4)

Measuring the Attenuation in Optical Fiber

Aim of the work:-

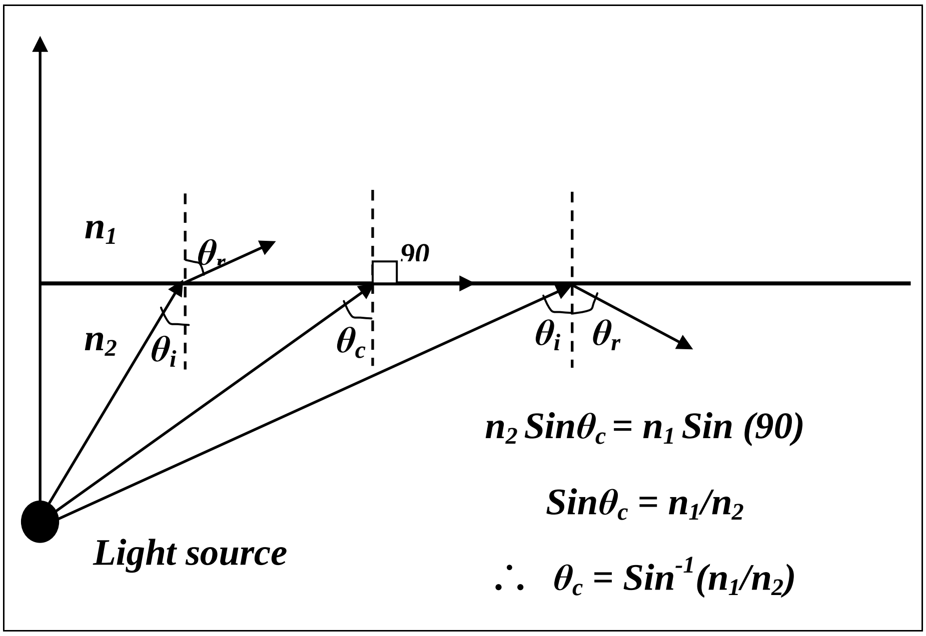
Studying the laser attenuation as a function to incident angle.

Instruments:-

Optical fiber, Carriers, He-Ne laser, Polarizer, Power meter.

Theory:-

The operation of an optical fiber is based on the principle of total internal reflection. When the light crosses materials with different refractive indices the light beam will be partially refracted at the boundary surface, and partially reflected. However, by increased the incident angle the refractive angle the refractive angle increased too until refractive of light be parallel to the boundary surface, and at this point the incident angle called the critical angle (***represent the boundary between the refraction and reflection***).then if the incident angle is bigger than the critical angle all the incident light will be reflected and this is know total internal reflected, as shown as fig (1).



$$n_2 \, Sin\theta_c = n_1 \, Sin\,(90)$$

$$Sin\theta_c = n_1/n_2$$

$$\therefore \quad \theta_c = Sin^{-1}(n_1/n_2)$$

Fig(1) the total internal reflection

An optical fiber consists of two different types of highly pure, solid glass, composed to form the core and cladding. A protective acrylate coating show (Fig 2) then surrounds the cladding. In most cases, the protective coating is a duallayer composition.

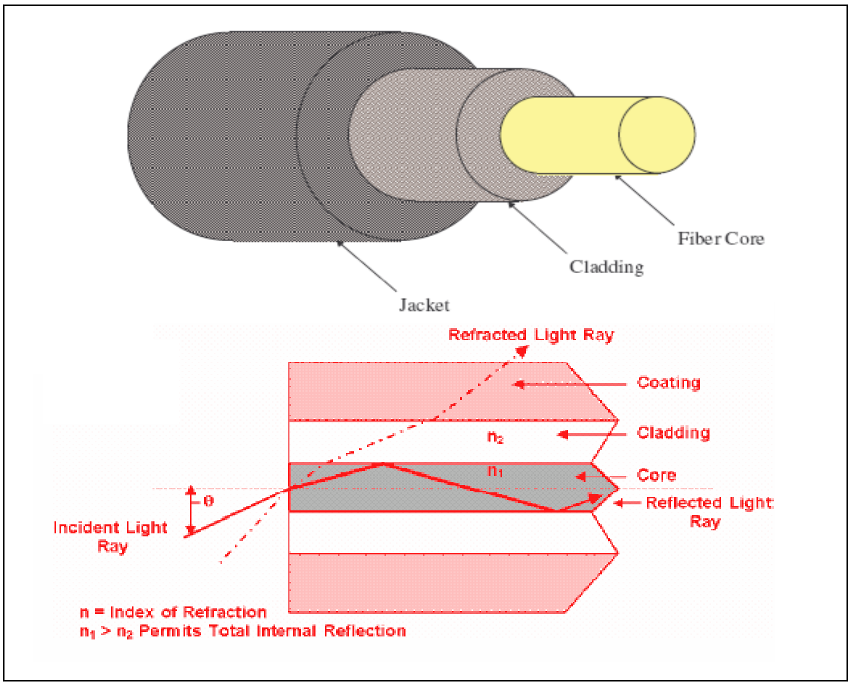


Fig (2) the cross section of optical fiber

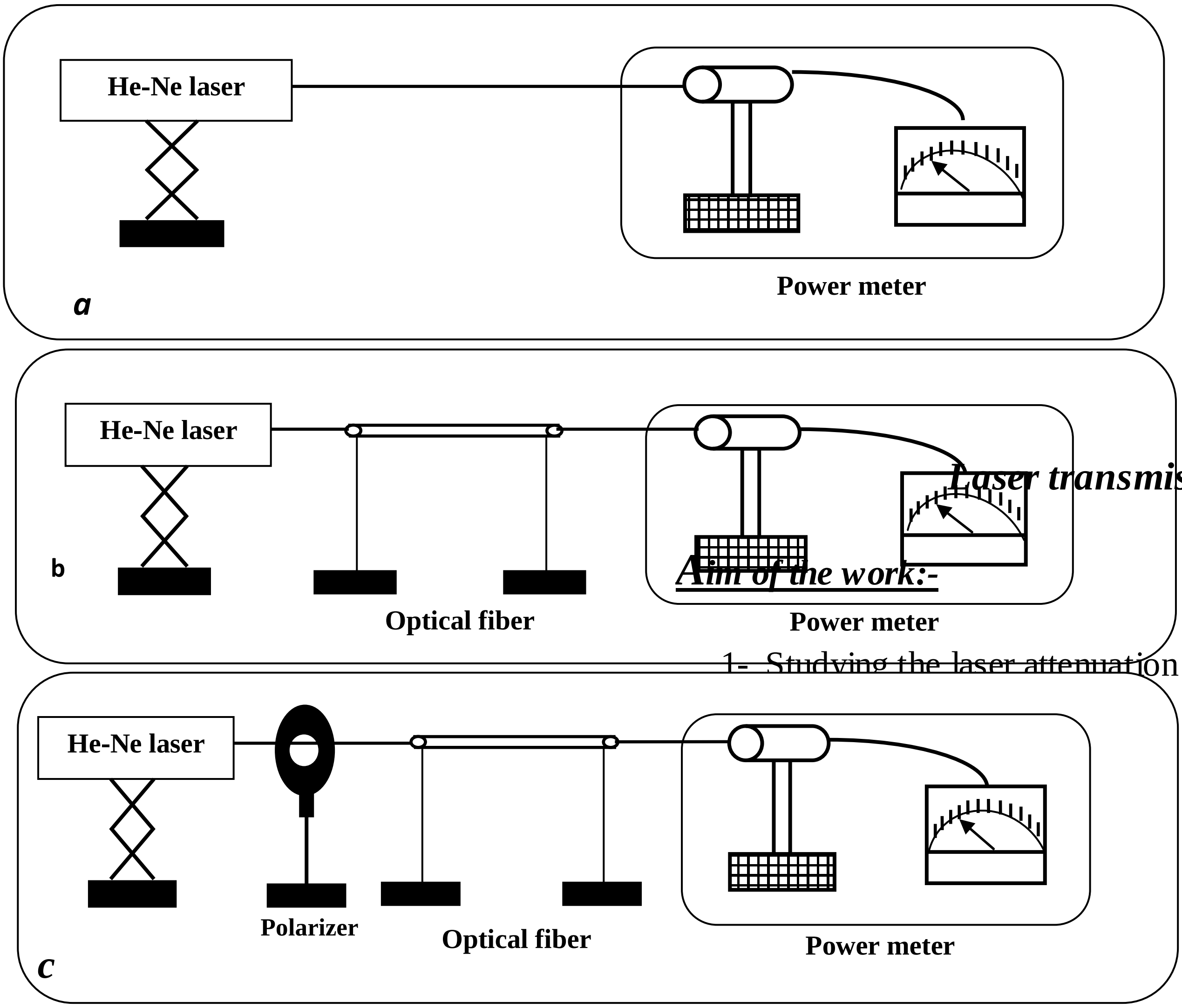
Attenuation is caused by several different factors, but primarily ***scattering, absorption*** and ***mechanical stress (bending)***. Attenuation is caused by light absorbed by residual materials, such as metals or water ions, within the fiber core and inner cladding.

Applications of optical fiber:

- Long distance telephone lines use fiber optics. Signals for many conversations can be carried over a single fiber without amplifiers.
- An anti-tank missile uses fiber optic cable for flight control. Signals on fiber optic cables cannot be jammed.
- Medical equipment uses fiber optics to illuminate and observe inside the body and in some cases to send high-energy laser pulses through the fiber to perform internal surgery.

Procedure:-

1. Array the devices as in figure (1).



2. From fig (a) measure the intensity of laser I_L.
3. From fig (b) measure the intensity out put from the optical fiber I_F.
4. From fig(c) measure the value of output intensity **(*I_{out}*)** of the light at different angles and begin from θ=0.
5. Change the incident angle as shown in the table below.

Experim

Laser transmission thro

Aim of the work:-

1- Studying the laser attenuation as a funct

Polarizer,

Fiber-optic communications is based on th can carry more information over longer distanc in a copper or coaxial medium or radio frequen The purity of today's glass fiber, combined fiber to transmit digitized light signals hundre few transmission losses, low interference and almost ideal transmission medium.

The operation of an optical fiber is based Light reflects (bounces back) or refracts (alter medium), depending on the angle at which i which the light waves are transmitted makes reach their destination. Light waves are guid much the same way that radio frequency (RF

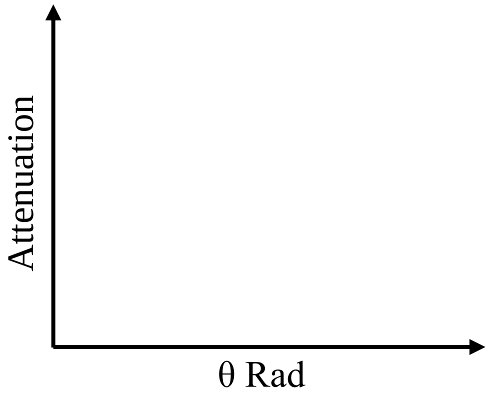
Calculations:

Θ Rad	I_{out} mwatt	$\Delta I = (I_F - I_{out})$	Attenuation $A = 10 \, Log(I_L / \Delta I)/L$
0			
5			
10			
15			

1. Arrange your measurements as this table.

Discussion:

1. Explain the ***principles work*** of optical fiber.
2. What is ***the types*** of optical fiber? And write ***the difference*** between them?
3. Why ***the core*** region has refractive index larger than refractive index of ***the cladding*** region?
4. Draw & discuss the ***attenuation*** as a function of ***incident angle.***



5. Define ***the critical angle***.
6. Explain ***laser fiber***.

Experiment (8)

Using light scattering method to find The surface tension of water

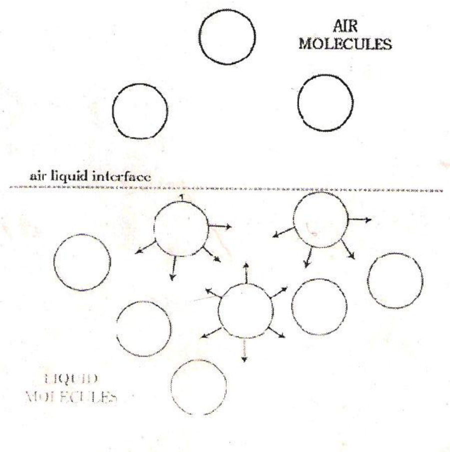
The aim o f work:

The goals of this experiment are to confirm the relationship between angular frequency © and wave vector q and to determine the surface tension q of water. ***Instruments:-***

Laser He-Ne , function generator ,loudspeaker ,screen, holder.

Theory:-

Surface tension is a property of fluids that causes tension or contraction of the fluid molecules near the surface or plane of interaction with another material or fluid. The molecules on the interior of the liquid experience relatively equal forces in all directions from the surrounding molecules. The water molecules at the surface experience a force from fewer surrounding water molecules. The change in density at the plane of interaction however, means that there are fewer molecules of air above the surface of the water than there are water molecules below
the surface of the water. These surface liquid molecules thus experience a smaller force of attraction from the gas molecules than from the interior liquid molecules and so the surface liquid molecules are drawn toward to the body of the liquid [1]. Fig. 1. shows the forces of interaction of both the gas and the liquid molecules.
surface tension is caused by Various intermolecular forces, such as, draw the liquid particles together. Along the surface, the particles are pulled toward the rest of the liquid. Surface tension is measured in of N/m (Newton per meter).



In my experiment, controlled sinusoidal waves were created on the surface of distilled water in a dish. This sinusoidal air-water interface acted as a diffraction grating for a beam of laser light incident at a grazing angle, causing interference patterns that could be observed at a range of frequencies for the surface waves. The relationship between the angular frequency ! and wave number q of surface waves in a liquid depends on the surface tension . Klipstein, Radnich and Lamoreaux derive a general expression for the surface tension of a liquid

$$\sigma = \frac{\omega^{-}\rho}{q^{3}} \quad \text{..................................(1)}$$

which assumed no frictional or rotational forces of the liquid which
q is the wave number of the surface waves.
co=27if is the angular frequency of the surface waves.
The surface tension _ is a measure of the amount of energy needed to increase the area of the surface of a liquid by one square unit of distance. An expression for the wave number of the surface waves produced is given by Weisbuch and Garbay in their simple experiment.

$$q = \frac{2\pi}{\lambda}\sin\left[\frac{r}{2}\right]\left(\sin\left[\theta - \frac{r}{2}\right] + \sin\left[\theta + \frac{r}{2}\right]\right) \quad \text{..................................(2)}$$

where ***X*** is the wavelength of the light used, GJs the angle of reflection of the incident beam, and r is the angle between the incident beam and the first maximum of the interference pattern.

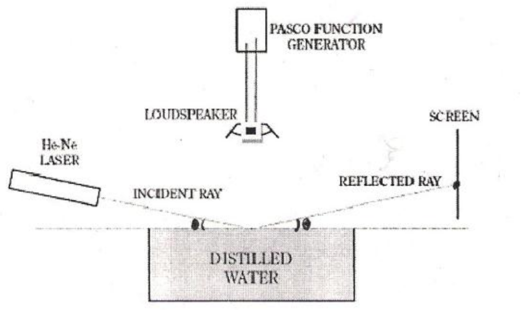


FIG. 2: A schematic of the setup of the apparatus. The container of distilled water rests on an air table with the laser beam incident near its center. The Pasco function generator and the He-Ne laser were isolated from the table.

Procedure :-A. Set up:-

1. *A paper clip attached to a loudspeaker was used to create sinusoidal surface waves in a dish of water.*
2. *Incident light from an Helium-Neon laser was then aimed at a small angle, approximately 40 , grazing the surface of the water. This incident light reflected onto the wall used as a screen for the interference pattern created.*
3. *The wave number of the water waves can be determined by measuring the maxima of an interference pattern from the diffraction of the light off the surface of the water.*
4. *The air-water interface acts as a diffraction grating for the laser light. The experimental apparatus was set up as shown above in Fig. 2.*
5. *The He-Ne laser was set up on a stand behind the air table. A loudspeaker with a straightened paper clip attached was set up on a clamp stand beside the air table with the tip of the paper clip just touching the surface of the water.*
6. *The circular dish was then adjusted beneath the loudspeaker so its attached paper clip was just touching the tip of the water directly above the center of the dish.*
7. *The circular dish was then adjusted beneath the loudspeaker so its attached paper clip was just touching the tip of the water directly above the center of the dish. The loudspeaker was attached to function generator, which was tuned to oscillate the cone of the loudspeaker sinusoidally creating surface waves from the oscillating paper clip.*
8. *The He-Ne laser was turned on with its beam skimming the surface of the water creating a single incident ray reflected on the screen.*
9. *The function generator was turned on to oscillate the loudspeaker sinusoidally at a frequency of approximately 100 Hz. This*
   frequency f was now the frequency of oscillation of the water waves in the dish.

10- The function generator was adjusted and an approximate range of 50 Hz to 400 Hz was found to create an interference pattern at the highest amplitude of the generator.

11- To determine the surface tension of the water, the wave number was measured and the frequency of oscillation recorded from the function generator.

B. Measuring the wave number of the waves:-

From Eq. 2, the angles 0 and r were measured and used to calculate the wave number of the surface waves. The angles 0 and r are defined by

$$\theta = \tan^{-1}\left[\frac{X}{L}\right] \quad \text{.......................................(3)}$$

And

$$r = \tan^{-1}\left[\frac{\Delta x}{L}\right] \quad \text{.......................................(4)}$$

where L is the horizontal distance from the point of incidence of the laser light on the surface of the water to the screen. Ax is the distance between the reflected beam and the first maximum on the interference pattern on the screen as shown in Fig. 3.

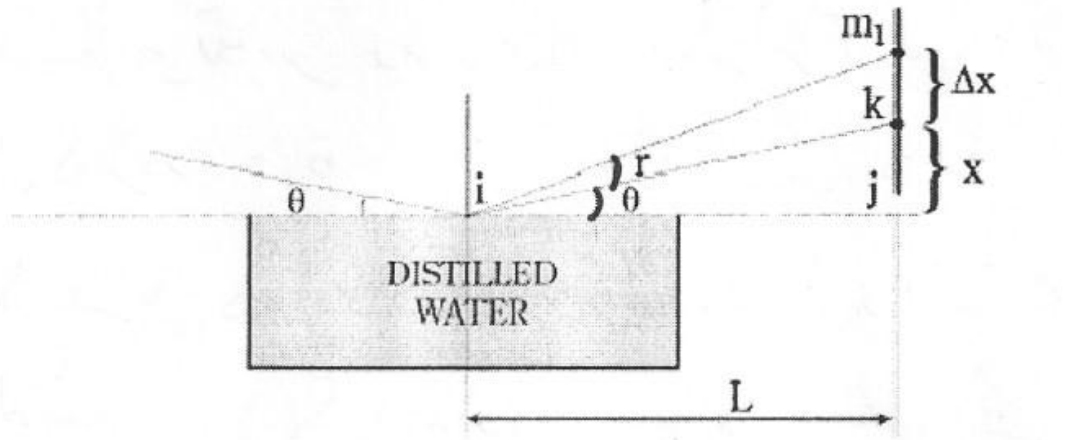


FIG. 3: A **schematic of the distances and the angles of the reflected ray and the interference pattern,** mi **is the first maximum of the interference pattern, k is the reflected beam, j is the horizontal level on the screen of the surface of the water and i is the point of incidence on the surface of the water.**

c. Determining the surface tension of water:-

The angular frequency of surface waves is given by the equation

$$\omega = 2\pi f \quad \text{.................................(5)}$$

where f is the frequency of the function generator.

Eq. 1 was combined with Eq. 2 and Eq. 5 to get an expression for the surface tension with respect to the frequency and the angles 0 and r from the interference pattern.

$$\sigma = \frac{4\pi^2 f^2 \rho}{\left(\frac{2\pi}{\lambda}\sin\left[\frac{r}{2}\right]\left(\sin\left[\theta-\frac{r}{2}\right]+\sin\left[\theta+\frac{r}{2}\right]\right)\right)^3} \quad \text{.................................(5)}$$

The wavelength of light from the He-Ne laser used is 632.8nm. By observing the interference pattern and measuring Ax for the interference pattern created, the surface tension was calculated.

Discussion:-

1- Discuss the effective of vibration surface on surface tension.
2- If we increase the temperature of liquid what will happen in value of surface tension
3- Define: Wave number, surface tension.

Producer:

1. **Array the devices as in figure (1).**

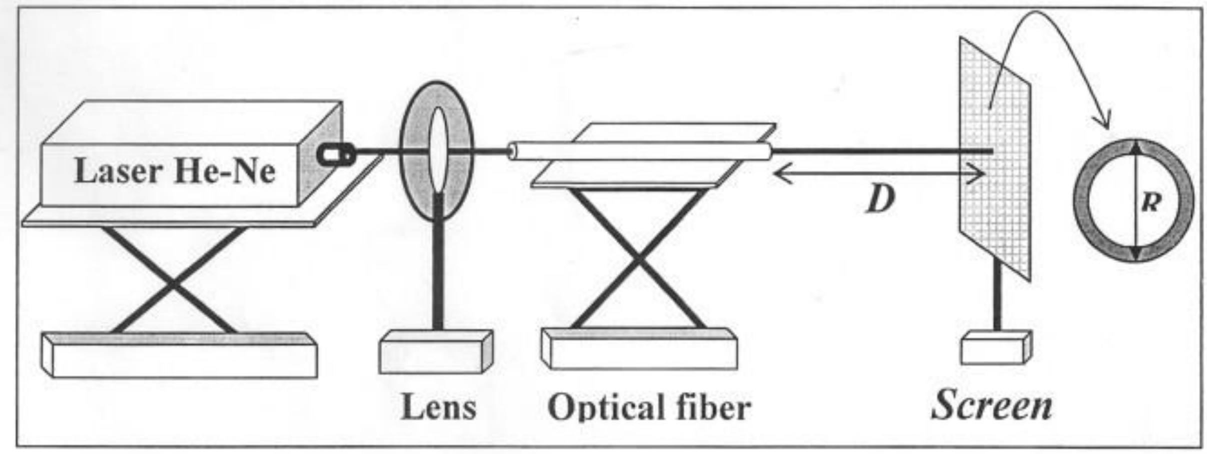


Fig (1)

2. **Measure the distance between the end of the optical fiber and the screen.**

3. **Measure the radius of the spot (r).**

Calculations:

1. **Calculate the area of the spot by applying this equation:**

$A = r^2 n$ ....(1)

2. **Calculate** ***Out Numerical Aperture (NA)*** **applying following equation:**

$NA = (A/2)/((A/2)^2+D^2)^{1/2}$ ....(2)

Discussions:

1. **Define:**

a. **Accepter angle.**

b. **Total internal reflection.**

2. **Compared between the accepter angle and critical angle.**

3. **What is the advantage to measure the NA?**

Experiment (5)

Measurement the Thickness of Thin Film

Aim of the work: -

Using laser beam to measure the thickness of thin film.

Instruments:-

He-Ne laser, power meter, standard film, film to measure its thickness.

Theory:-

Thin film defined as a specified material which thickness not more than few micrometers, having physical properties differ from its bulk material. Thin film thickness is one of the main and important information's is assigning chips properties. There are several methods which used to measure thin film thickness like:-

1. ***Electrical method*** which depend on measuring some electrical properties of the material such as resistance
2. ***Mechanical method*** using a very fine needle
3. ***Optical method*** which consider one of important and precise method to measuring the thin film thickness by using the laser beam.

Procedure

Interference way (fringes forming) occurred when the light waves reflected from the film edge. Film thickness can be calculated by using lamberts' law where an interference pattern(fringes) are formed when the light incident on a thin film ,part of the light reflected from the front surface ,another part which transmitted inside the film and reflected from the lower surface ,and there for a phase difference accord between the two rays which reflected from the upper and lower surface of the thin film and interference fringe, from these fringe we can calculate the thin film thickness by the equation:-

Thickness (t) = L/ΔL* λ/2…………………… (2)

L = width of darkness of fringes.

ΔL = width of lightness of fringes.

λ = wave length of the laser.(632.8nm)

Discussion:-

Experiment (7)

Concentrations Measurement

Aim of the work:-

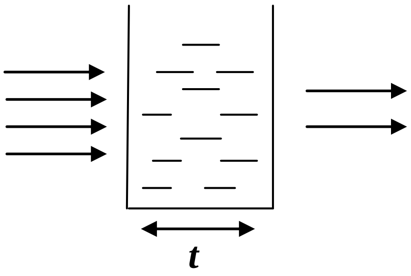
1. Measurement of concentration.
2. Measurement of absorption coefficient (α).

Instruments:-

He-Ne laser, power meter, standard liquid, sample liquid.

Theory:-

When a monochromatic light passed through a liquid, then some of light will absorbed (intensity decreases) by the liquid as in figure below.



A main law is put to describe this absorption by Lambert and beer, where Lambert shows that intensity of the transmitted light from the liquid decreases exponentially with increases of the cell thickness (t) (light path length inside the liquid) and beer shows that light intensity transmitted from liquid is decreases exponentially with its concentration (c) increase. Lambert – beer law is given by:-

$$I=I_o \exp^{(-kct)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where

$I_{o:}$ Incident intensity. I : Transmitted intensity. c: Concentration.

t: Cell thickness (light path length), k : constant.

Since the transmission is expressed as the ratio between the transmitted light to incident light.

$$T = I/I_o \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

And since the absorption is given by:-

$A = 2 - \log T\%$............................(3)

Where:

T% = percent transmittance.

Beer law is given by:-

$A = \alpha c t$ ………………………. (4)

Where $=\alpha$ absorption coefficient with unit of cm^{-1}

As absorption is directly proportion with the concentration in beer law, it can be possible to determine an unknown liquid concentration (sample) after knowing the absorptivity and compare it with standard liquid absorptivity known concentration.

$A_{sa} / A_{st} = C_{sa} / C_{st}$………….(5)

i.e. $C_{sa} = A_{sa} / A_{st} * C_{st}$ ……. (6)

A_{sa} =sample absorptivity.

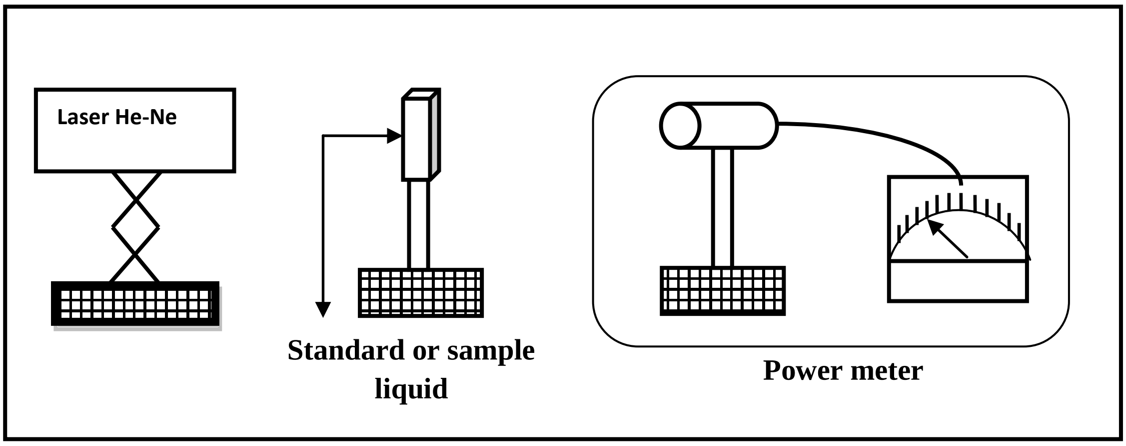
A_{st} =standard liquid absorptive.

C_{sa} =sample concentration.

C_{st} =standard liquid concentration.

Procedure:-

1- Make the device like in the following figure:-



2- Measure the intensity of laser before put the standard or sample liquid I_o

3- Measure the intensity that transmitted from standard liquid I_{st}

4- Measure the intensity that transmitted from sample liquid I_{sa}

Results:

1. Arrange your results as this table.

I_o mw	I_{st} mw	I_{sa1} mw	I_{sa2} mw	I_{sa3} mw

Calculations

1- Calculate the transmission for standard liquid from this equation :

$T = I_{st}/I_o$

2- Calculate the absorption for the sample liquid by equation (3)

3- Calculate the transmission for sample liquid by the equation

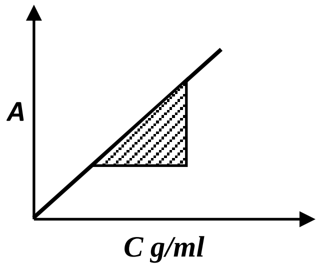
$T = I_{sa}/I_o$

4- Calculate the absorption for sample liquid by equation(3)

5- Find the concentration when apply equation (6) if you know the concentration of standard liquid equal ***(4) g/ml***.

Discussion:-

1. What are the effective parameters on beer law?
2. Plot a graph between the absorptivity on the y-axis and the concentration on the x-axis, and discuss the graph and calculate the absorption coefficient (α) from the slop.



$$Slop = \Delta A/\Delta C$$

$$\alpha = slop/t$$

$$t = 2cm$$

$$\alpha(cm^{-1}) = \Delta A/\Delta C * t$$

3. Define: standard liquid, sample liquid.
4. Calculate the concentration of Hydroxide Al-Potassium ***(KOH)*** liquid if you know the weight (w) of ***KOH*** is ***(0.4488g)***, the m.w (molecular weight) is ***(56.10)*** and the volume is ***4ml***.

Note: If you know the concentration equal:

$C_{th} = w/m.w * 1000/V$

(Molecular weight (mw)) g/ml = Σ atomics weight

Later ***Find & discuss***:

The error ratio if you know $E.R = (C_{sa2} - C_{th})/C_{th} * 100\%$.

5. Discuss: If the thickness of cell larger than ***2cm*** what will happen for absorption coefficient and transmission value.