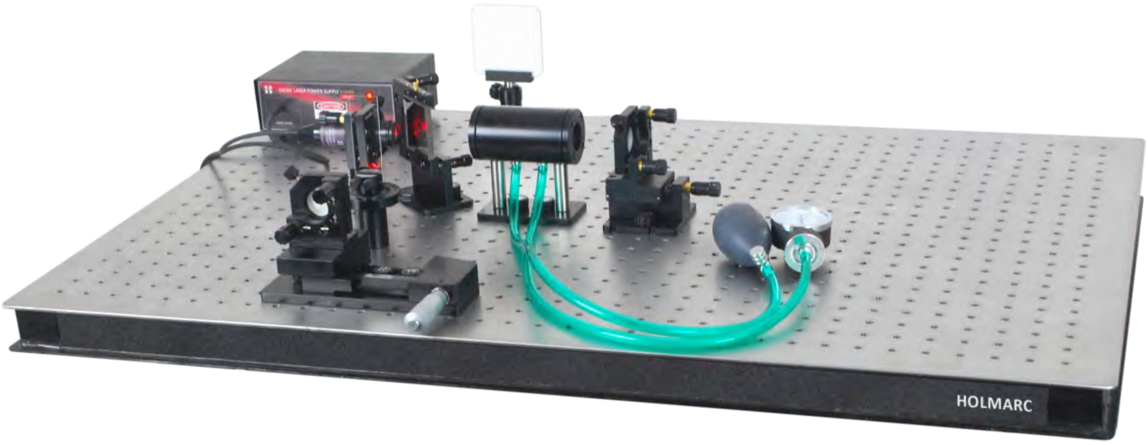
# Instruction Manual




## Michelson Interferometer

Model: HO-ED-INT-06

CONTENT Page

## Product Features

Michelson interferometer is a widely used instrument for measuring the wavelength of light, refractive index of transparent materials etc. HOLMARC's interferometer model No. HO-ED-INT-06 is designed and constructed in modular fashion. Students can assemble the interferometer out of individual modules by fixing them on an optical breadboard. All components required for assembling interferometer, including screws and allen keys, are supplied with this package.

The instrument uses diode laser as light source. The assembling is easy to understand. Laser, mirrors and beam splitter are mounted on precision kinematic mounts for fine tuning. The interference fringes are obtained on a screen and can be viewed with naked eye. The Experiments possible are,

1. Determination of wavelength of laser beam.
2. To find the refractive index of transparent material.
3. To find the refractive index of air.

## Getting Started

### a. Quick Start

Please remember to check the following items are present while the instrument package is delivered.

1. Optical Breadboard with Support
2. Kinematic Laser Mount
3. Beamsplitter Mount
4. Mirror Mount with translation
5. Mirror Mount with Precision Translation
6. Rotation Stage
7. Pressure Cell
8. White Screen with mount
9. Beamsplitter
10. Mirror
11. Glass Slide
12. Diode Laser with Power supply (Red)
13. Diode Laser with Power supply (Green)

## b. Safety Instructions

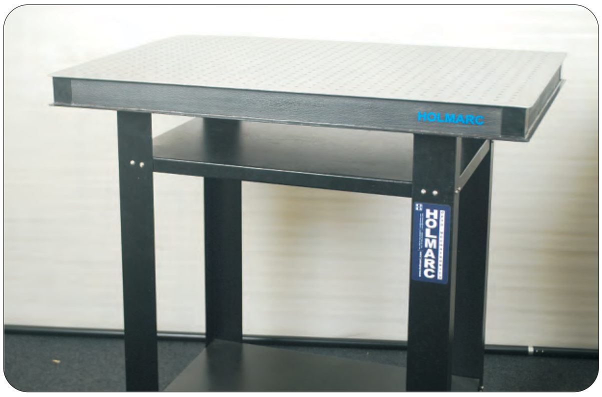
- Laser radiation predominantly causes injury via thermal effects; avoid looking directly into the laser beam.
- It is best that students work in low light and dust free atmosphere.
- Care must be taken while handling the Optical components since this experiment uses high quality Optical Components.
- Please don't put your fingers on the main optical surfaces but hold components by their edge.
- Always keep the equipment in a moisture and dust free atmosphere.
- Mirrors in the apparatus are front surface aluminized. Do not touch the surfaces, nor wipe them. They can easily be permanently damaged.

## c. Items included

### 1. Optical Bread Board with Support

Size ..................... 800 mm x 600 mm

Material ......................... Stainless Steel



## 2. Kinematic Laser Mount

Fine adjustments ... Using 80 tpi lead screws
Adjustment Range .............. +/-3degrees
Sensitivity ........................ 20 arc sec
Maximum laser module
holder diameter ..................... 25 mm
Material ...... Black anodized Aluminum alloy


## 3. Beam splitter Mount

Angular Tip / Tilt ..................... +/- 3degree
Linear Resolution ..................... 0.25 mm
Sensitivity ........................... 4 arc sec.
Mounting Orientation ... Vertical & Horizontal
Material ........................ Aluminium

## 4. Mirror Mount with Translation

Angular Tip / Tilt ................. +/- 3degree
Linear Resolution ................ 0.25 mm
Sensitivity ......................... 4 arc sec.
Material ............................ Aluminium

## 5. Mirror Mount with Precision Translation

Least count of the micrometer ....... 0.01 mm

Angular Tip / Tilt ................ +/- 3 degree

Linear Resolution ................ 0.25 mm

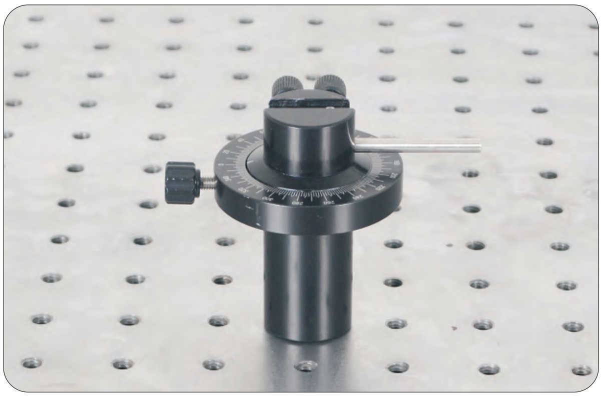
Sensitivity ........................ 4 arc sec.

Material ......................... Aluminium


## 6. Rotation Stage

Resolution ................ $2^0$

Material ..... Black anodized aluminium alloy



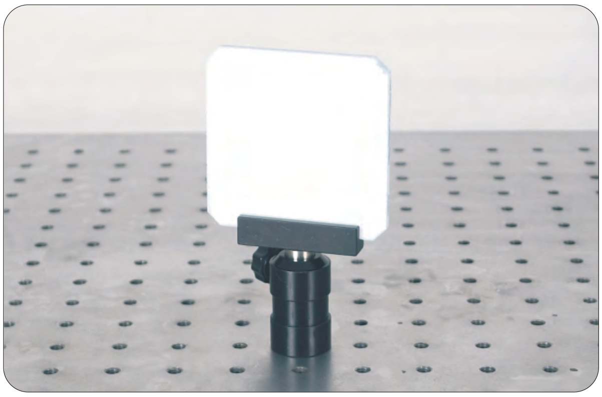
## 7. Pressure Cell

Length ............................ 10 cm

Max Pressure .................... 300 mm Hg

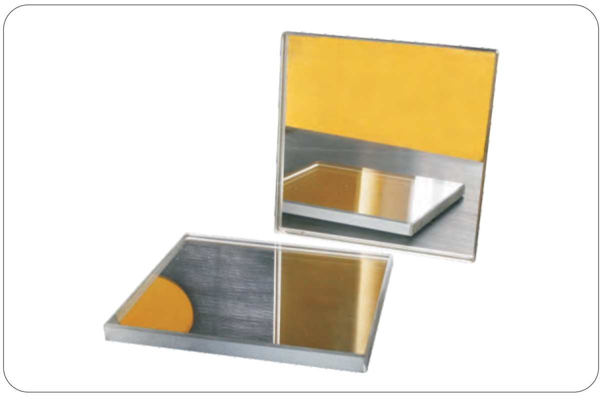
### 8. White Screen with mount

Model No: HO-ED-WS-01



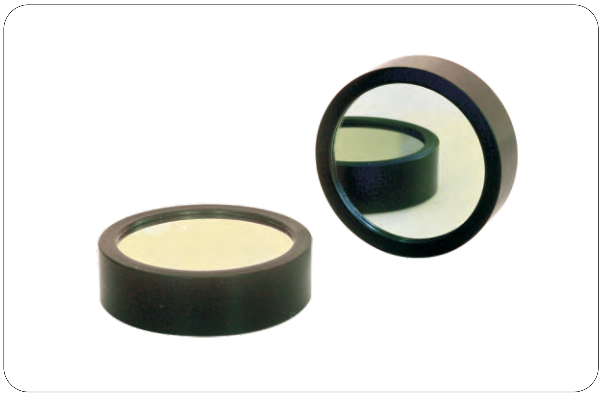
### 9. Beamsplitter

Dimension .................. 50 mm X 50 mm
Thickness ......................... 4 mm
R/T ratio ............................. 50 / 50
Material ........................... Bk7
Coating ........................... Aluminum



### 10. Mirror

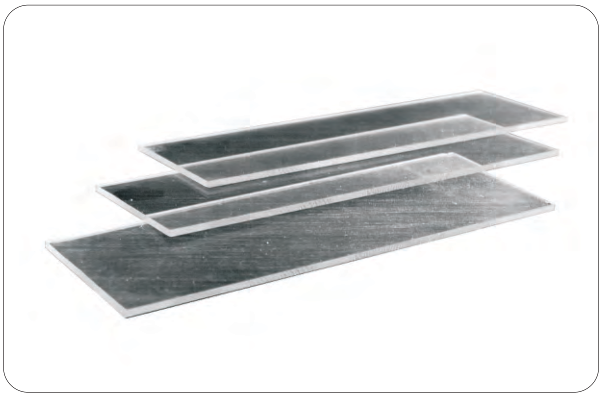
Diameter ........................ 25 mm
Thickness ......................... 6 mm
Material ........................... Borofloat
Coating ............... Protected Aluminium



### 11. Glass Slide

Model No : HO-GS-01

(Microscope glass slides )



### 12. Diode Laser with Power supply (Red)

Wave length ........................ 650 nm

Input ......................... 230V AC / 50 Hz

Optical power ............................ 5 mw

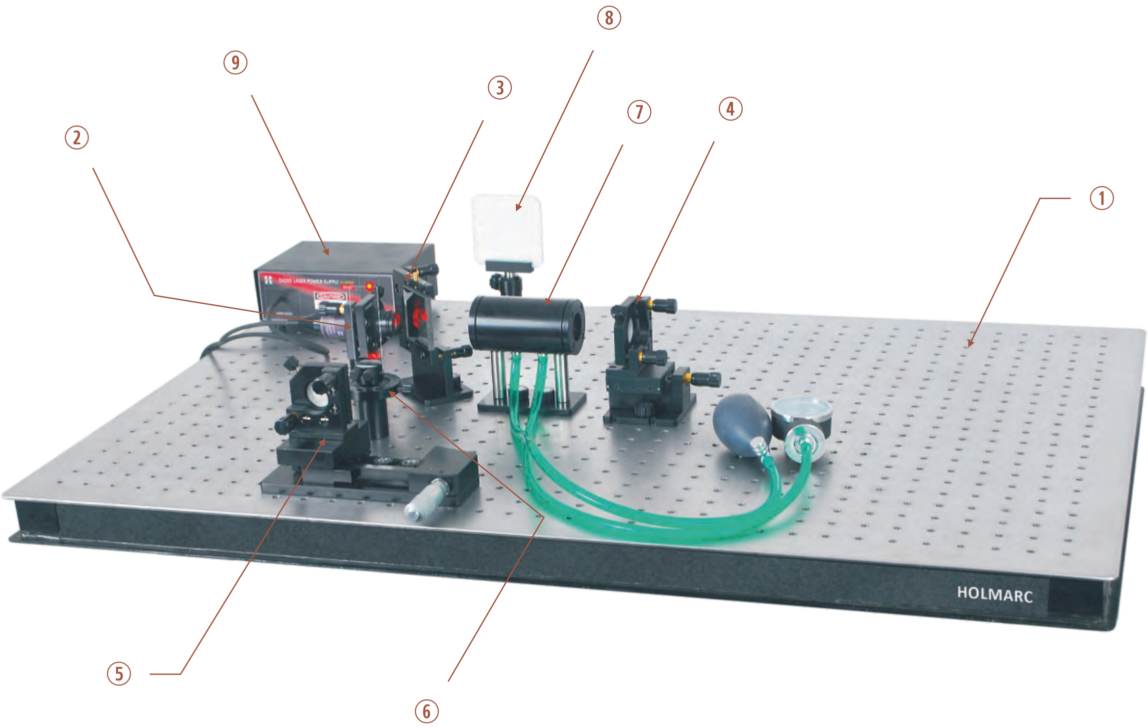

### 13. Diode Laser with Power supply (Green)

Wave length .................... 532  nm

Input .......................... 230V AC / 50 Hz

Optical power ......................... 5 mw

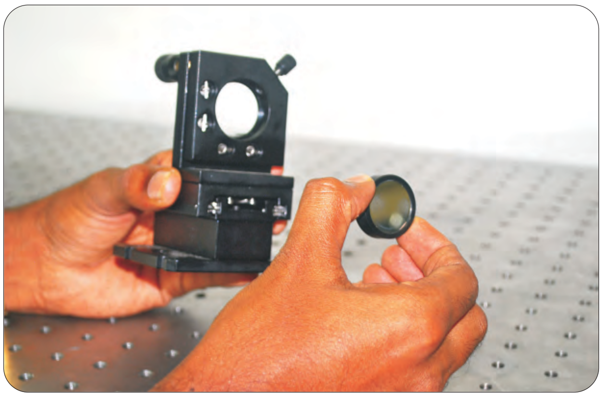
## d. Parts Listing :



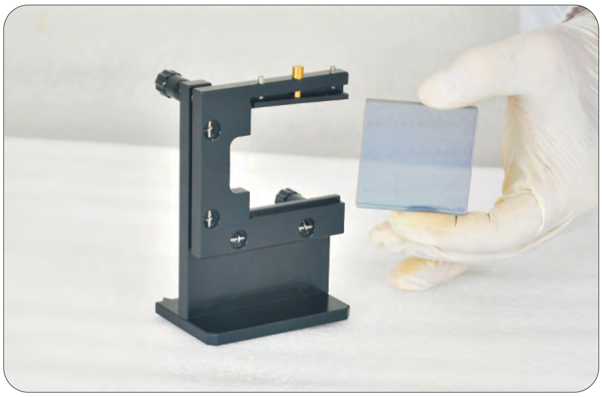

1. Optical Breadboard with Support
2. Kinematic Laser Mount
3. Beamsplitter with Mount
4. Mirror Mount with translation
5. Mirror Mount with Precision Translation
6. Rotation Stage with Glass Slide
7. Pressure Cell
8. White Screen with mount
9. Diode Laser with Power supply (Red)

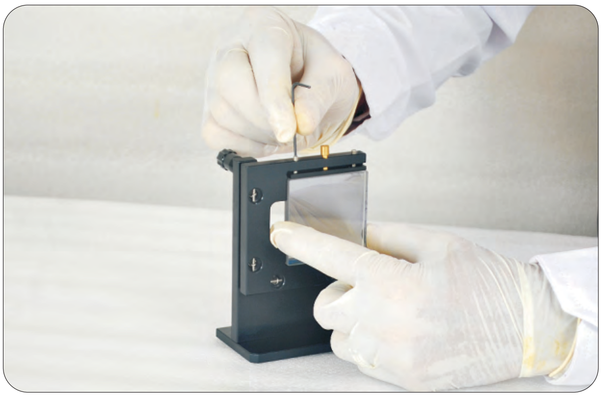
## Constructing Michelson Interferometer

**Making components ready for the construction:**



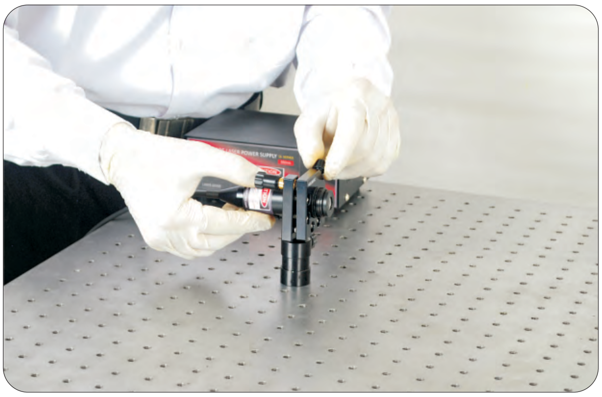
Insert mirrors into mirror mounts, Mirror mount with translation, $M_2$ and mirror mount with precision translation, $M_1$. (Insert it carefully without touching on polished faces.)



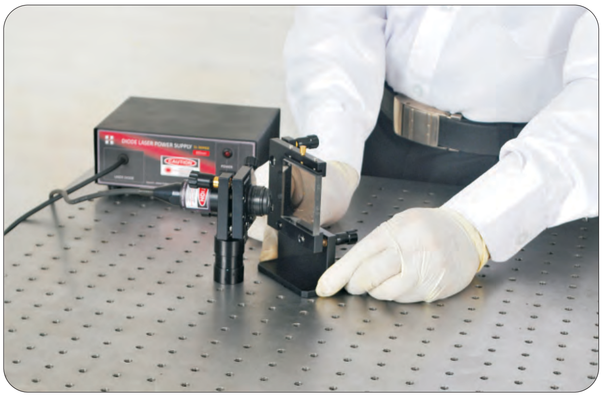


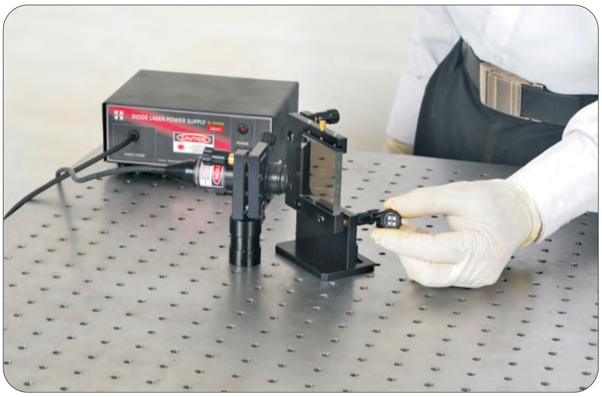
Insert beam splitter into the beam splitter mount, It should be inserted in a manner that the coated face of the beam splitter will come in front of the mount. (It's important to be so to get the interference pattern.)

Now start the construction of interferometer,

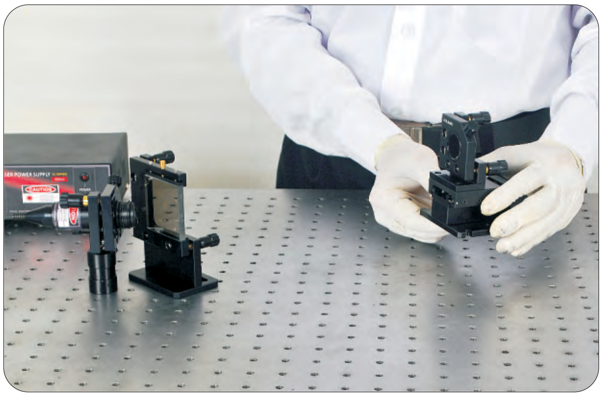


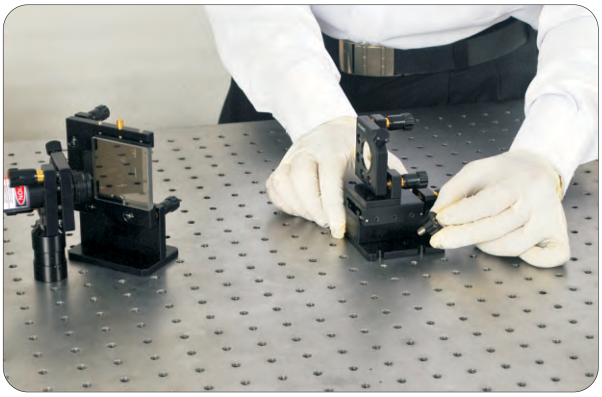
First place laser mount on the bread board, and insert laser module into the mount.



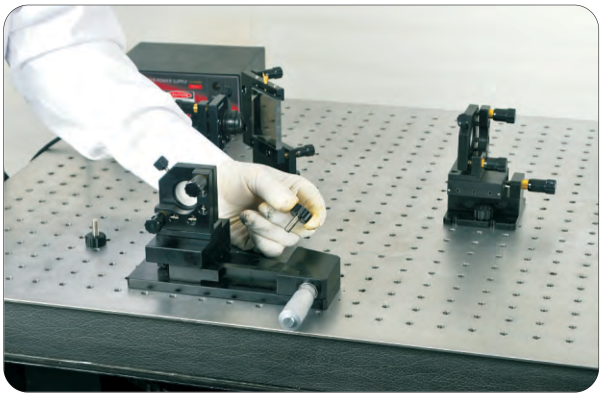


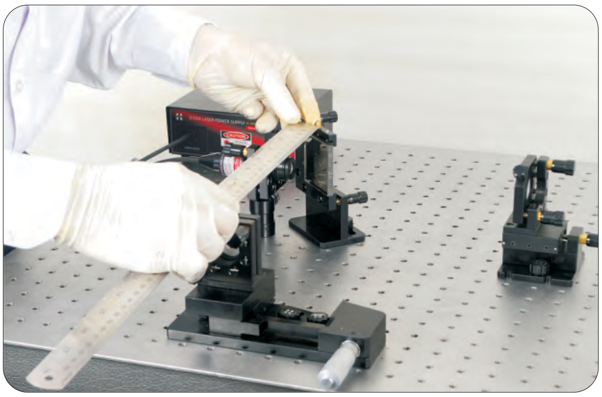
Then, fix the beam splitter in front of the laser source using thumb screws with an inclination of 45 degree with the laser.



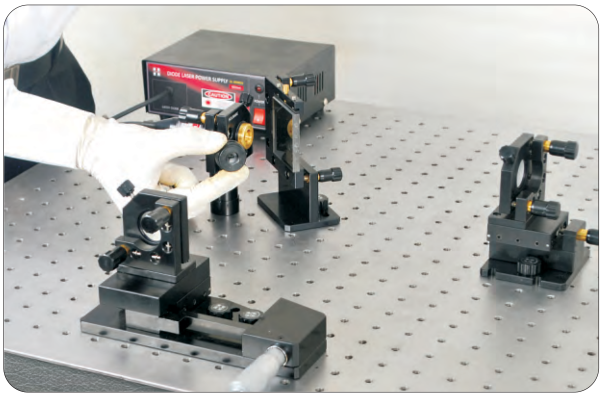
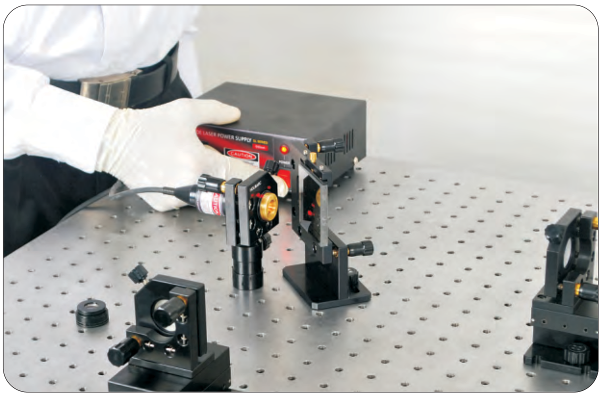


Place the mirror with translation at a particular measured distance directly in front of the laser source and fix it with the thumb screws. (We call it $M_2$).

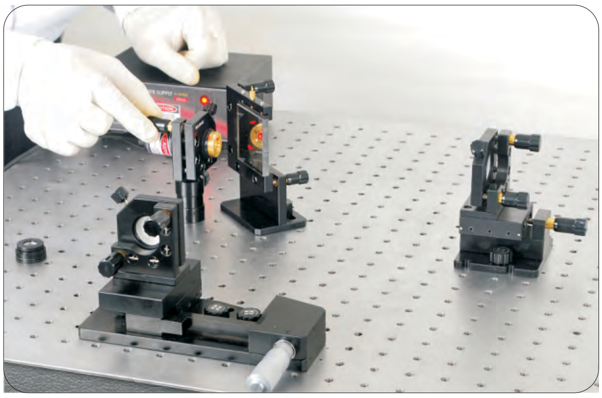
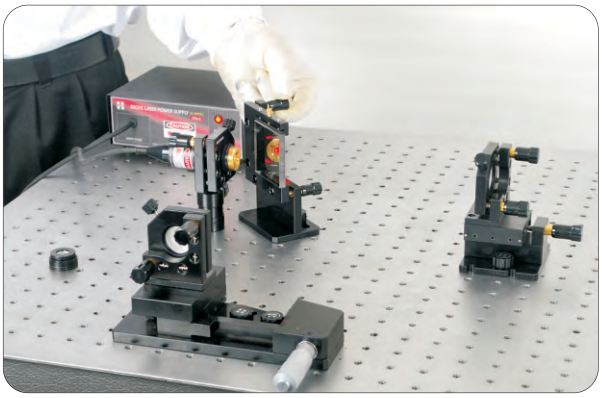




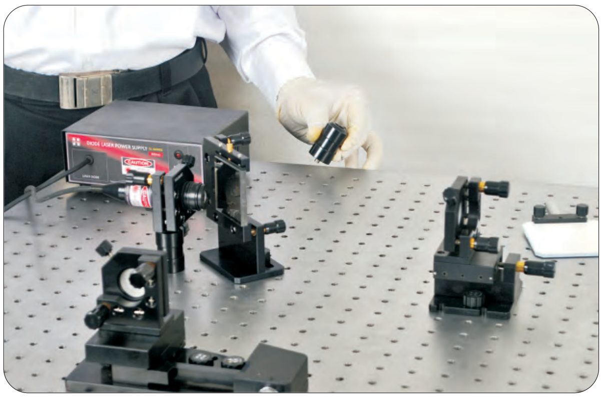
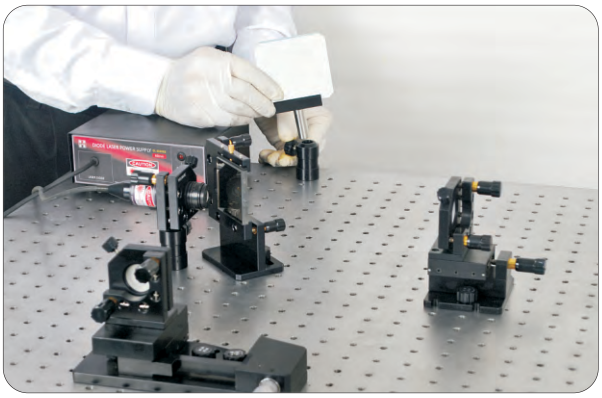
Now, mount the mirror with precision translation in a position perpendicular to the first mirror (we call it $M_1$), in such a way that the distance of it from beam splitter is nearly equal to the distance where $M_2$ is mounted.

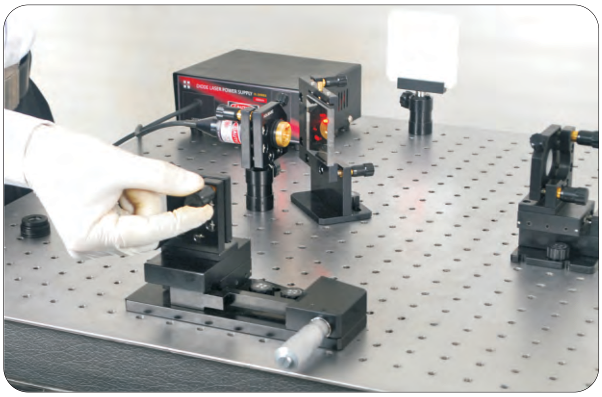
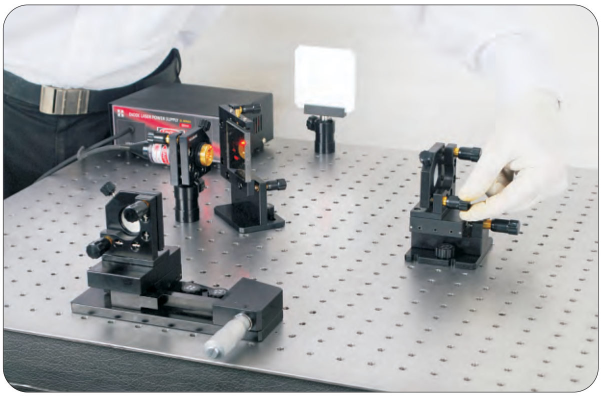
Remove the divergence lens from laser module and switch on the laser power supply.

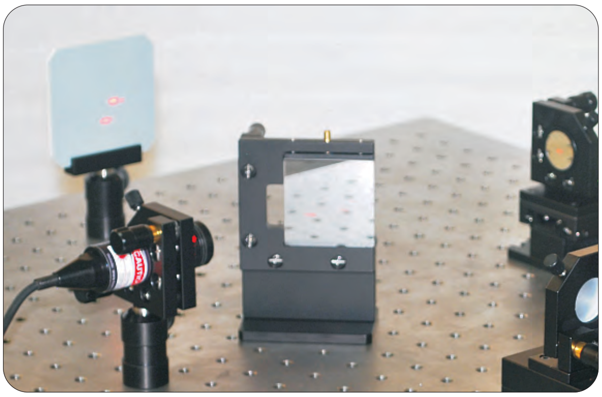
Make the beam spots to fall at the center of the beam splitter using the fine adjustment screws provided with the beam splitter and laser mount. Also make sure that the light transmitted and reflected by the beam splitter falls on the respective mirrors.

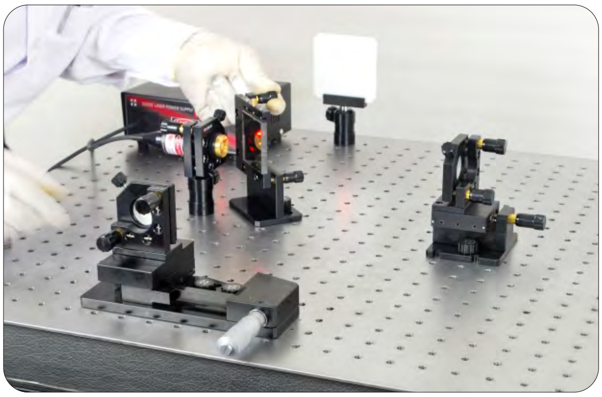



Now, fix the screen in a position perpendicular to the mirror $M_2$, and directly opposite to mirror $M_1$.

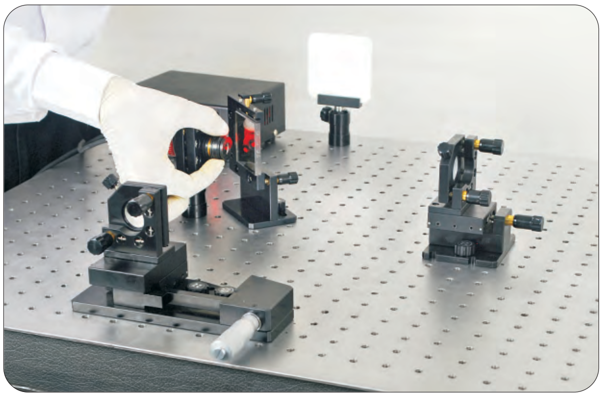



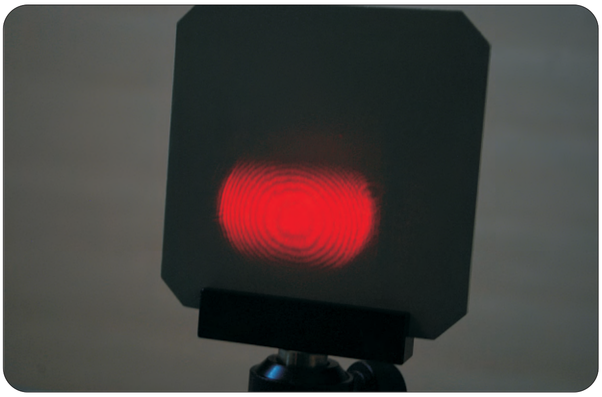
Now adjust the mirror mounts so that the light falls at its centre and exactly passes through the beam splitter to the screen. Also, readjust the angle of beam splitter, if required so that the reflected beams reach the screen. (The beam should fall at the centre of both mirrors and should be reflected directly back into the laser aperture).





There will be two bright spots on the screen one that is reflected from the first mirror and the other from the second mirror, then adjust the beam splitter angle as well as mirror mount's translation so that both the beam spots coincide at the screen, as the beam spots merge together there will be a flickering on the screen or we can see a small part of fringe pattern.(that is ,the Interference occurs).





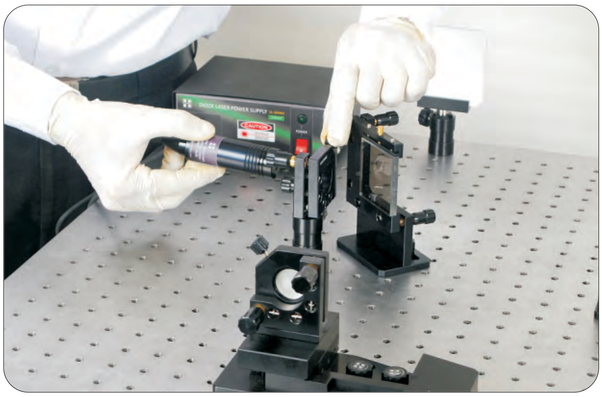
Now fix the divergence lens back to the laser module. The interference pattern appears on the screen. To make it more clear adjust the course movement with the mirror M2 and check the movements of fringes using the micrometer provided with the other mirror.

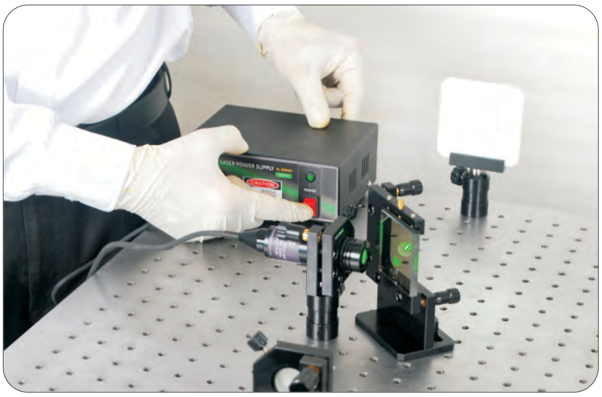
The Michelson interferometer is ready to operate now...

## Micrometer calibration :

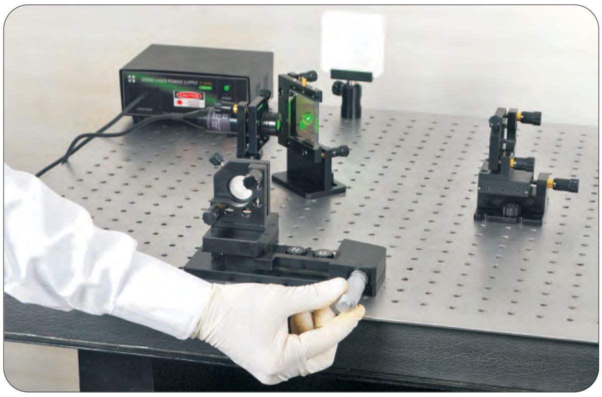
To calibrate micrometer we can use green laser (532 nm).Since it gives a clear pattern and the translation of mirror can be accurately measured.

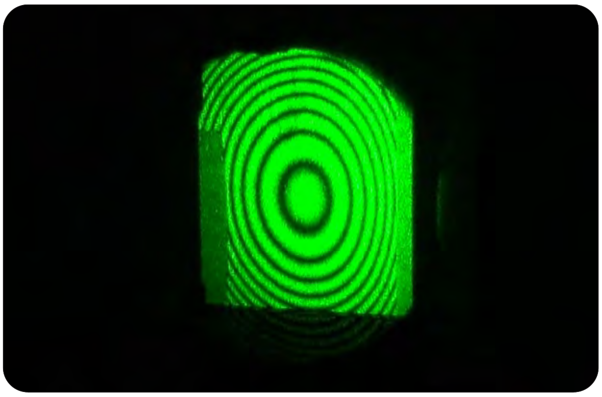
First, insert green diode laser module into the laser mount.





After aligning the laser with interferometer, turn the micrometer knob and make sure that the fringes moves when the micrometer screw turns. Fix a position on the observing screen (either a dark fringe on the center or a bright fringe) and note the micrometer reading. Now start counting the number of fringes that passes (either outward or inward) as the screw is turned (turn the screw with your hand and look at the screen, you must apply a steady pressure over it so that you could clearly count the fringes). Count at least 20 fringes that pass after the initial fixed position.





Now note the current reading on the micrometer as d.

We have , $\lambda = (2d / N)\, \Delta$

And the calibration constant is given by,

$$\Delta = \lambda / (2d / N)$$

Where $\lambda$ is the known wavelength of the laser and $N$ is the number of fringes counted. Repeat the same for accurate calibration constant.

## Observations

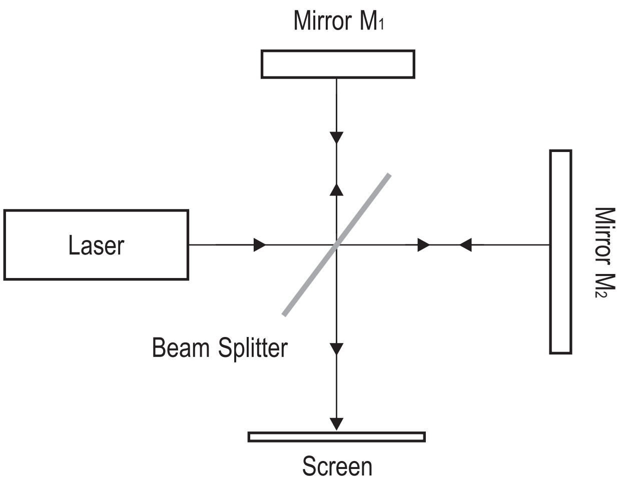
Wavelength of laser beam = 532 nm

| Trial No | No. of Fringes (N) | Micrometer reading | | Distance Moved (d) mm | Calibration Constant $\Delta = (\lambda N / 2d)$ |
|---|---|---|---|---|---|
| | | Initial | Final | | |
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |

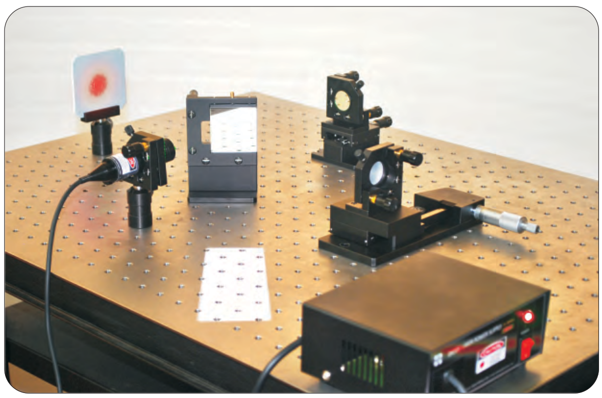
Average calibration constant, $\Delta$ =

# Wave Length of Laser Beam

## Theory :




In the Michelson interferometer, coherent beams are obtained by splitting a beam of light that originates from a single source (a monochromatic source) with a partially reflecting mirror called a beam splitter(BS). The resulting reflected and transmitted waves are then re-directed by ordinary mirrors to a screen where they superimpose to create fringes. This is known as 'interference by division of amplitude'.



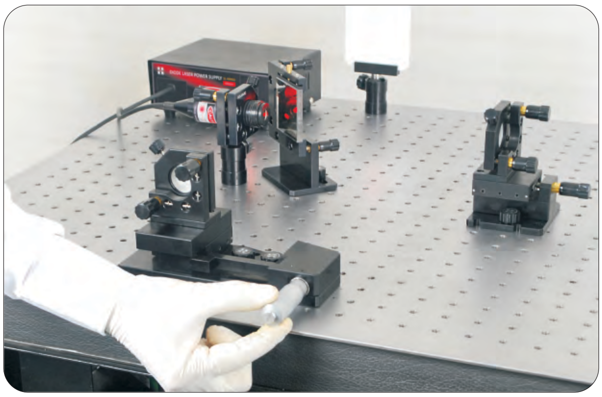
Light from a monochromatic source (Laser) is allowed to fall on a beam splitter which is partially silvered and oriented at an angle $45^0$ to the beam, producing two beams of equal intensity. One of them is transmitted to $M_2$ and the other is reflected to $M_1$, the light hitting on them is reflected back again to beam splitter. 50% of returning beam from $M_2$ is reflected by the beam splitter to the screen, and 50% from $M_1$ is transmitted by the beam splitter to the screen. The relative phase of the two beams determines whether the interference will be constructive or destructive. The wavelength of light can be obtained as,

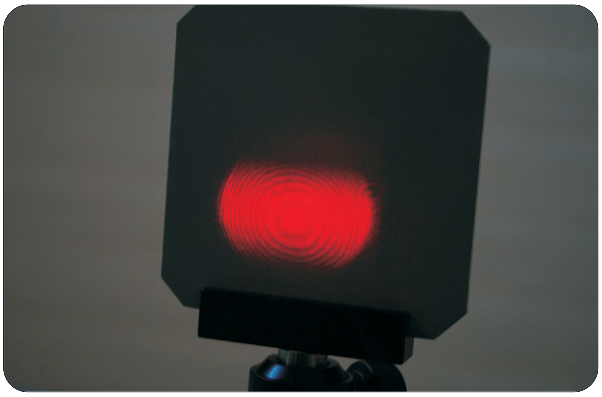
$$\lambda = (2d / N)\,\Delta$$

Where N = no : of fringes counted ,
d = distance moved to have 20 number of fringes,
$\Delta$ = calibration constant.

## Procedure :

To find the wavelength of laser source set the interferometer with red diode laser. Obtain the fringe and note the initial reading on the micrometer of mirror $M_1$ as before. Start rotating the micrometer and count the number of fringes that passes by.





Count at least 20 fringes and note the corresponding change in the micrometer reading. This gives the change in the position of the mirror. Note it as ‘d’ and calculate wavelength using the given equation.

Repeat the same and find an average value for the wavelength.

## Observations

Calibration Constant for the micrometer, $\Delta$ = ..............................

Least count of the micrometer = .............................. mm

| Trial No | No. of Fringes Counted, (N) | Micrometer reading | | Distance Moved (d) mm | Wavelength $\lambda = (2d / N)\Delta$ |
|---|---|---|---|---|---|
| | | Initial(mm) | Final(mm) | | |
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| 5. | | | | | |

Average value of wavelength, $\lambda$ = .......................... nm

## Result

Wavelength of the laser beam = ............................ nm

*By adjusting the inclination of $M_1$ and $M_2$, one can produce circular fringes, straight - line fringes, or curved fringes. In our experiment we use circular fringes.*

## Refractive Index of Transparent material

### Theory :

If a glass plate of thickness 't' and refractive index 'n' is introduced in the path of two interfering beams of Michelson interferometer the path length of the beam changes to $(n - 1)\, t$. Since the beam traverses twice through the plate the total path difference $= 2(n - 1)\, t$.

So the refractive index of glass plate can be calculated from, $N\lambda = 2(n-1)\, t$ .

(The path difference is now increased due to the fact that the index of refraction of the solid is different from that of air, that's why we took the change in path length as $(n-1)\, t$) The refractive index of glass slide is,

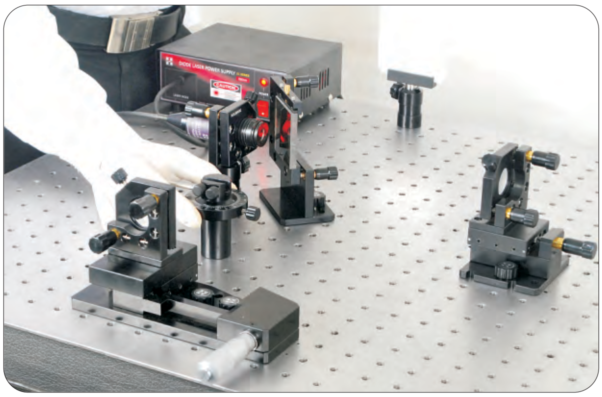
$$n = \frac{(2t - N\lambda)(1 - \cos\theta)}{2t(1 - \cos\theta) - N\lambda}$$

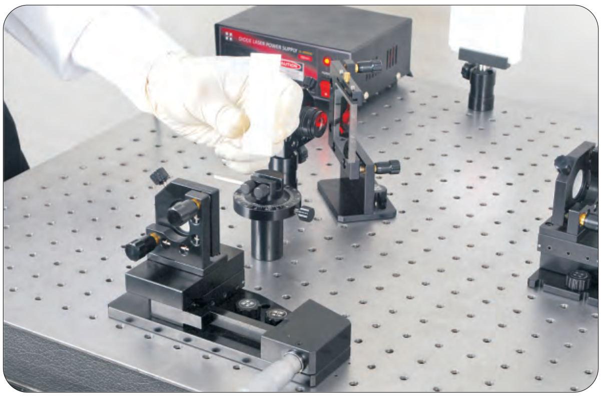
Where 'θ' is the angle turned for '$N$' fringes.

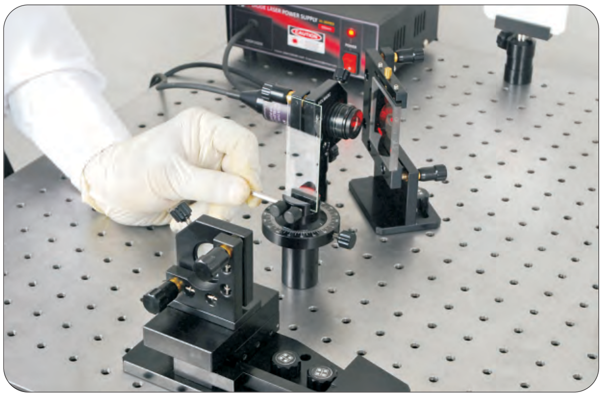
### Procedure :

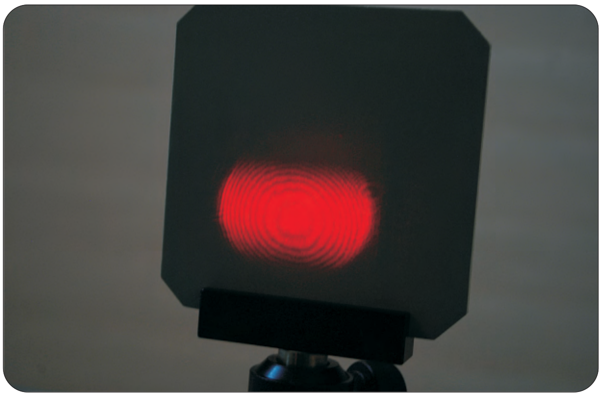
Introduce the rotational stage in one of the arms of the interferometer. Mount glass slide over the rotational stage.

*Note : As we introduce the glass plate in one of the arms of interferometer fringe shifts and become blur. To make it sharp use the course movement behind the mirror with translation ($M_2$) and it's to and fro motion gives a clear fringe.*









From the dial note the initial position of the glass slide, slowly rotate the rotational stage using hands and count the number of fringes that passes by (count at least 20 fringes). Note the final reading on the dial, the difference between the initial and final reading gives the angle of rotation ‘θ’.

## Measurements

Least count of the rotation stage = .....................

| Trial No | No. of Fringes Moved (N) | Angle rotated, θ | | Mean θ | Refractive index n |
|---|---|---|---|---|---|
| | | Left | Right | | |
| | | | | | |
| | | | | | |
| | | | | | |

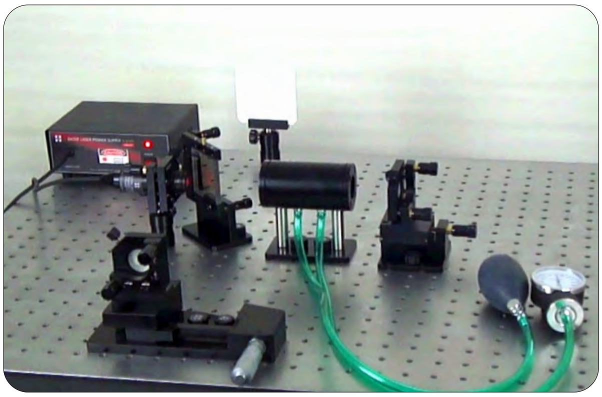
## Result :

Refractive index of Glass Slide n = ...................................

# Refractive Index of Air

## Theory :

When a material of thickness‘ d’ and refractive index ‘n m’ is introduced in one of the arms of Michelson interferometer the change in path length is given by ‘$(n_m - n_{air})$ d’ since the beam traverses twice through the material we have $2d(n_m - n_{air})$ as a total path length.

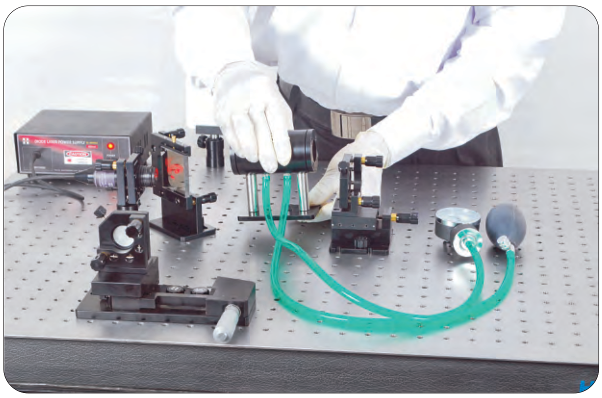


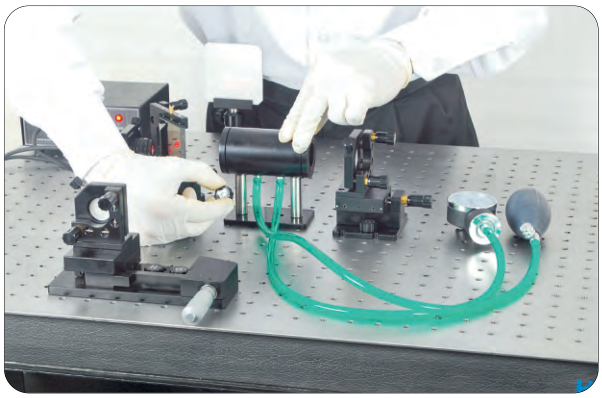
Let λ be the wavelength of light, n the refractive index of air at atmospheric pressure, d the length of the air cell, $P_{atm}$ the current atmospheric pressure and ΔP the pressure change. The relationship between the pressure change ΔP and the number of fringe shift $m_{\Delta P}$ is given by,

$$m_{\Delta P} = (2d\,(n - 1) / \lambda)\,(\Delta P \;/\; P_{atm}) \qquad or$$

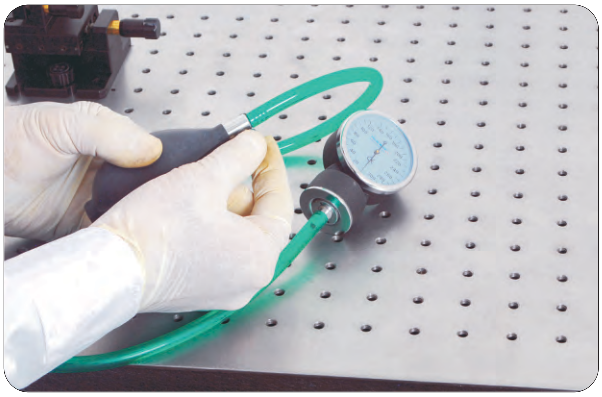
$$(n - 1) = (m_{\Delta P} / \Delta P)\,(\lambda \;/\; 2d)\,P_{atm}$$

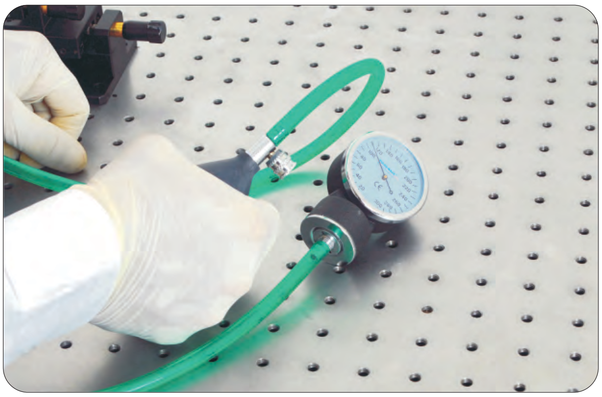
## Procedure :





To find the refractive index of air first place the pressure cell in one of the arms of Michelson interferometer, fix it with thumb screws.(as before the fringe pattern gets distorted as we introduce pressure cell make it clear with the help of course movement provided with $M_2$).

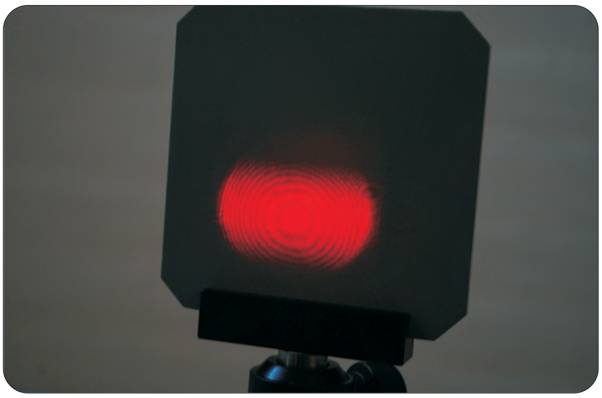




Tight, knob of the pump. Increase the pressure up to 300 mm Hg by pressing on the pump.

*(Caution: Do not increase the pressure beyond 300mm Hg since this may damage the manometer)*

Look at the screen, and slowly release the pressure, fringes passes, count certain number of fringes (at least 20) and note the pressure change again count another 20 fringes and note it as 40(as the total number of passed fringes is 40) and again note the change in pressure. Continue the process up to the total release of pressure from the chamber.



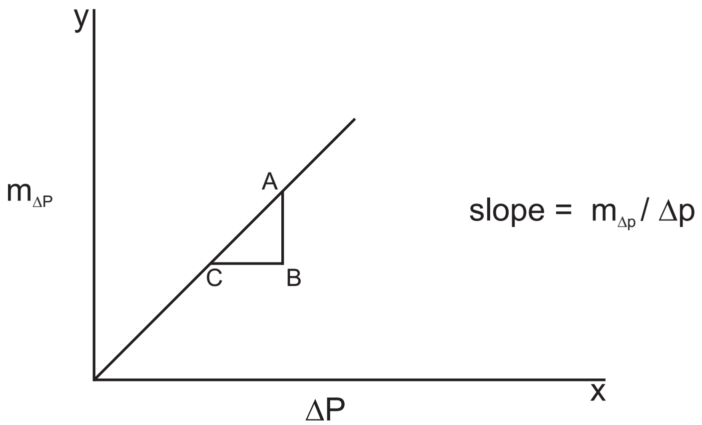
Plot a graph number of fringes and corresponding pressure change. The slope of the graph will give the value $(m_{\Delta P}/\Delta P)$. Put this value in the equation,

$$(n - 1) = (m_{\Delta P} / \Delta P)(\lambda / 2d) P_{atm}$$

And hence we can obtain refractive index of air 'n'.

## Measurements

| Number of Fringes Counted $m_{\Delta P}$ | Change in pressure at each interval $\Delta P$ |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |



We have,

Length of the pressure cell, d =

Wavelength of light used , λ =

$m_{\Delta P}$ / ΔP from graph =

using equation $(n - 1) = (m_{\Delta P} / \Delta P)(\lambda / 2d) P_{atm}$ we can calculate the refractive index of air.

## Result :

Refractive index of air $n$ = ……………......…………

*Michelson interferometer have applications in standardising a particular length, it's application is in the field of astronomy, to find the distance between a star and earth, distance between two stars etc by observing the wavelength of light coming out of the stars.... The Michelson interferometer has been used for the detection of gravitational waves!! Are you aware of the Michelson morley experiment? the very first attempt to find the secrets of nature, the very first application of Michelson interferometer.....*

## Maintenance Notes

- Always keep the equipment in a moisture and dust free atmosphere.
- Do not touch the active region of the optical components with bare hands
- ‘Switch on’ all the electronic devices used in this experiment at least once in a week.

## Technical Support

Before you call the HOLMARC Technical Support staff, kindly gather the following information:

- Title and model number (usually listed on the label)
- Approximate age of apparatus
- Detailed description of the problem / sequence of events
- Have the manual in hand to discuss your query

## Feedback

If you have any comments regarding our product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, kindly inform us. HOLMARC appreciates any customer feedback. Your inputs help us evaluate and improve our product.

For technical support, contact us at
E-mail : sales@holmarc.com
Web: www.holmarc.com

# Holmarc Limited Warranty

Every Holmarc Instruments and its accessories are warranted by HOLMARC OPTO-MECHATRONICS LTD for a period of ONE YEAR from the date of original purchase.

Holmarc will repair or replace a product, or part thereof, found by Holmarc to be defective, provided the defective part is returned to Holmarc, with proof of purchase.

This warranty applies to the original purchaser and our distributors and is non-transferable.

Each returned part or product must include a written statement detailing the nature of the claimed defect, as well as the end user's name, address, and phone number.

This warranty is not valid in cases where the product has been abused or mishandled, where unauthorized repairs have been attempted or performed, or where depreciation of the product is due to normal wear-and-tear.

Holmarc specifically disclaims special, indirect, or consequential damages or lost profit which may result from a breach of this warranty. Any implied warranties which cannot be disclaimed are hereby limited to a term of one year from the date of original retail purchase.

Holmarc reserves the right to change product specifications or to discontinue products without notice.

Please refer our commercial invoice for warranty claim.

(Authorized Signatory)