# VNR VJIET

## Presents

TAMASOMA JYOTHIRGAMAYA

# VNR PROTOCOL FOR LABORATORIES

Engg. Physics Lab- H&S Dept

TAMASOMA JYOTHIRGAMAYA

# INTRODUCTION TO ENGINEERING PHYSICS LAB COURSE

# VNR Lab Protocol

## Objectives

1. *To structure and conduct the Lab course as* ***"Interconnected whole rather than isolated contingent parts"***

*2. To continuously map lab work on to class work and syllabus to enhance the depth of learning[**WIL**]*

*3. To **engage**, **involve and engross** the students to make them more imaginative, creative and independent in problem solving through "**Design and Planning** " of experiments rather than just conducting experiments.*

*4. To **actively involve** (not just present) the students in lab work by making them feel that they are **accomplishing** a major project or task out of their experimentations in the lab and current class room learning*

.

*5. To impress the values by incorporating the use of traditional and classical lab **concepts and skills** through intellectual and manual **'Dexterity'***

# RESOURCES IN THE LAB

## MATERIAL RESOURCES:

**OPTICAL SOURCES**: Lasers (Semi Conductor lasers, λ = 632.8 nm & He-Ne laser) Sodium Lamp (λ = 589 & 589.6 nm), Mercury Lamp (White light), LEDs

**OPTICAL SCREENS:** Telescopes, Travelling Microscopes, Optical Fibers, White sheets

**OPTICAL ELEMENTS:** Lenses, Prisms (Crown, Flint glass and Calcite), Single Slits, Double Slits, Multiple Slits (Gratings)

**MEASURING INSTRUMENTS:** Vernier Scales, Screw Gauges, Spherometers, Galvanometers, Ammeters (μA, mA and A), Voltmeters (mV & V),Deflection Magnetometers, Stop Clocks Manual, Stop Watches (Digital), Spirit Levels.

# RESOURCES IN THE LAB

## MATERIAL RESOURCES:

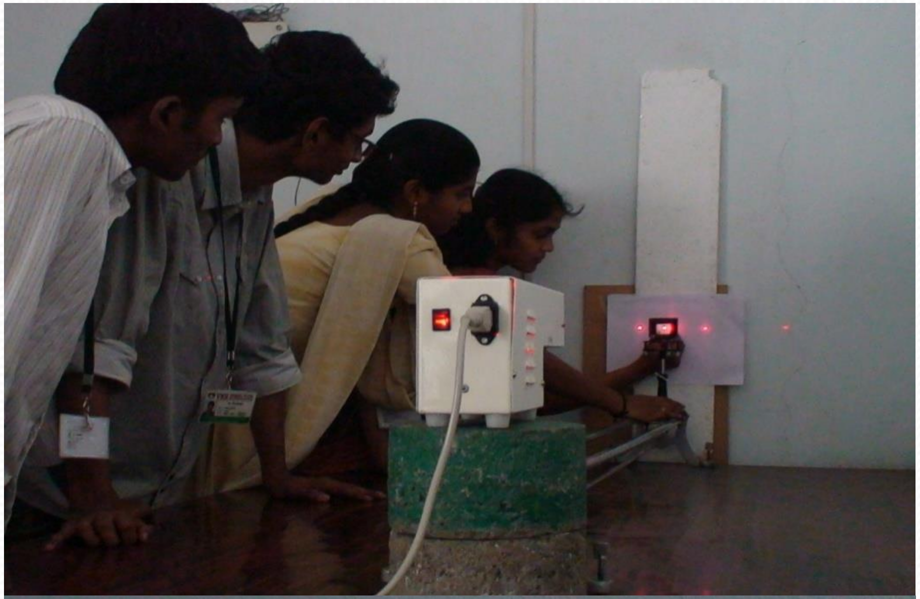
**ELECTRONIC COMPONENTS & ELECTRICAL EQUIPMENT:**

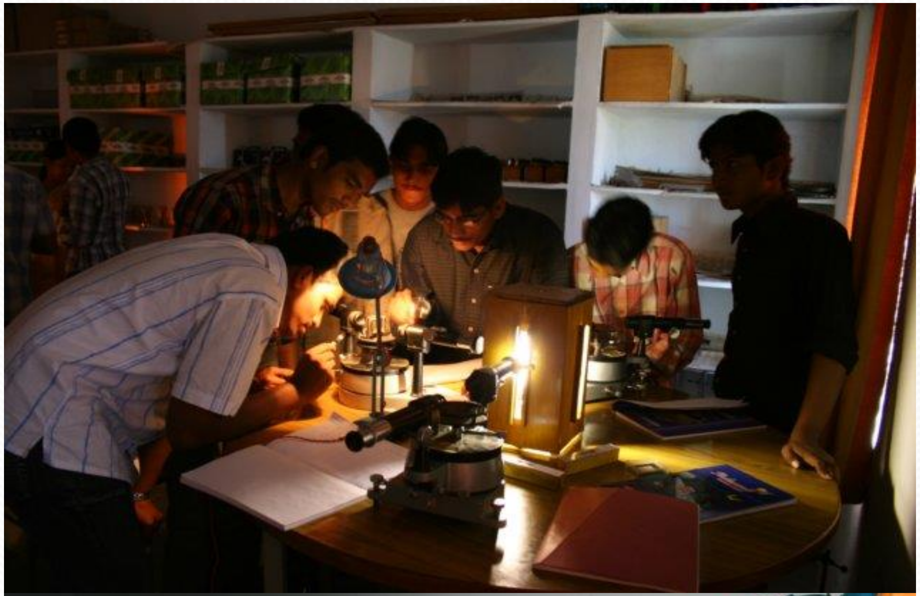
Resistors ( 39 kΩ, 33 kΩ, 27 kΩ, 15 kΩ, 10 kΩ etc.)
Capacitors (220 µF, 1000 µF, 2200 µF, 4700 µF etc.)
Rheostats, Keys, Commutator (Two way keys), Bread Boards
Regulated Power Supplies, Battery Eliminator
Stewart Gee Apparatus
Boards for studying LED characteristics
Boards for studying characteristics of Optical Fibers

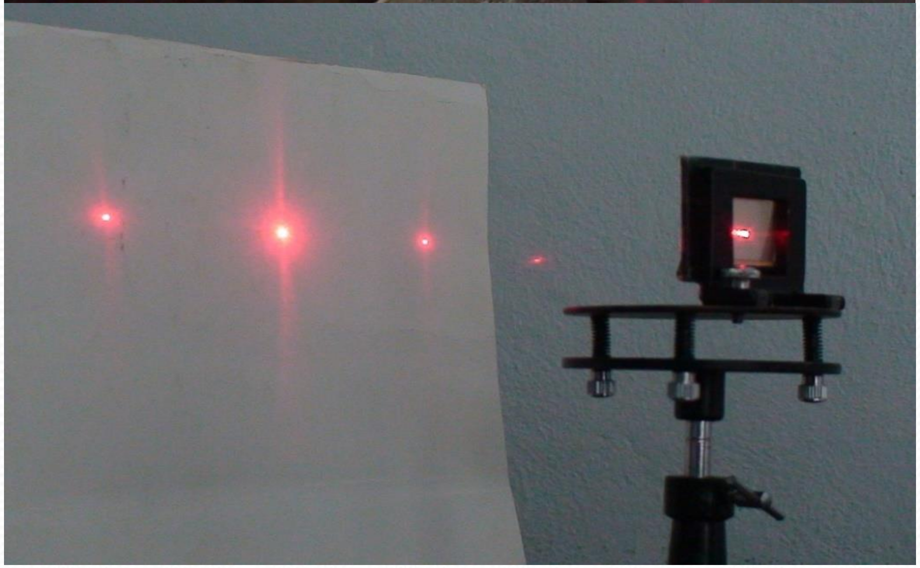
**GENERAL EQUIPMENT:**

Spectrometers
Travelling Microscopes
Sonometer/A.C.Sonometer Boards
Circular Metal Discs with chuck nuts
Optical Benches & Magnifying lenses
Copper, Brass and Steel Wires

# ENGINEERING PHYSICS LAB







# THE INFAMOUS DOUBLE SLIT EXPERIMENT

Video

# Experimental Sessions

## OPTICS - 4 Sessions

1. Dispersion of light
2. Interference ( Newton Rings )
3. Diffraction ( Grating with LASER)
4. Diffraction ( Single slit with LASER)

## ELECTRONICS & ELECTRICAL 4 Sessions

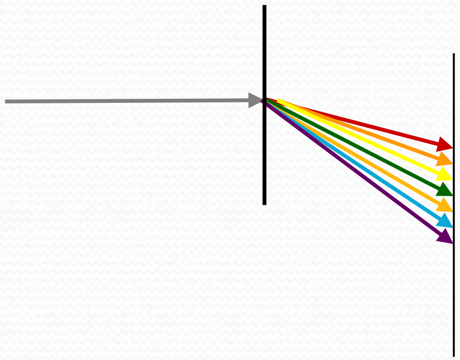
1. C-R circuit
2. LED characteristics
3. Energy gap of a semiconductor
4. Stewart-Gee Experiment

# THE FOUR CONCEPTS IN OPTICS:

Video

## 1. DISPERSION OF LIGHT

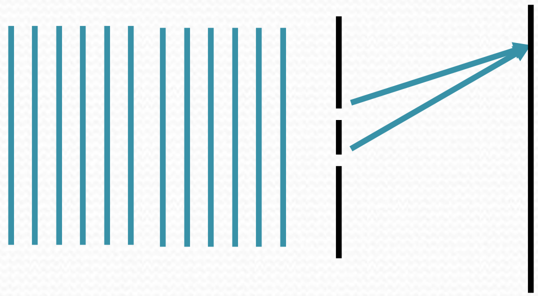
Light splits into constituent colours



Video

## 2.INTERFERENCE OF LIGHT

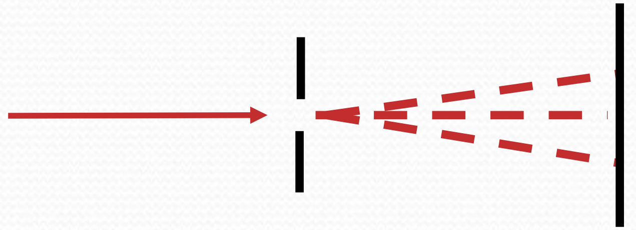
Superposition of coherent waves



# THE FOUR CONCEPTS IN OPTICS: CONTD..

Video

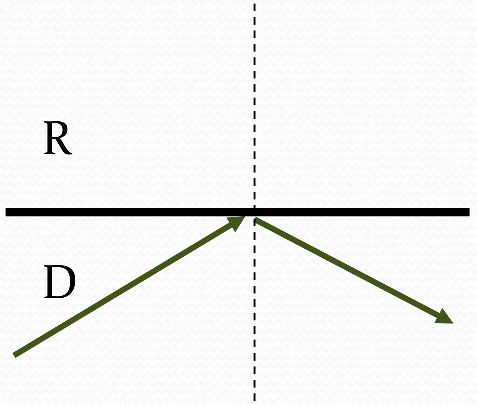
## 3.DIFFRACTION OF LIGHT



Bending of light at sharp obstacles

Video

## 4.TOTAL INTERNAL REFLECTION OF LIGHT




Reflecting back into the same medium



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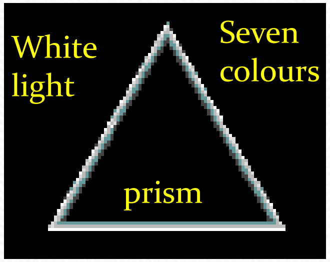
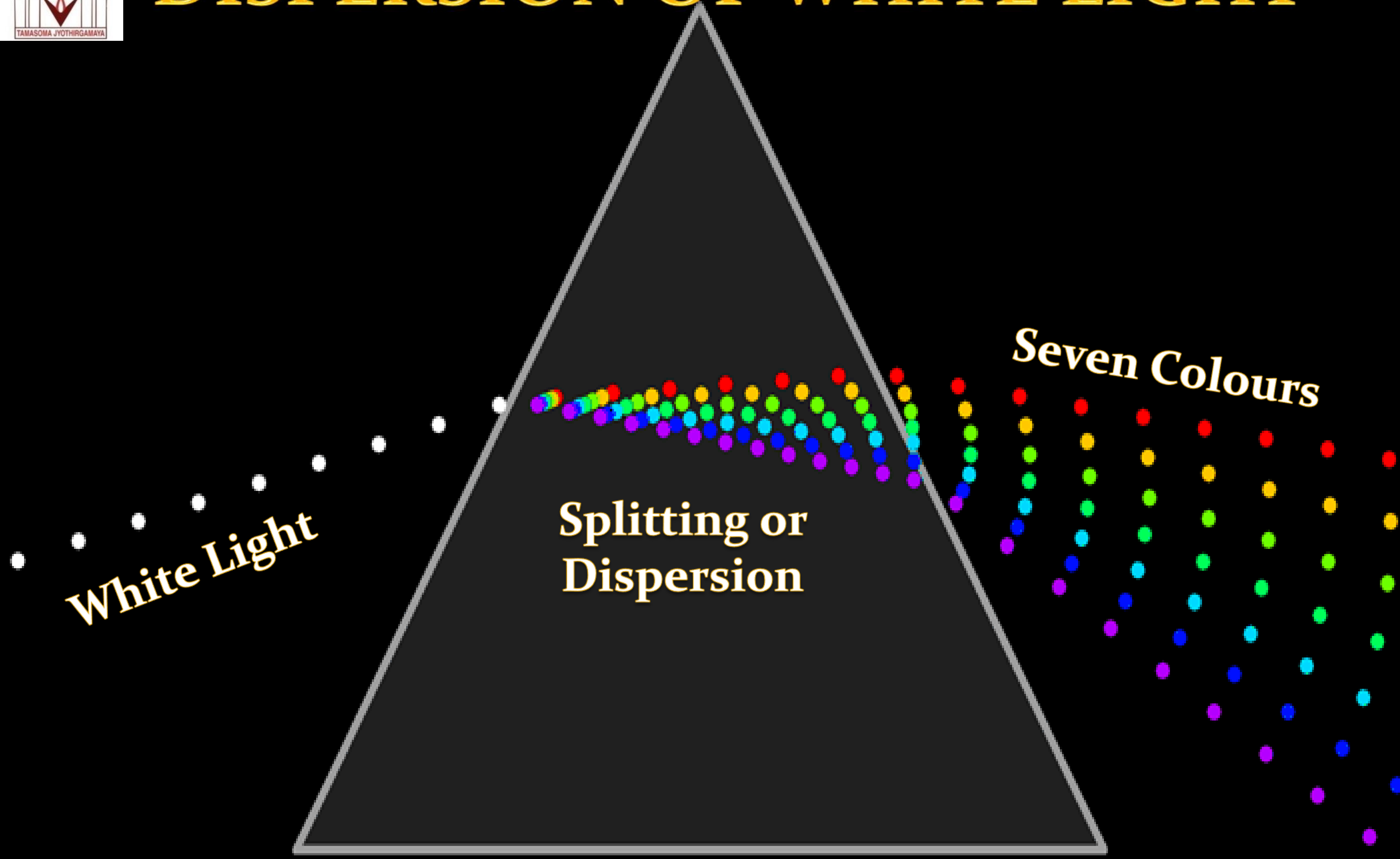
# Dispersion

Dispersion of Light

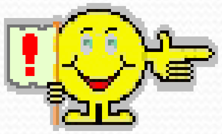



- Composite wave passing through a medium splits into constituent colors (Wave lengths)
- Longer the wave length –spreads less in a medium
- The reason why red ray travels shorter distance than violet ray while dispersing through the medium.

# DISPERSION OF WHITE LIGHT



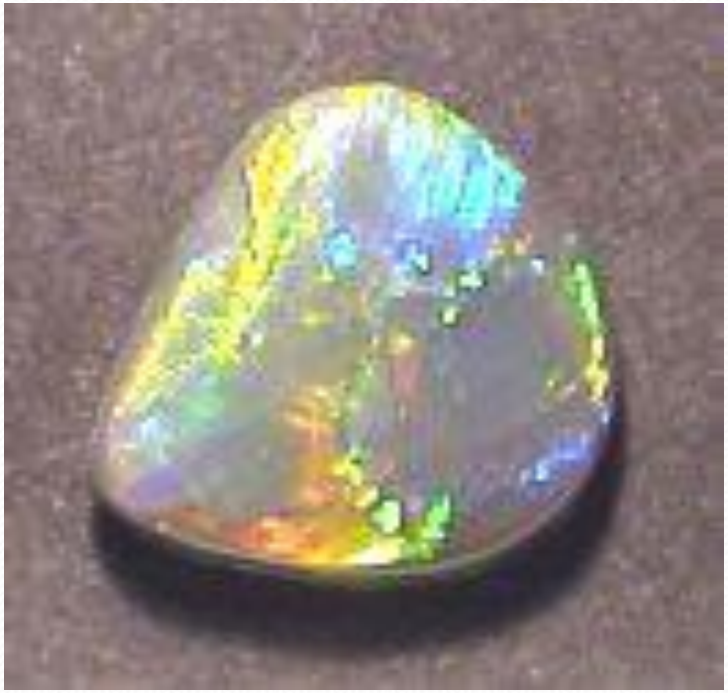
# Let us understand Dispersion of light with some examples



# The Beautiful side

- Most Colors in nature are due to dispersion





**Photographs of opals displaying rainbow of colours that change as the angle of observation changes.**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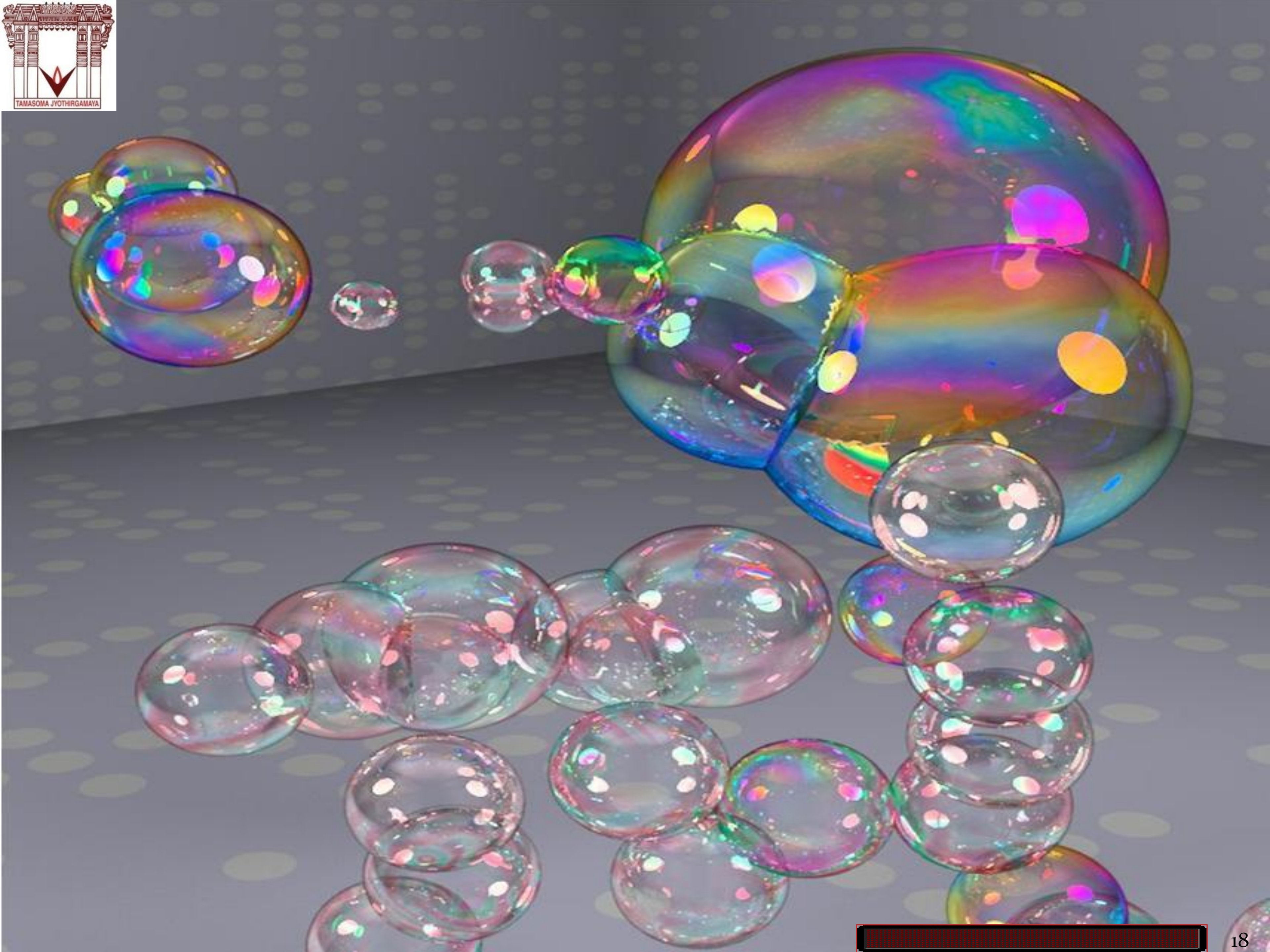
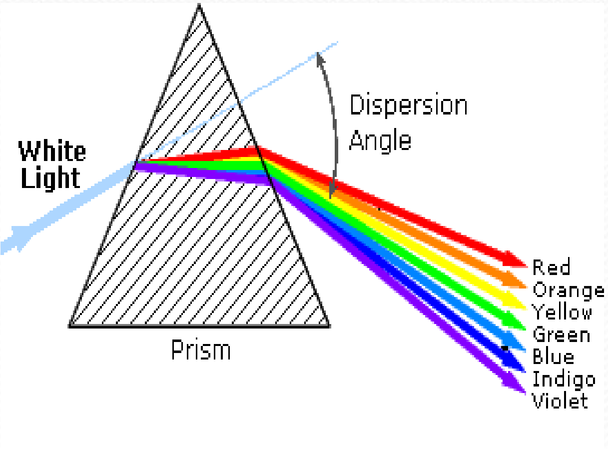
Photograph by Beverly Joubert
NATIONAL GEOGRAPHIC



# The other side

- All Electro Magnetic waves ,not only visible rays passing through the medium disperse, resulting in overlapping, noise creation etc. and thus
- Leads to distortion of information transferred.
- Leads to chromatic aberration.
- Leads to modal dispersion in optical fibers

# Dispersive power of the material of a prism




$$\mu = \frac{\sin((A + D_m)/2)}{\sin(A/2)}$$

$$\omega = \frac{\mu_1 - \mu_2}{\mu - 1}$$

Where,

$\mu$ = Refractive index for the given color

A = Angle of Prism

$D_m$ = Angle of Minimum Deviation

$\omega$ = Dispersive Power

# SPECTROMETER


SPECTROMETER

# Spectrometer

- **Spectrometer** is a precise instrument to obtain pure spectrum from light passing thru either prism or grating

- Essentially has 3 parts:

  **COLLIMATOR** to render parallel incident beam

  **ROTATING PRISM TABLE** to mount prism /grating

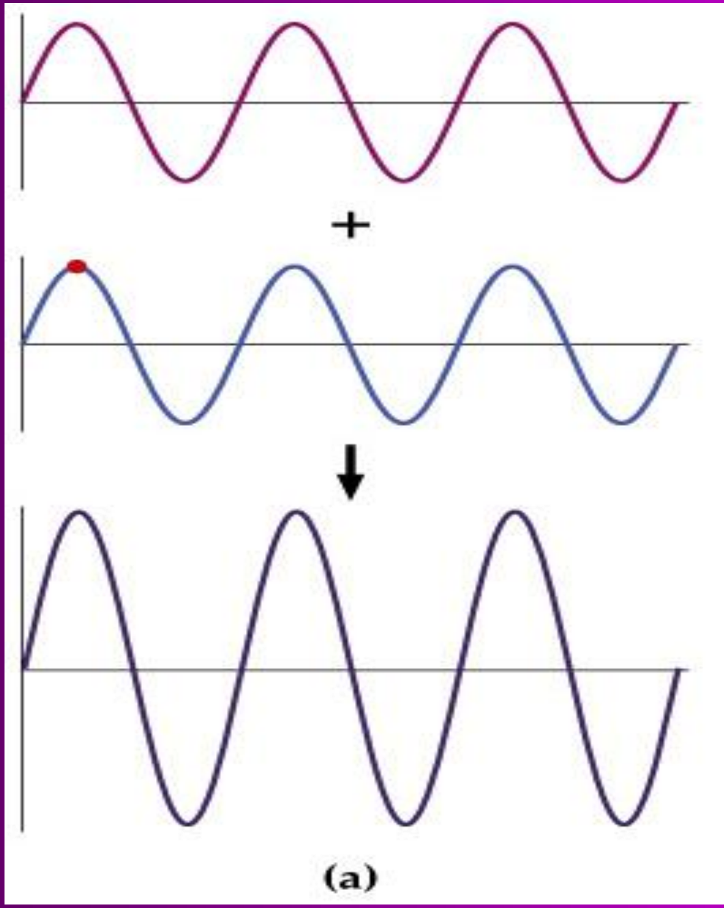
  **TELESCOPE** to observe pure spectrum

# Interference

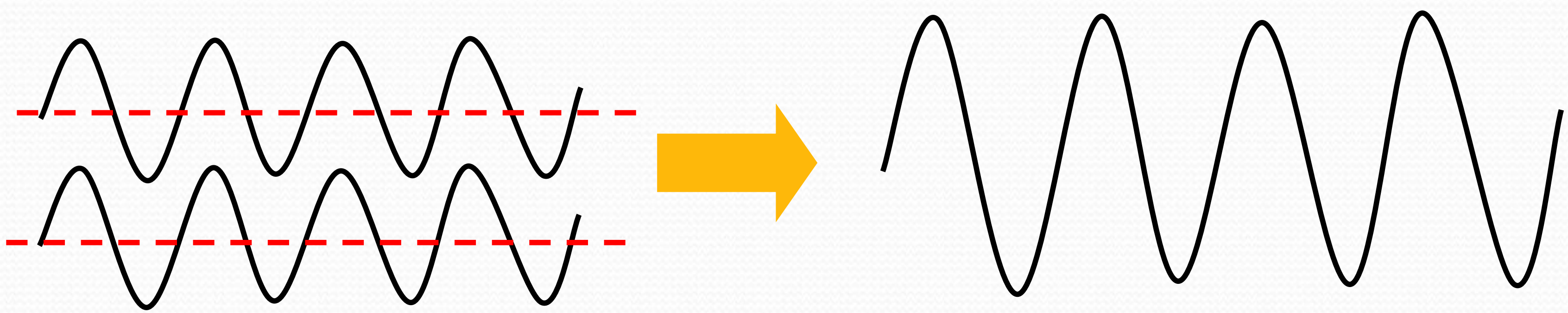
*When two or more waves super impose over each other at a common point of the medium then the resultant displacement of the particle is equal to the vector sum of the displacements produced by the individual waves.*

# *Constructive Interference*

*In Constructive interference the amplitude of the resultant wave is greater than that of either individual wave*

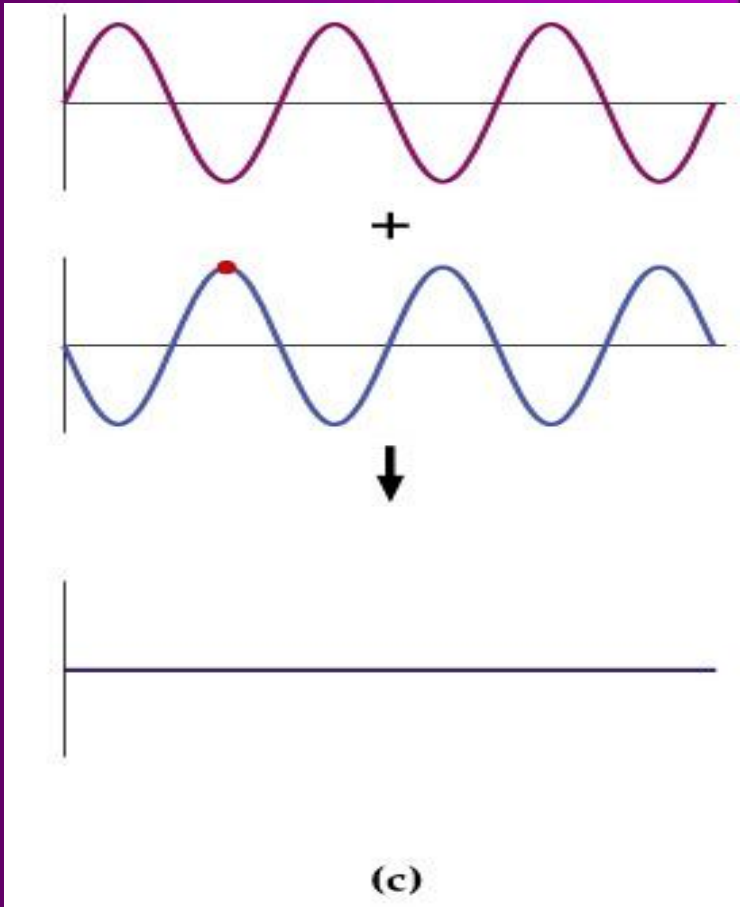


# *Constructive Interference*

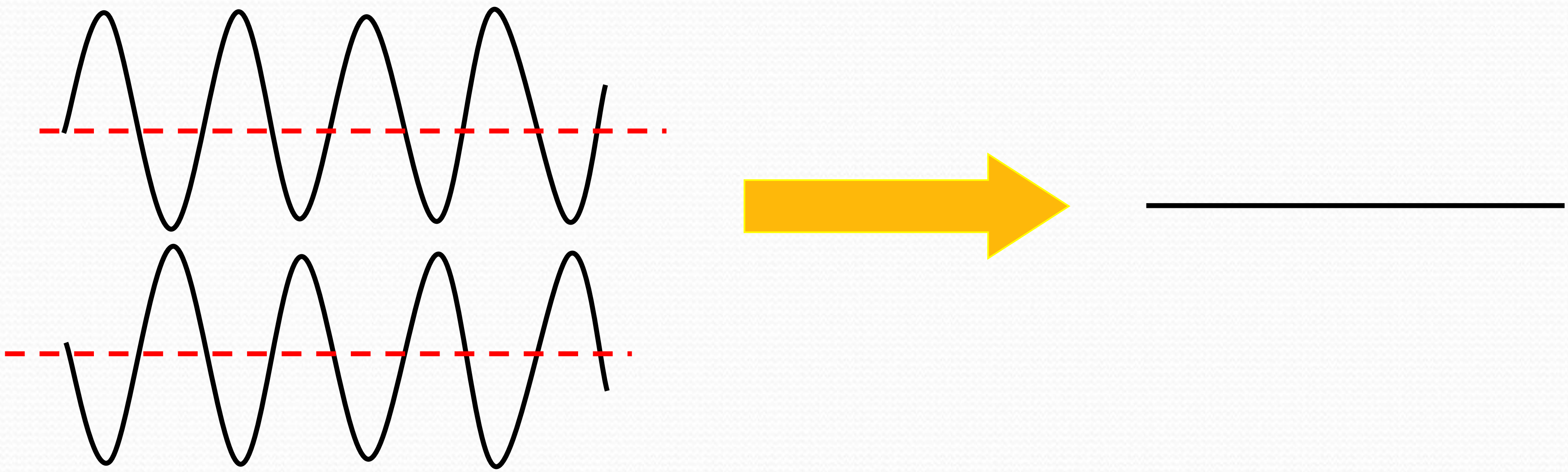


# *Destructive Interference*

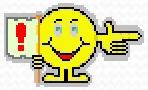
*In Destructive interference the amplitude of the resultant wave is less than that of either individual wave*



# Destructive Interference

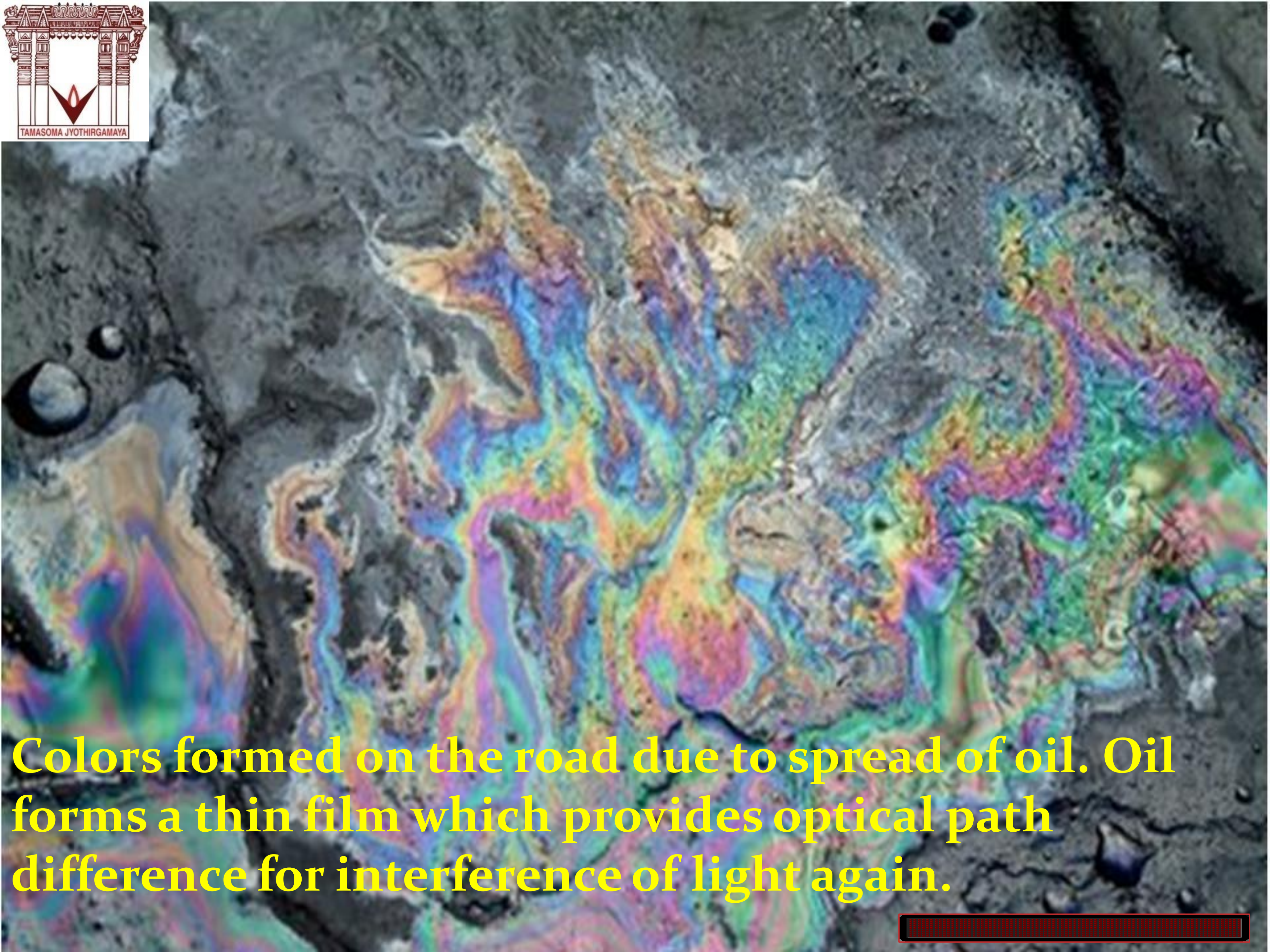


# *Let us understand Interference of light with some examples*



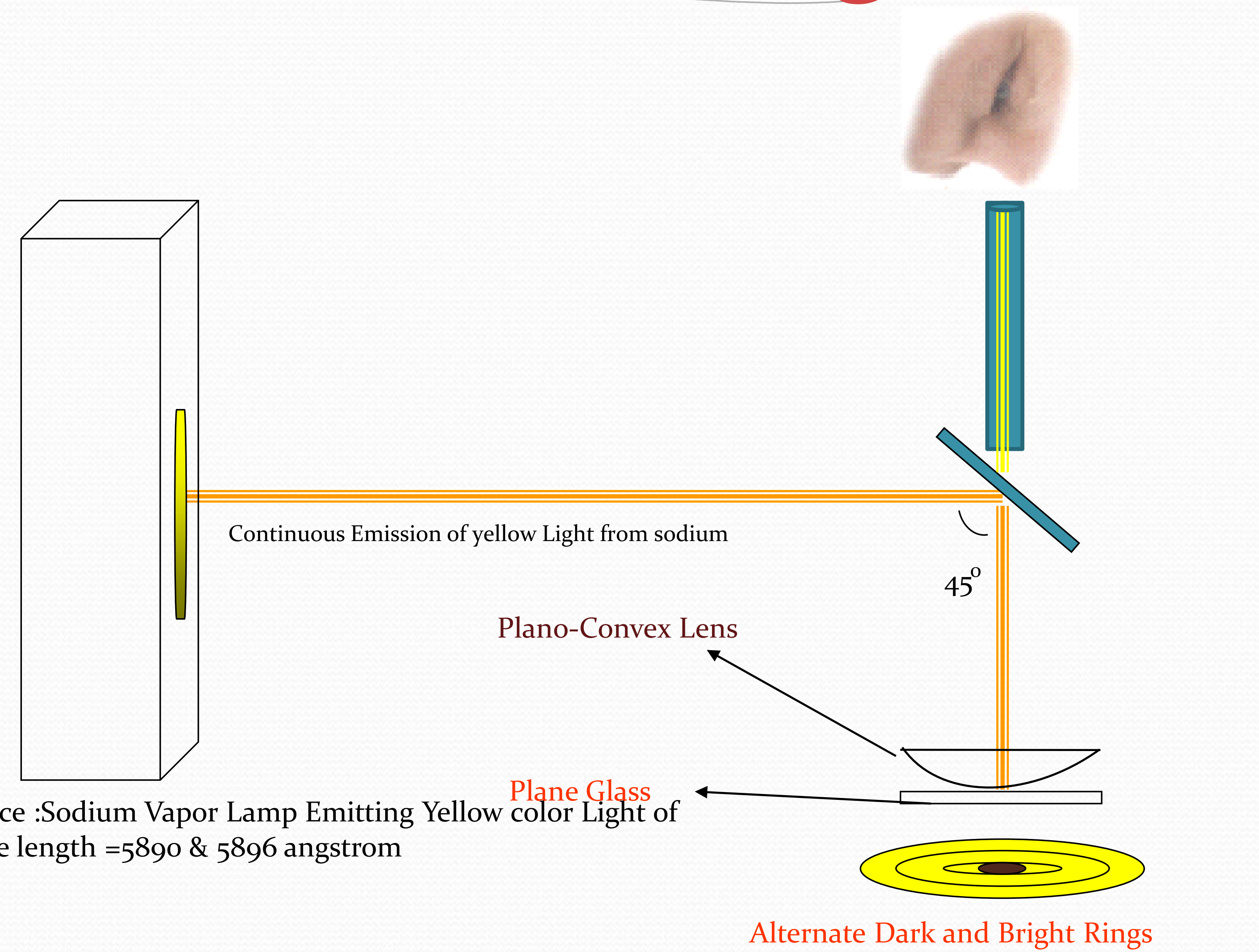
# *Colors exhibited by the thin oil spreads on flat surfaces*

Colors formed on the road due to spread of oil. Oil forms a thin film which provides optical path difference for interference of light



**Colors formed on the road due to spread of oil. Oil forms a thin film which provides optical path difference for interference of light again.**

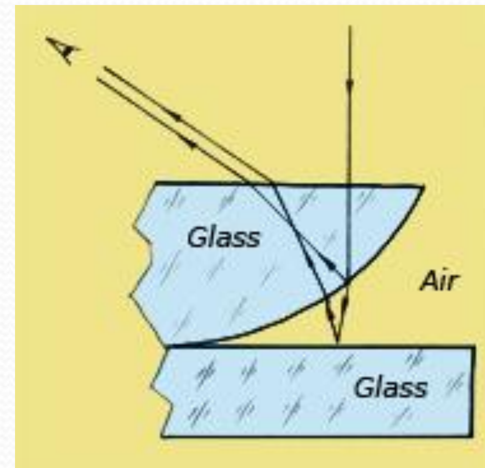
# Newtons Rings




Source :Sodium Vapor Lamp Emitting Yellow color Light of Wave length =5890 & 5896 angstrom

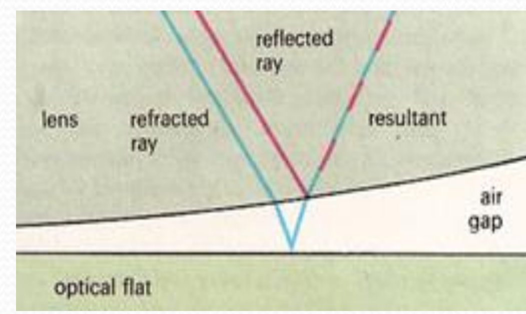
# What are Newton Rings

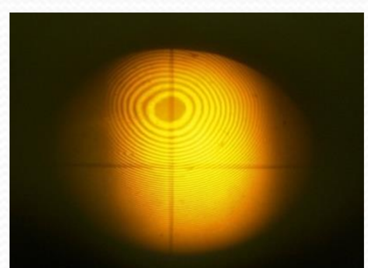
- They are due to interference of light




- A thin air film enclosed between the lower surface of a plano- convex lens and the top surface of a glass plate provides the necessary optical path difference.

- Optical path difference being equal to certain number of wavelengths creates either a dark or a bright ring



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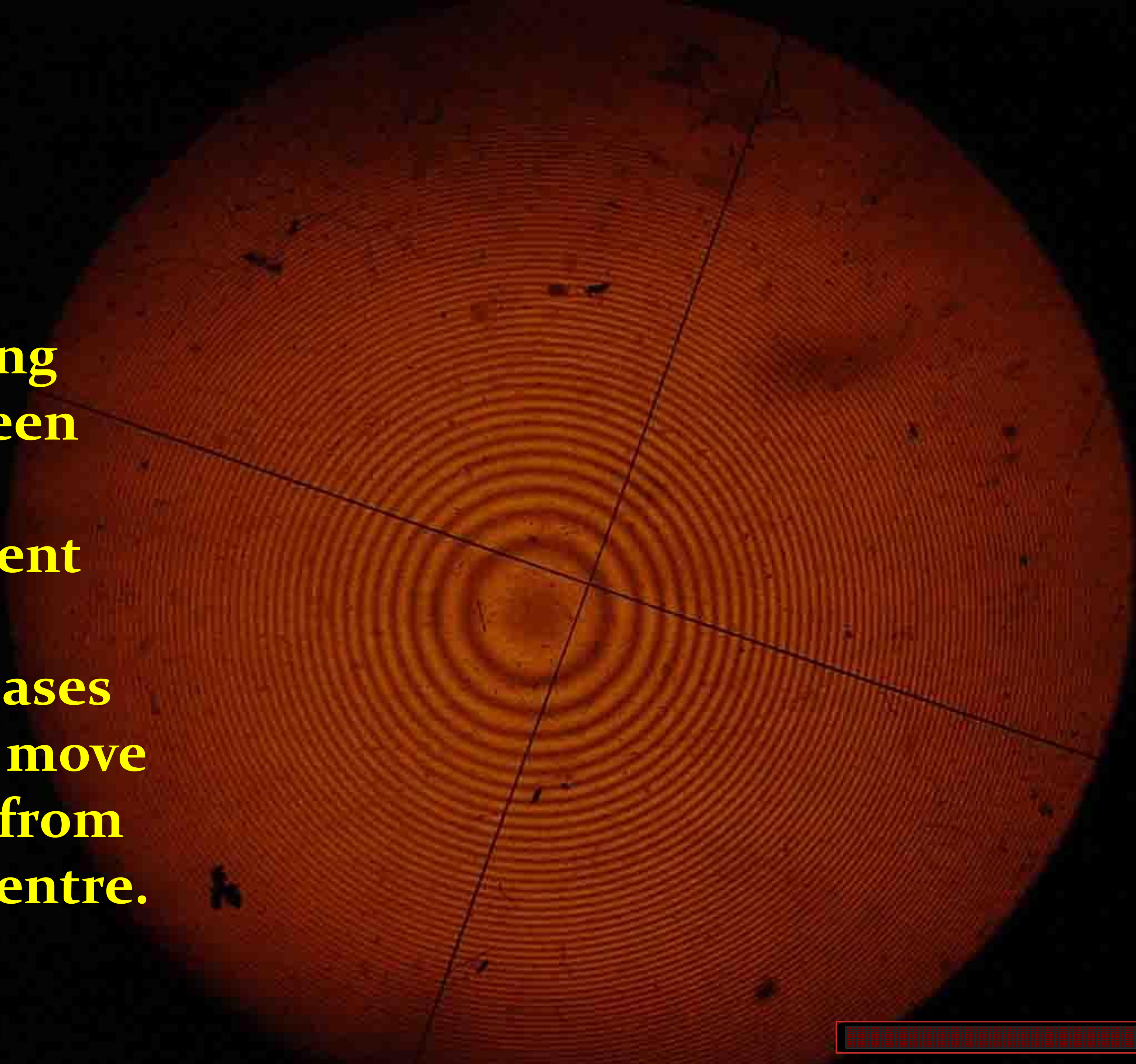
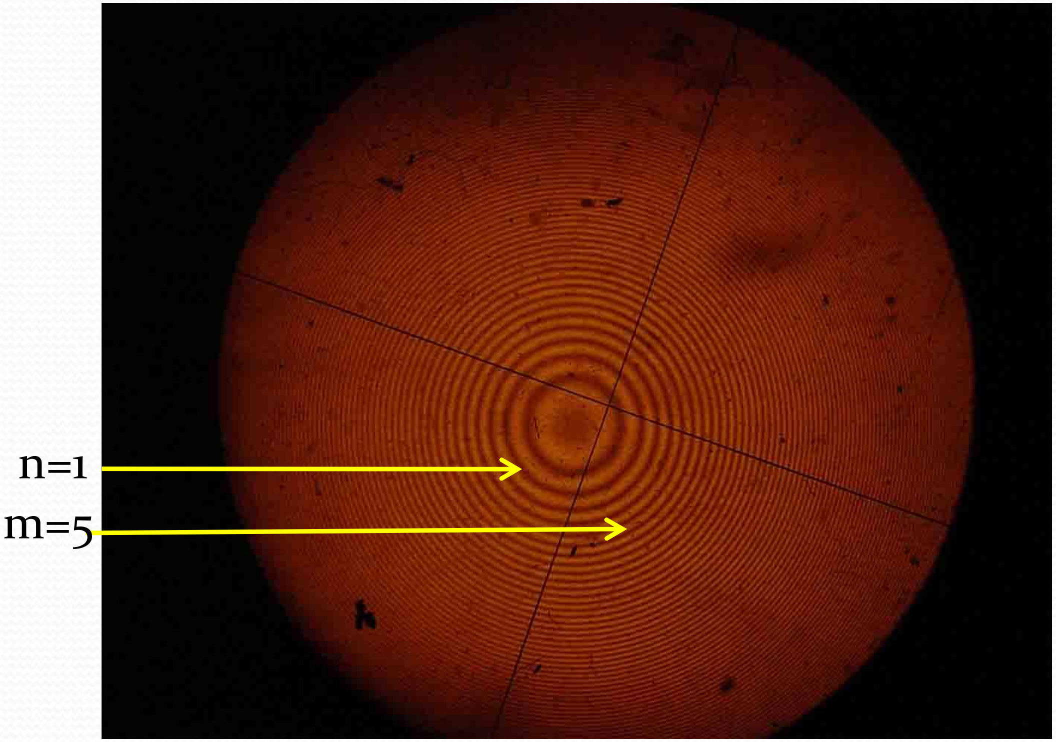


**The spacing between the adjacent rings decreases as we move away from the centre.**

# a) By forming Newton Rings We can calculate the radius of curvature of the given <u>Plano-Convex lens</u>

$$R = \frac{D_m^2 - D_n^2}{4\lambda(m-n)}$$



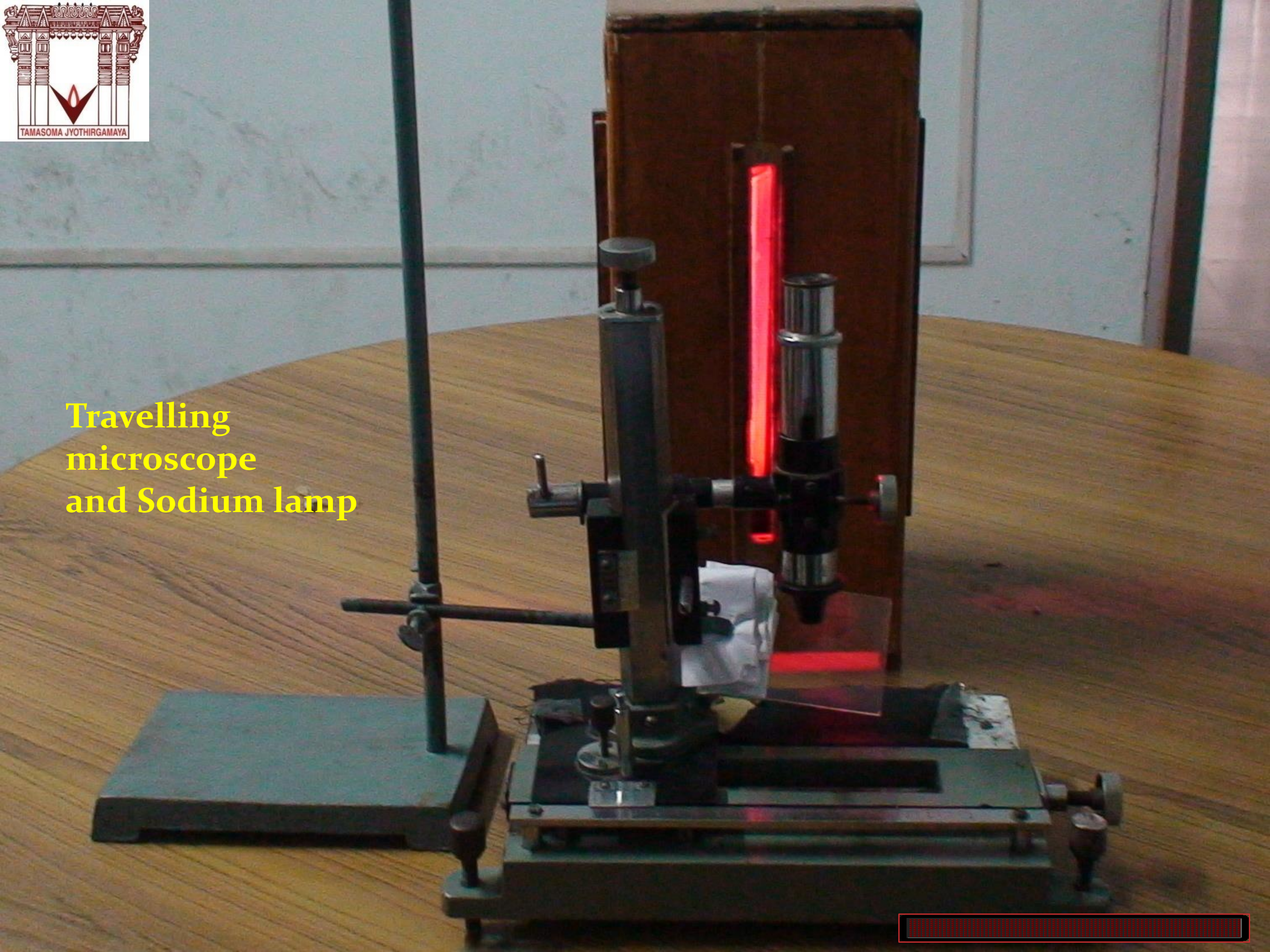

Where

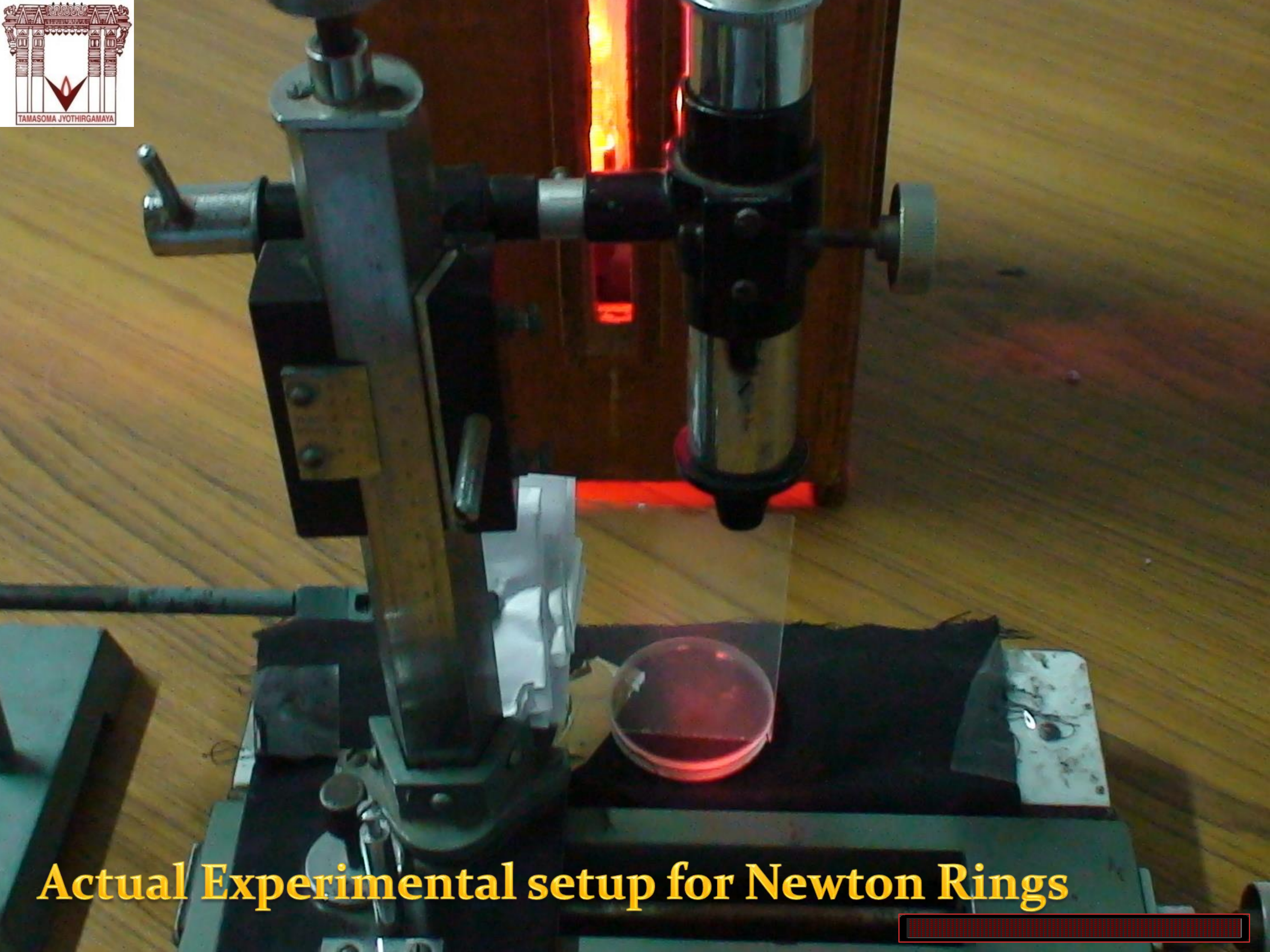
R = Radius of curvature of the given Plano-convex lens

$D_m^2$ = Square of the diameter of the $m^{th}$ ring

$D_n^2$ = Square of the diameter of the $n^{th}$ ring

λ = Wave length of the source of light (λ = 589.3 nm for sodium light)


Travelling
microscope
and Sodium lamp



Actual Experimental setup for Newton Rings


Plane Glass
Plano-Convex Lens

# DIFFRACTION

- Spreading (bending) of a wave around the sharp edge is diffraction

- The size of the obstacle should be comparable to the wavelength.

- Diffraction of light is so profound that it gives credence to the wave nature of light.

# DIFFRACTION contd..

- Diffraction is interference of the waves originating from every point on the incoming wave-front.

- The reason why the pattern looks almost the same, that is alternate dark and bright fringes.

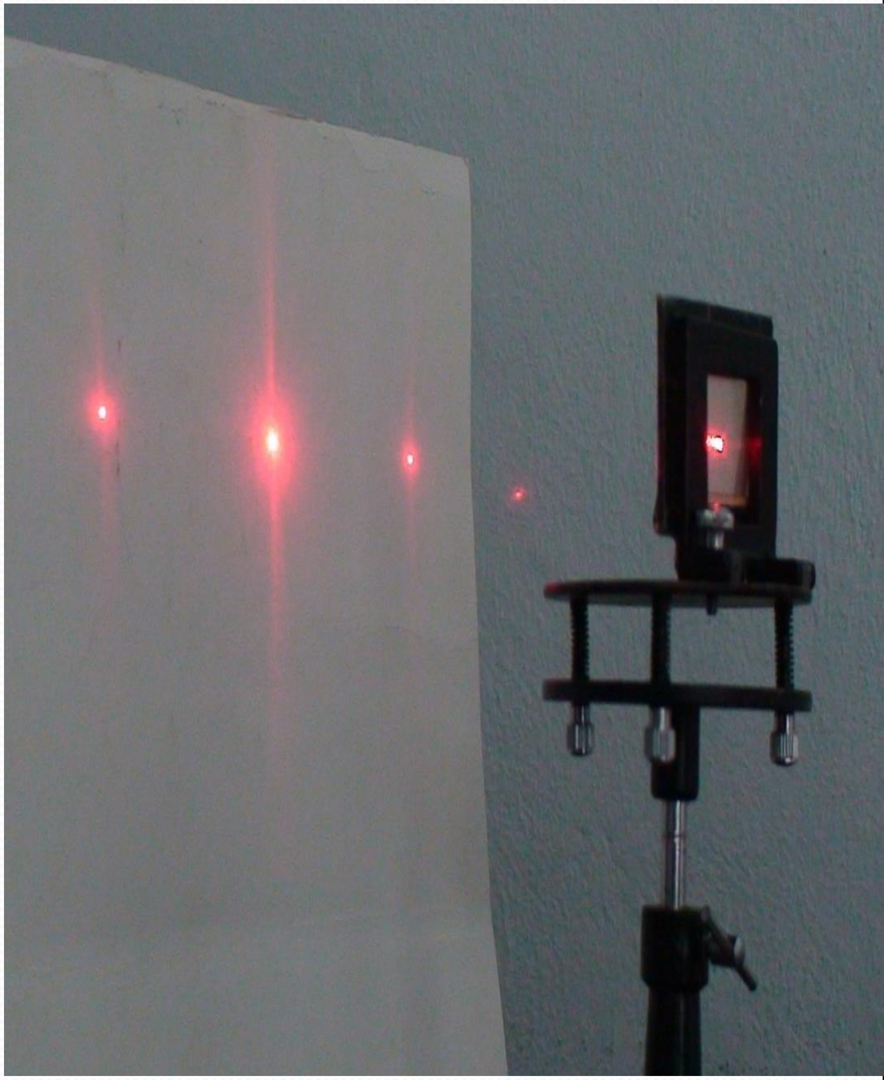
# DIFFRACTION contd..

- Diffraction Experiment establishes the wave nature of a beam of particles.
- Diffraction resolves the image produced by a source consisting of two slightly different wavelengths, a fact that can be used in:

i) recording and reproducing the data on CD with different wavelengths

ii) focusing in biological microscopes

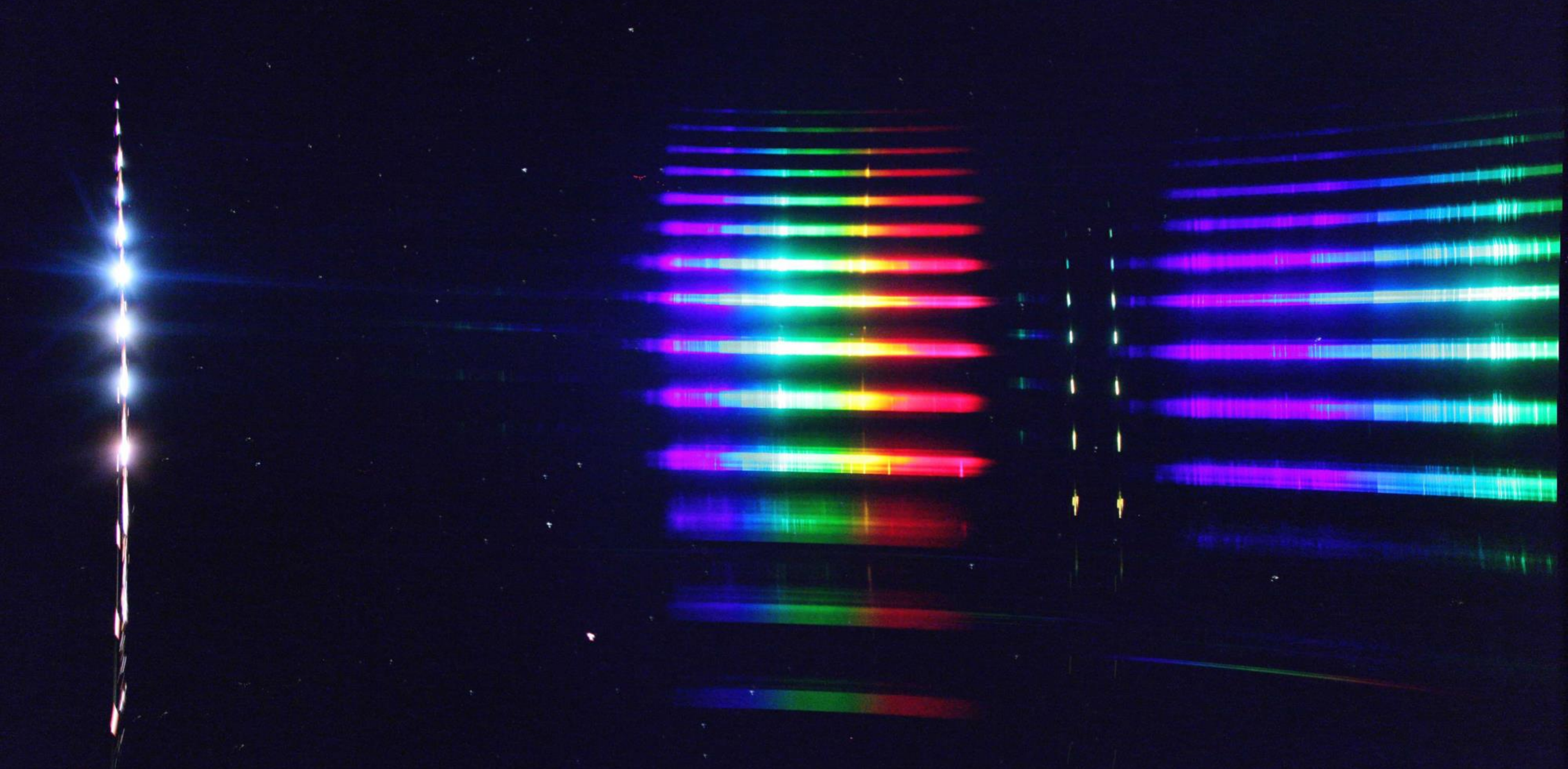
iii) holography



# Diffraction in Application:


Hologram

X-Ray Diffractometer



**This is a diffraction pattern obtained from the light emitted from the burning of the space craft re-entering the earth's atmosphere.**

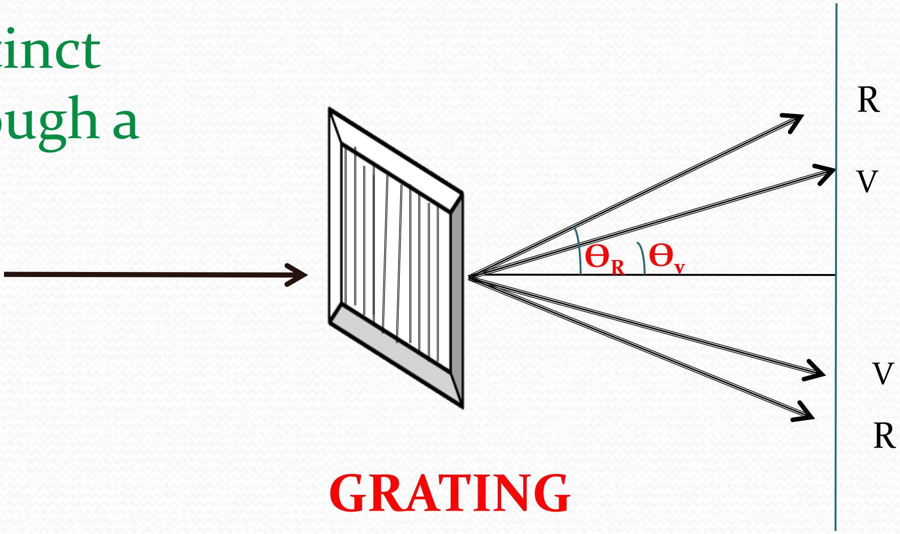
**- Courtesy NASA**

# Diffraction Experiments:

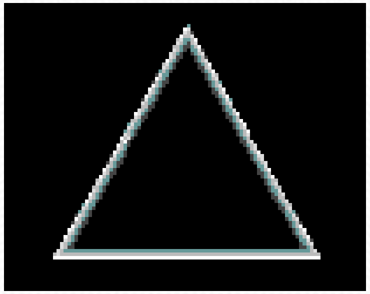
- Single Slit diffraction with laser light
- Grating (Multiple Slits) with laser light
- Grating (Multiple Slits) with white light (Uses Spectrometer)

# Differences in spectra

Using a spectrometer pure and distinct spectra can be obtained either through a prism or through a grating.




**GRATING**



**PRISM**

- Although pure, not so fine spectrum
- Only one order of spectrum
- **Violet** deviates more than **Red**

- Very fine spectrum
- No. Of Orders  of spectra are possible
- As $\Theta \alpha \lambda$, **Red** color deviates more than **Violet**
- Chromatic separation increases with the order of the spectrum

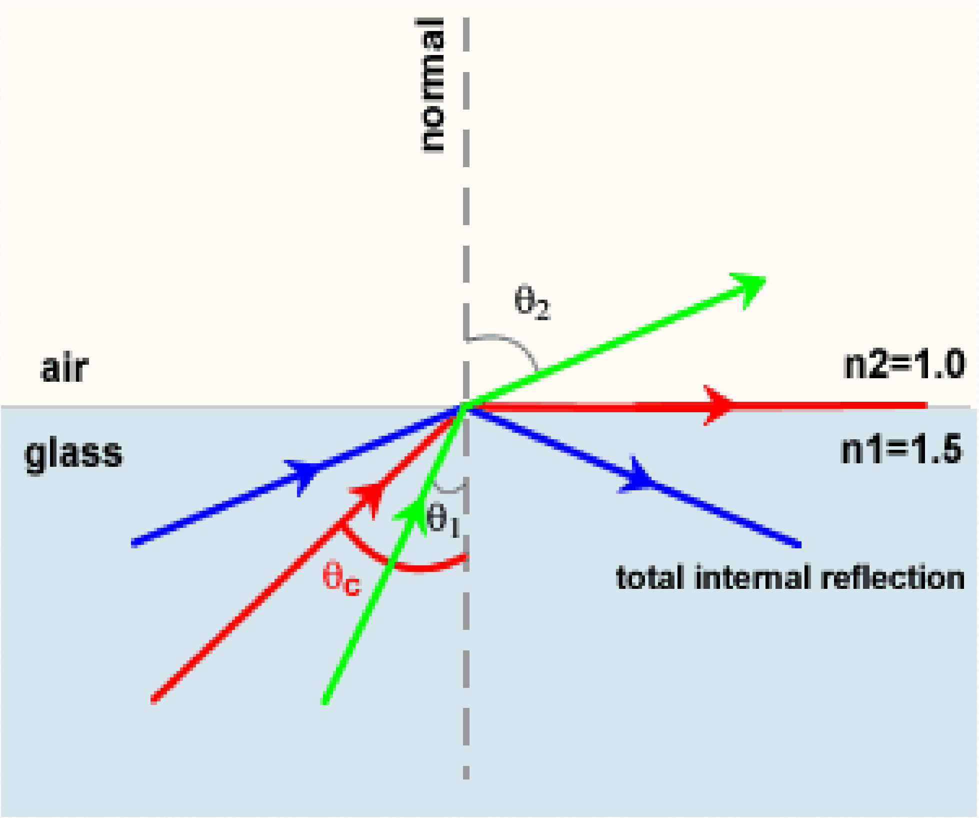
# The Total Internal Reflection

Ray passing from denser medium to rarer medium will be reflected back into the same medium,  if the angle of incidence is greater than critical angle.

Mirages, shining of diamond, the brilliance of water drop against light are examples

# The Total Internal Reflection

Contd..




The angle of incidence in denser medium for which the refracted ray grazes the interface is CRITICAL angle.

If the angle of incidence is greater than critical angle the ray is totally reflected.

# Electronics

Video

**R-C CIRCUIT**: Heart in a human body acts as a capacitor, collecting and pumping blood and the body provides resistance. Thus human body is a physical analogy for an RC circuit.

LIGHT EMITTING DIODE

Video

# Semi Conductors

- According to Band Theory of Solids, a semi-conductor material has a small energy gap between conduction band and the valence band ( of the order 1 to 2 eV).
- In a semiconductor two types of charge carriers exist
- Negative charge carriers are ‘electrons’
- Positive  charge carriers are ‘holes’
- Both charge carriers are responsible for conduction

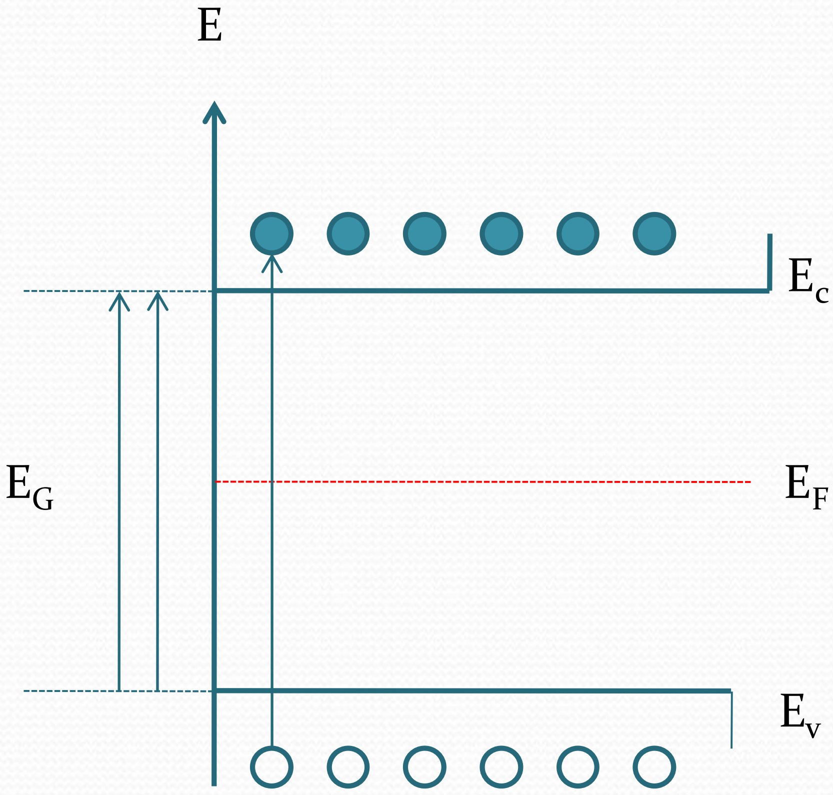
# Semi Conductors

- Semi conductors are pure or impure types.
- In pure or intrinsic semi conductor both charge carriers are equal in numbers
- Impure semiconductors are two types:

  N-type semiconductors in which electrons are majority carriers

  P-type semiconductors in which holes are majority carriers

# Intrinsic Semiconductors




Intrinsic Semiconductor

$E_G$ : Energy Gap

$E_c$ : Lowest Energy State of Conduction Band

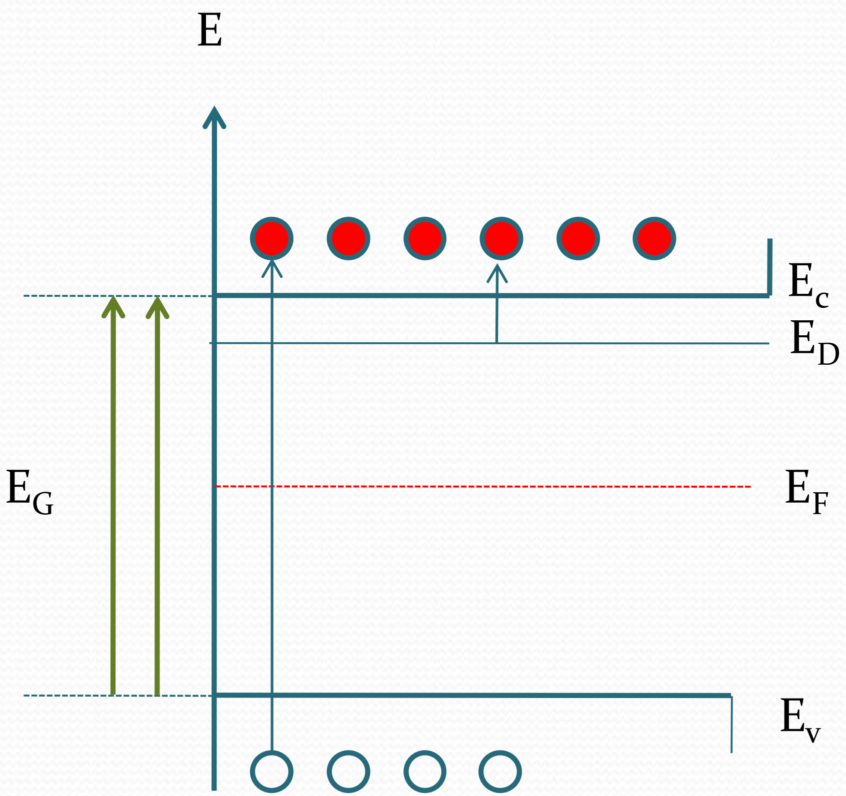
$E_v$ : Highest Energy state of valence band

$E_F$ : Fermi Energy Level

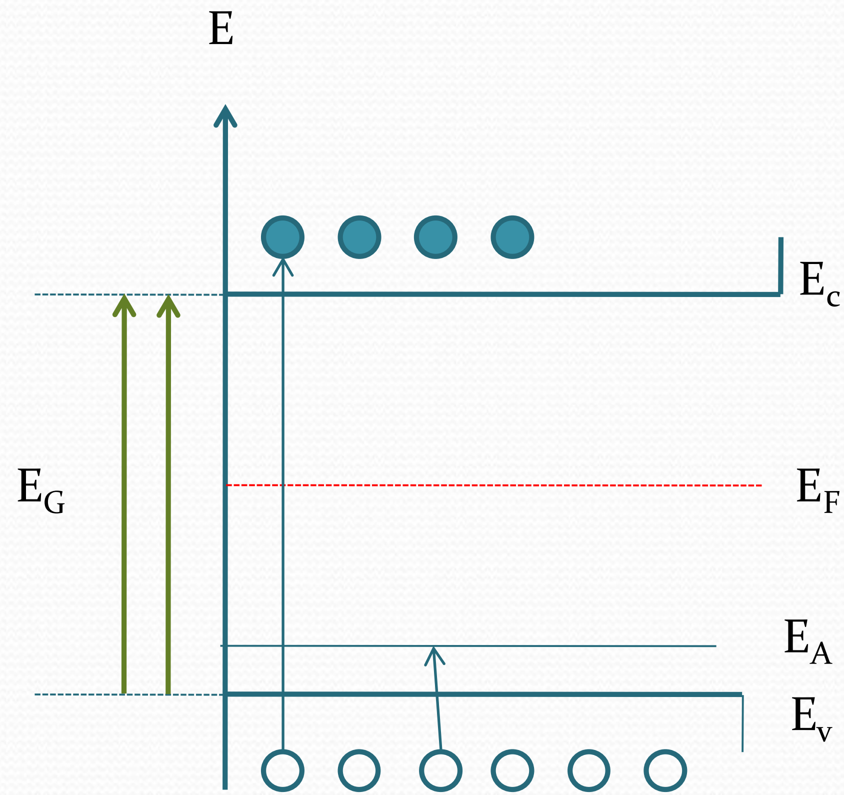
Energy gap
for silicon crystal : 1.2 eV
for Germanium crystal: 0.7 eV

[redacted]

# Extrinsic Semiconductors



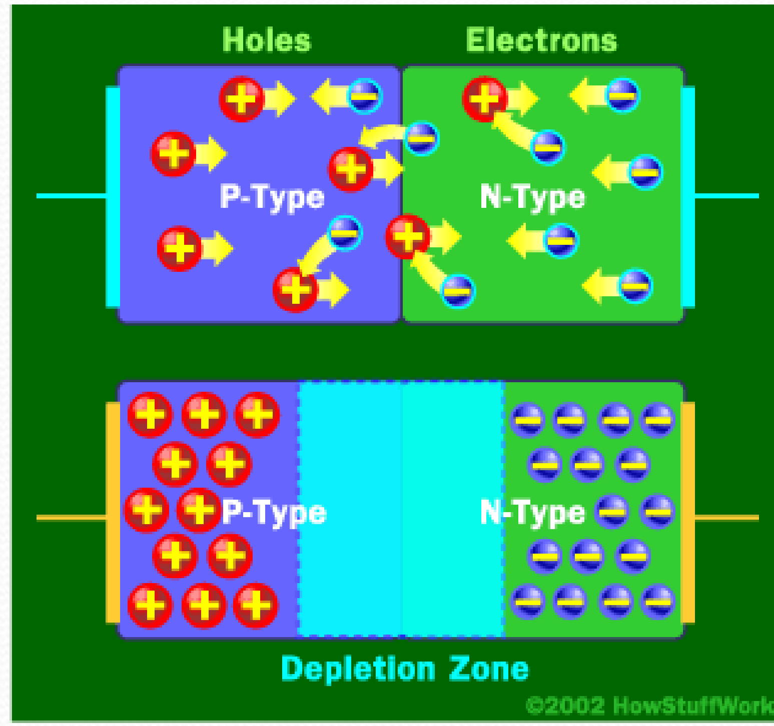

n-type Semiconductor




p-type Semiconductor

# Semi Conductor diode

- In a diode N-type material is bonded to P-type material, with electrodes on each end.
- This arrangement conducts electricity in only one direction.
- When no voltage is applied to the diode, electrons from N side fill holes from P side material across the junction in between the layers, and it forms a depletion zone.
- In a depletion zone, the semiconductor material is returned to its original insulating state -- all of the holes are filled, so there are no free electrons or empty spaces for electrons, and charge can't flow.

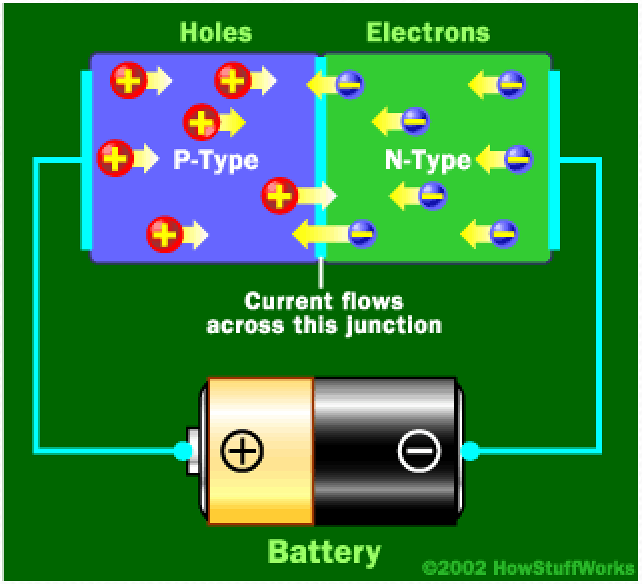



**At the junction, free electrons from the N-type material fill holes from the P-type material. This creates an insulating layer in the middle of the diode called the depletion zone.**

# Semi Conductor Cont..

## Forward biasing

- N side of the diode is connected to the negative end of a circuit and the P side to the positive end.
- The free electrons in the N-type material are repelled by the negative electrode and drawn to the positive electrode. The holes in the P-type material move the other way.
- As the potential increases the depletion zone disappears, and charge moves across the diode. Thus the current is allowed to flow through the diode

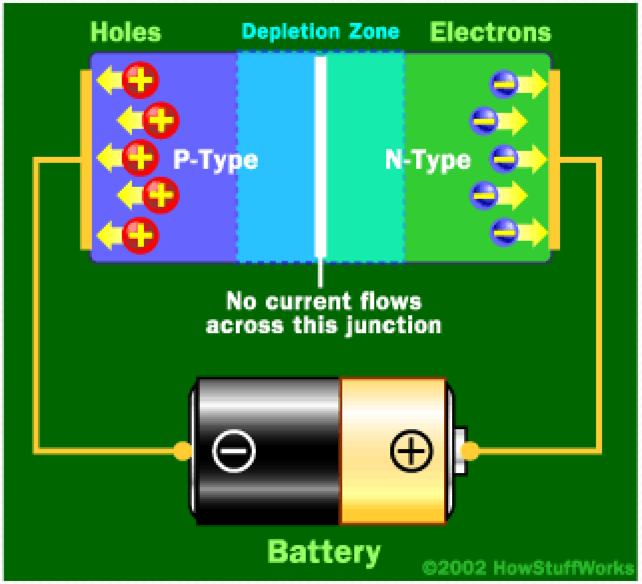



**When the negative end of the circuit is hooked to the N-type layer and the positive end is hooked to P-type layer, electrons and holes start moving and the depletion zone disappears.**

# Semi Conductor Cont..

## Reverse biasing

- If the P-type side is connected to the negative end of the circuit and the N-type side is connected to the positive end, current will not flow.
- The negative electrons in the N-type material are attracted to the positive electrode. The positive holes in the P-type material are attracted to the negative electrode.
- No current flows across the junction because the holes and the electrons are each moving in the wrong direction. The depletion zone increases.




When the positive end of the circuit is hooked up to the N-type layer and the negative end is hooked up to the P-type layer, free electrons collect on one end of the diode and holes collect on the other. The depletion zone gets bigger.

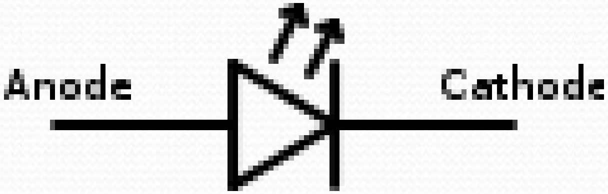
# LIGHT EMITTING DIODE

Type — Passive, optoelectronic

Working principle — Electroluminescence

Invented — Nick Holonyak Jr. (1962)

Electronic symbol




Pin configuration — Anode and Cathode

# Astroculture Facility

**From spuds to space medicine. Quantum Devices Inc., of Barneveld, Wis., builds the light-emitting diodes used in medical devices and for growing plants, like potatoes, inside the ASTROCULTURE facility -- a plant growth unit developed for use on the Space Shuttle by the Wisconsin Center for Space Automation and Robotics (WCSAR).**

A panel of red LEDs used for illumination for a plant growth experiment with possible future application to food growing in space [redacted]

# LEDs as Wound Healing Devices

•A nurse practitioner places the LED array on the outside of a patient's cheek where it shines for just over a minute each day, promoting wound healing and preventing mouth sores caused by radiation and chemotherapy

The wound-healing device made by Quantum Devices Inc. in Barneveld, Wis., is a small 3.5-inch by 4.5-inch (90 by 145-millimeter) portable, flat array of light-emitting diodes, or LEDs.

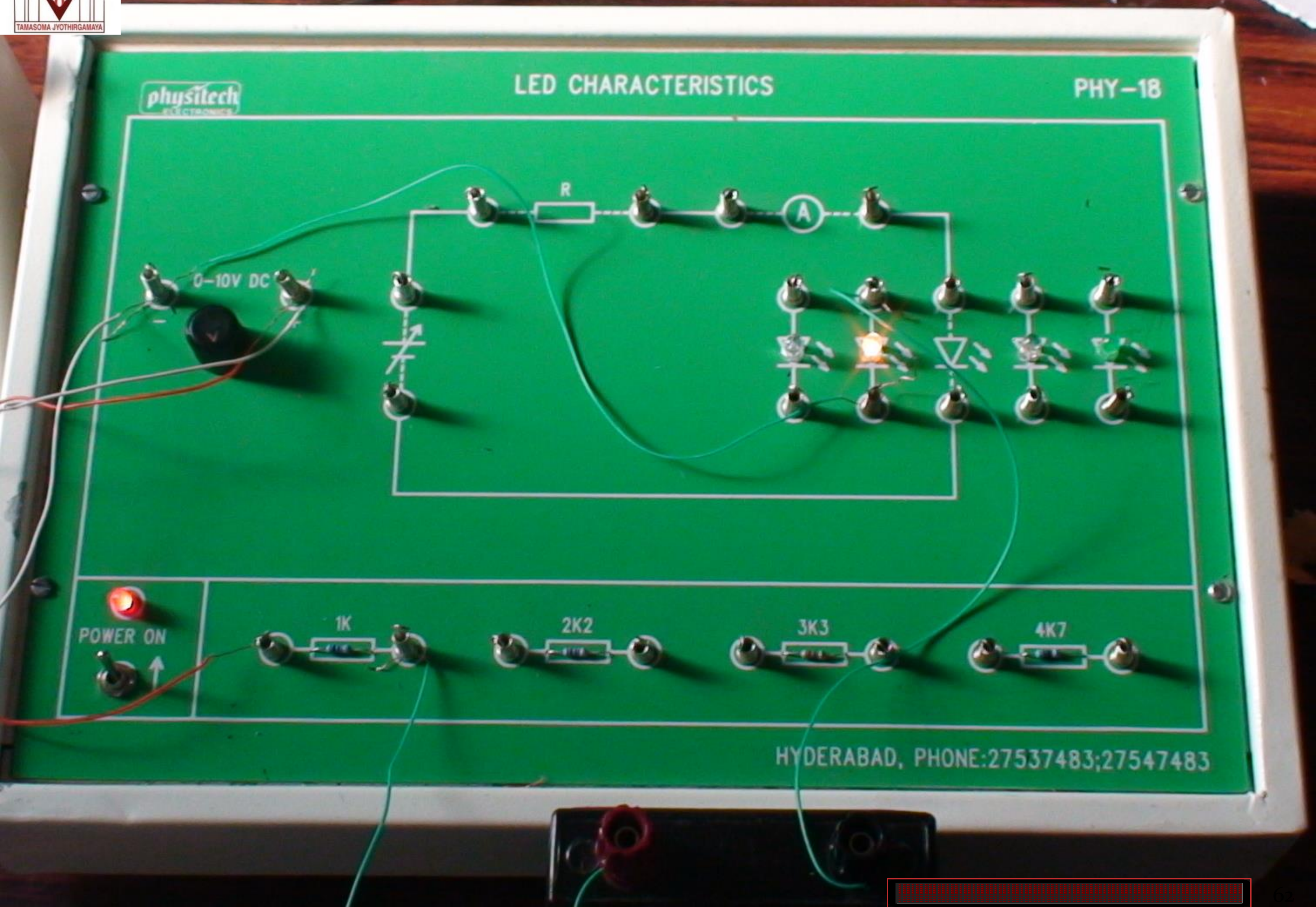
# LED lighting

**LED lighting in a aircraft cabin of the Airbus A320**

# LED display

A large LED display behind a disc jockey.

# LIGHT EMITTING DIODE



# LIGHT EMITTING DIODE..

- The LED is based on the semiconductor diode.
- Principle is electroluminescence and the color of the light is determined by the energy gap of the semiconductor.
- An LED is usually small in area (less than 1 $mm^2$), and integrated optical components are used to shape its radiation pattern and assist in reflection.

# LIGHT EMITTING DIODE…

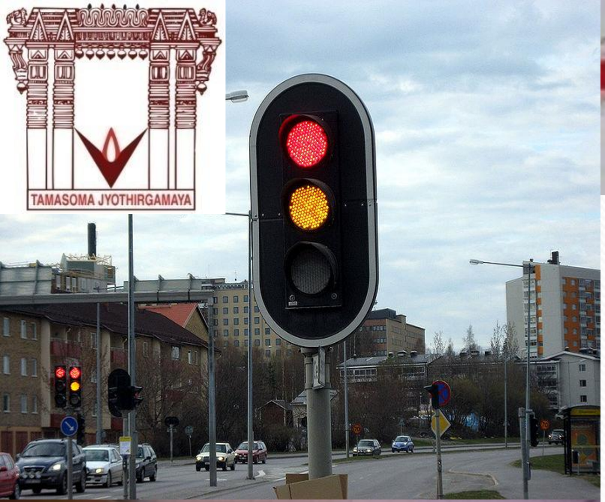
- Visible light-emitting diodes (VLEDs), such as the ones that light up numbers in a digital clock, are made of materials characterized by a wider gap between the conduction band and the lower orbitals.
- The size of the gap determines the frequency of the photon -- in other words, it determines the color of the light.

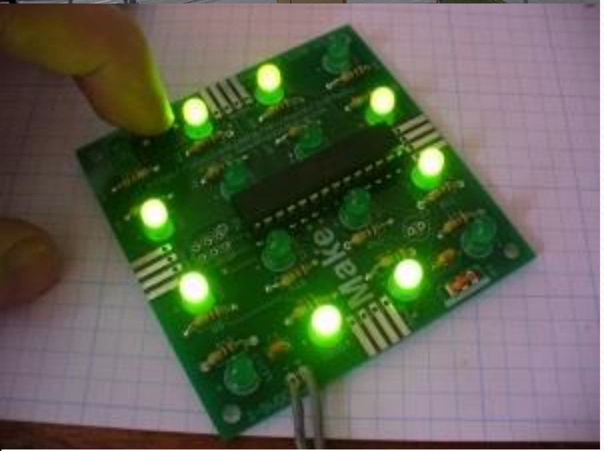
Among other things, LEDs

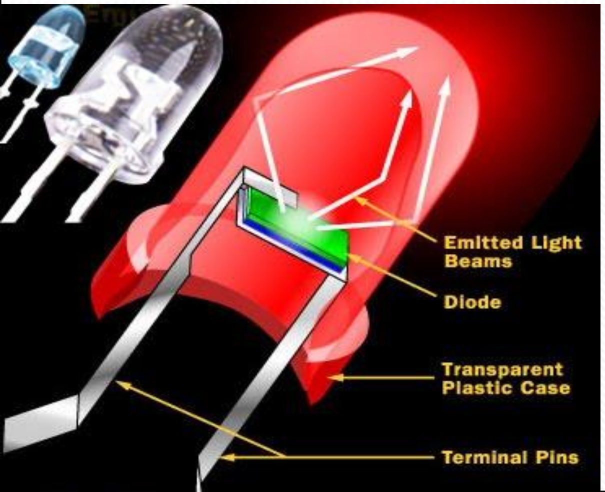
- form the numbers on digital clocks,
- transmit information from remote controls,
- light up watches and
- tell you when your appliances are turned on.


Collected together, they can form images

- On jumbo television screens or
- Illuminate traffic lights.







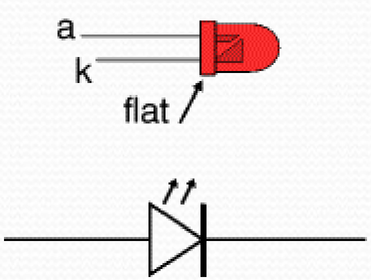


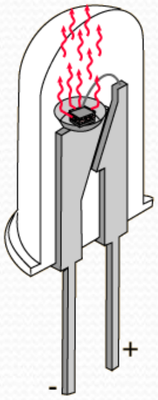
- Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs they don't have a filament that will burn out, and they don't get especially hot.

- They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor.

A light emitting diode (LED) is essentially a PN junction opto-semiconductor that emits a monochromatic (single color) light when operated in a forward biased direction.

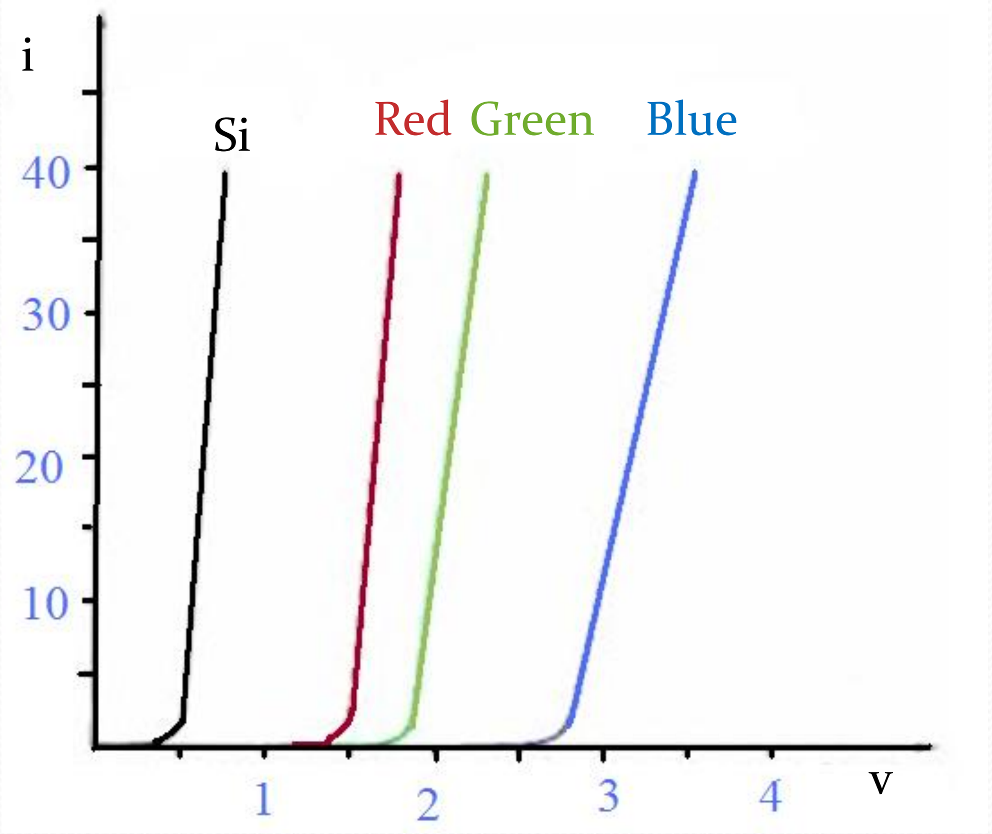
LEDs convert electrical energy into light energy. They are frequently used as "pilot" lights in electronic appliances to indicate whether the circuit is closed or not.




- Current Vs voltage

This Graph Shows the threshold voltages for different coloured LEDs



[redacted]

- **IMPORTANT!**
  An only slightly higher voltage means to lead a substantially higher current, that very fast can destruct an LED !!!
  Therefore also a resistance must lie in each electric circuit with an LED, which limits the current.

# LED ADVANTAGES

- LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability.
- However, they are relatively expensive and require more precise current and heat management than traditional light sources.
- There are organic light emitting diodes also.

# ENERGY GAP OF SEMICONDUCTOR

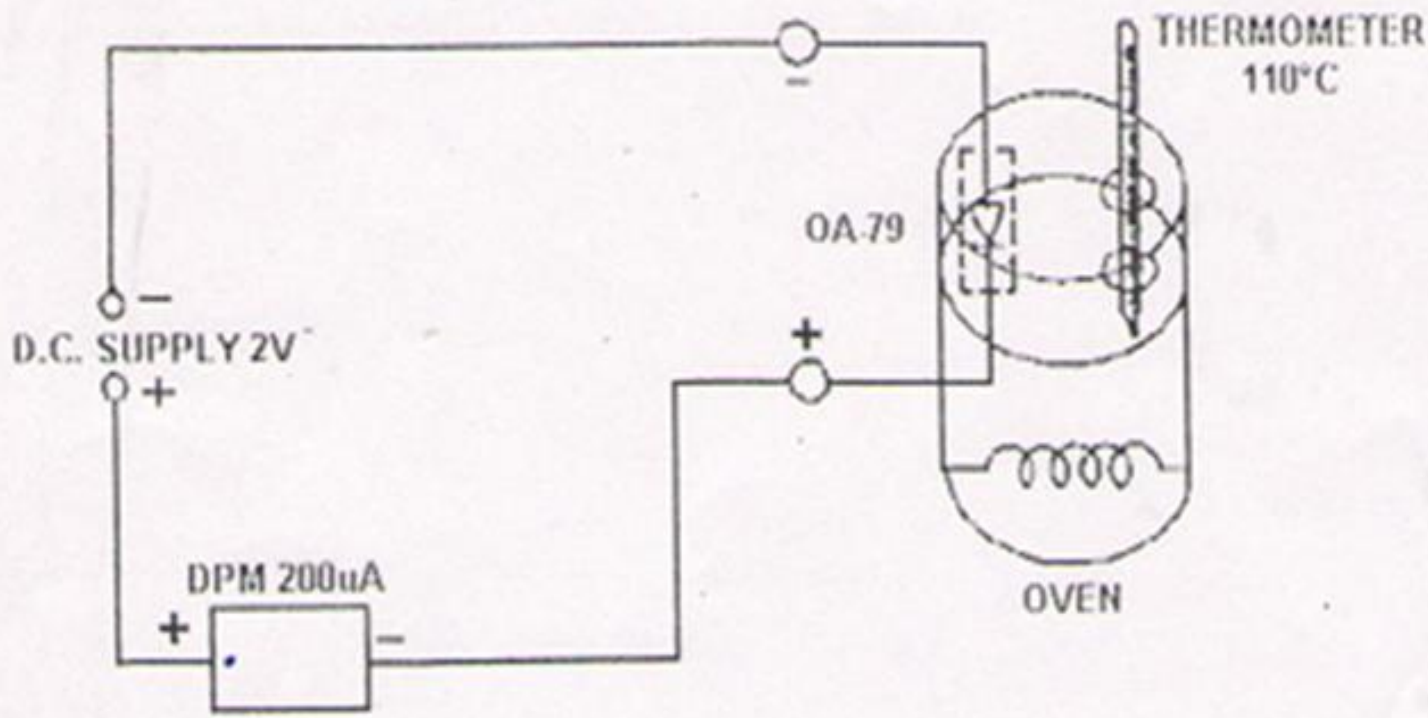
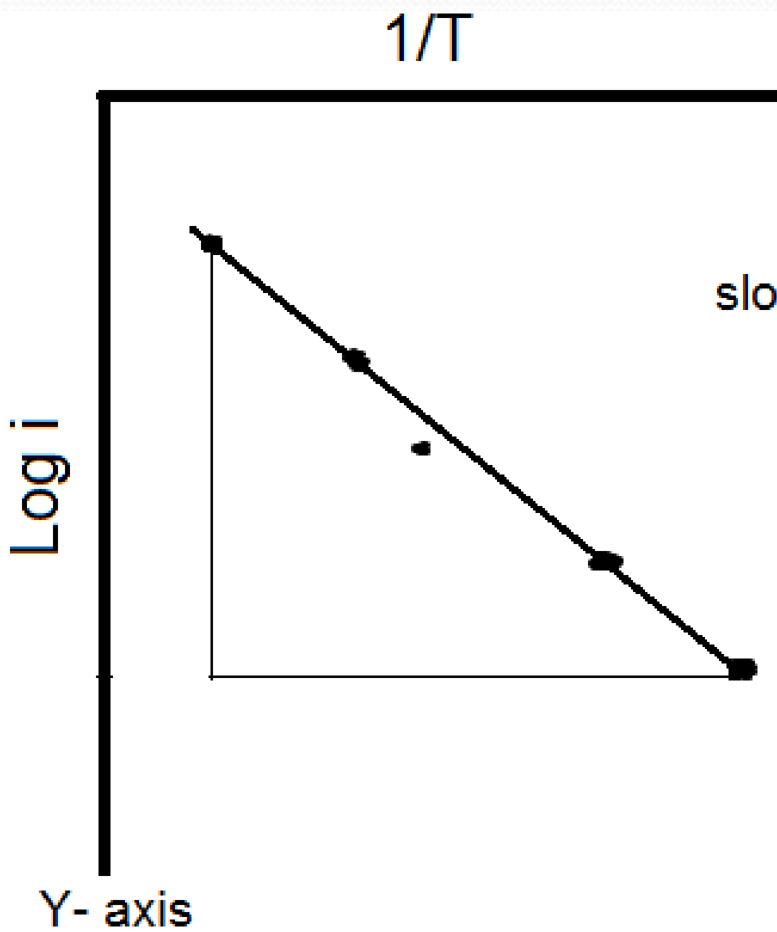



**Fig. 1 Experimental Setup**

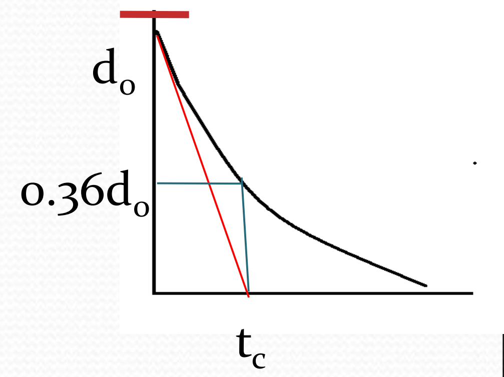
TAMASOMA JYOTHIRGAMAYA

# Experimental Graph

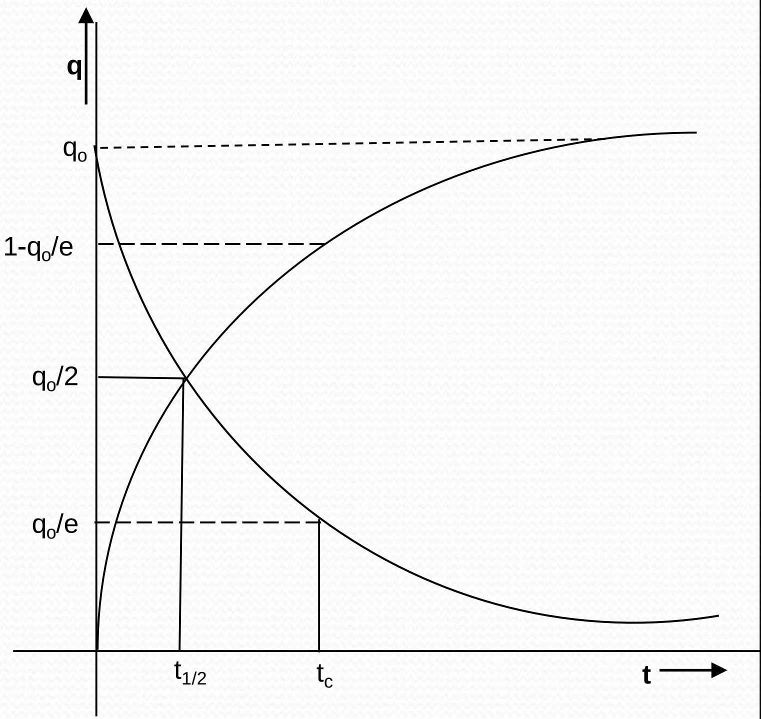



# R-C CIRCUIT

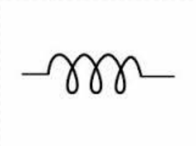
- $t_c = R\,C$
- Time taken to discharge nearly 64%(significant portion)is usually called time constant




- **Physical significance of time constant**

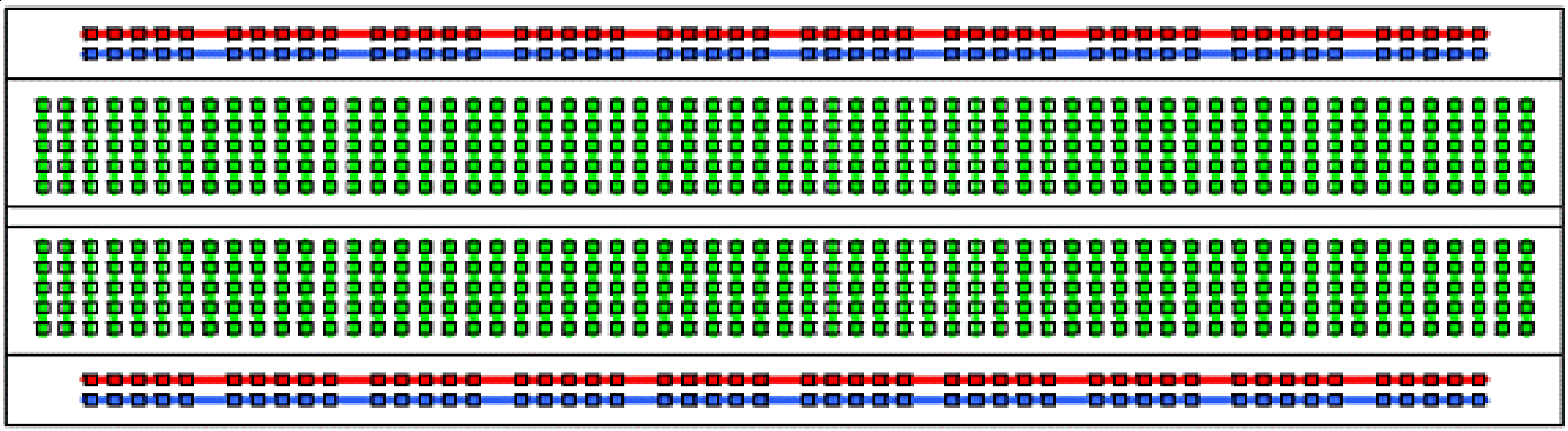



  - If the capacitor discharges linearly, the time taken to empty the capacitor is time constant. OR
  - If it discharges exponentially, it becomes practically empty in 5 time constants interval.

| Device | | Type of energy | Energy | Remarks |
| --- | --- | --- | --- | --- |
| Capacitor |  | Electrical | $Q / (2C^2)$ | Q is charge stored in the capacitor, C is capacitance |
| Inductor |  | Magnetic | $L\, i^2 / 2$ | i is the current,<br>L is inductance |
| Spring |  | Mechanical | $k\, x^2 / 2$ | x is the extension of the spring, k is spring constant |


16


General
About
Screensaver
Aerial
Sleep After
1 hour
Accessibility
Restrictions
Off
Privacy
SIRI
Siri
On
About Siri and Privacy
USAGE

**Laboratory Set up for R-C CIRCUIT**

# CAPACITORS

- Capacitor is a device that stores electrical Energy
- Capacitor discharges in exponential way.
- Time constant is Product of R and C

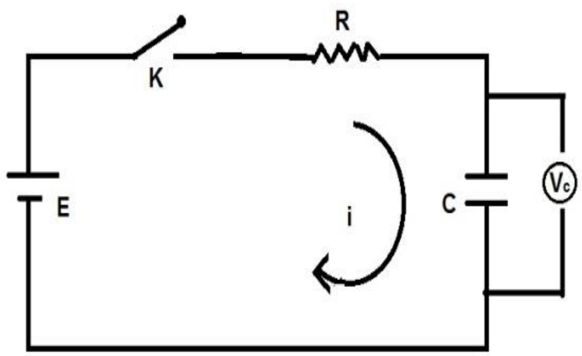
Capacitance for a parallel plate capacitor with plate area A and Separation ‘d’:

$$C = \epsilon A/d ,$$

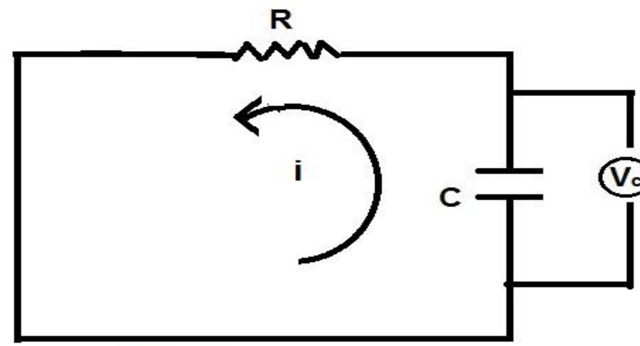
$\epsilon$ = permitivity constant of a medium,

Energy of the capacitor

$$E = \frac{1}{2} C V^2$$




Charging




Discharging

# DIFFERENT CAPACITORS

ceramic

**Electrolyte**

**plastic**

Variable Capacitor

Some more types are **air**, **paper**, **plastic film**, **mica**, **ceramic**, **electrolyte**, and **tantalum**.

# STEWART –GEE EXPERIMENT

→ To *study* the variation of magnetic field along of a circular coil carrying current.

→ To verify Biot Savart law.

$$B = \frac{\mu_o n i a^2}{2(x^2+a^2)^{3/2}} \text{ Tesla.}$$

**B- Magnetic field**

**$\mu_0 = 4\pi \times 10^{-7}$ Henry/meter**

**n- no.of turns in a coil**

**i- current in coil**

**a- Radius of circular coil**

**x- At any distance**

$$B = B_e \tan\theta$$

**B- Magnetic field**

**$B_e$ = Horizontal component of earth‘s magnetic field**

**= $0.38 \times 10^{-4}$ Tesla (or $Wb \cdot m^{-2}$)**

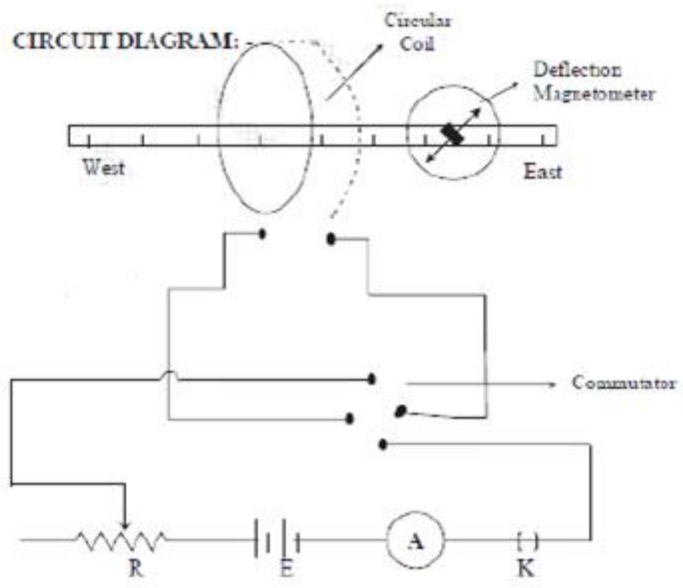
**Θ= Defelction in Deflection Magneto Meter**

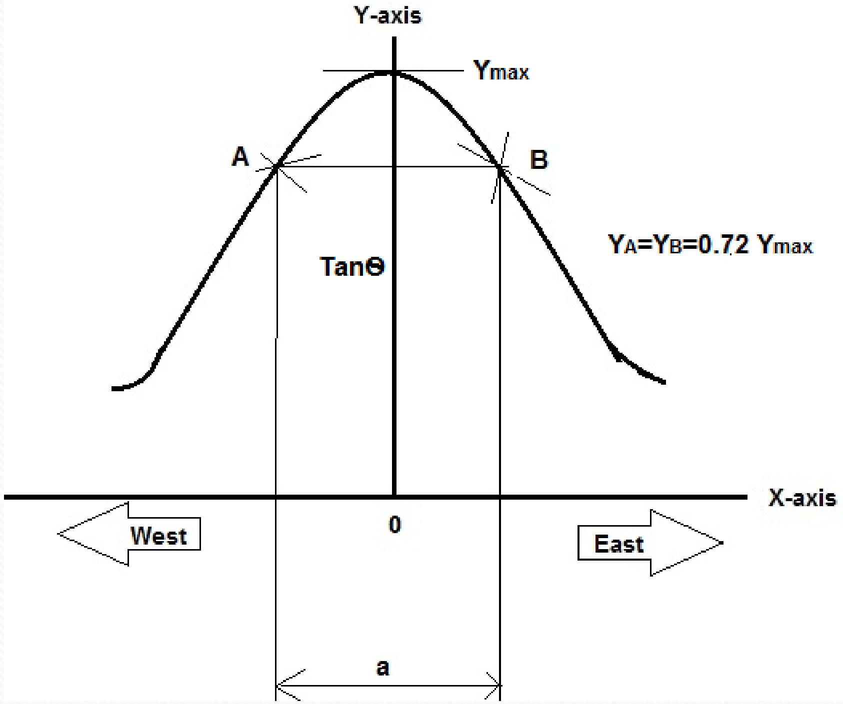
# STEWART-GEE EXPERIMENT

Experimental Setup

Video

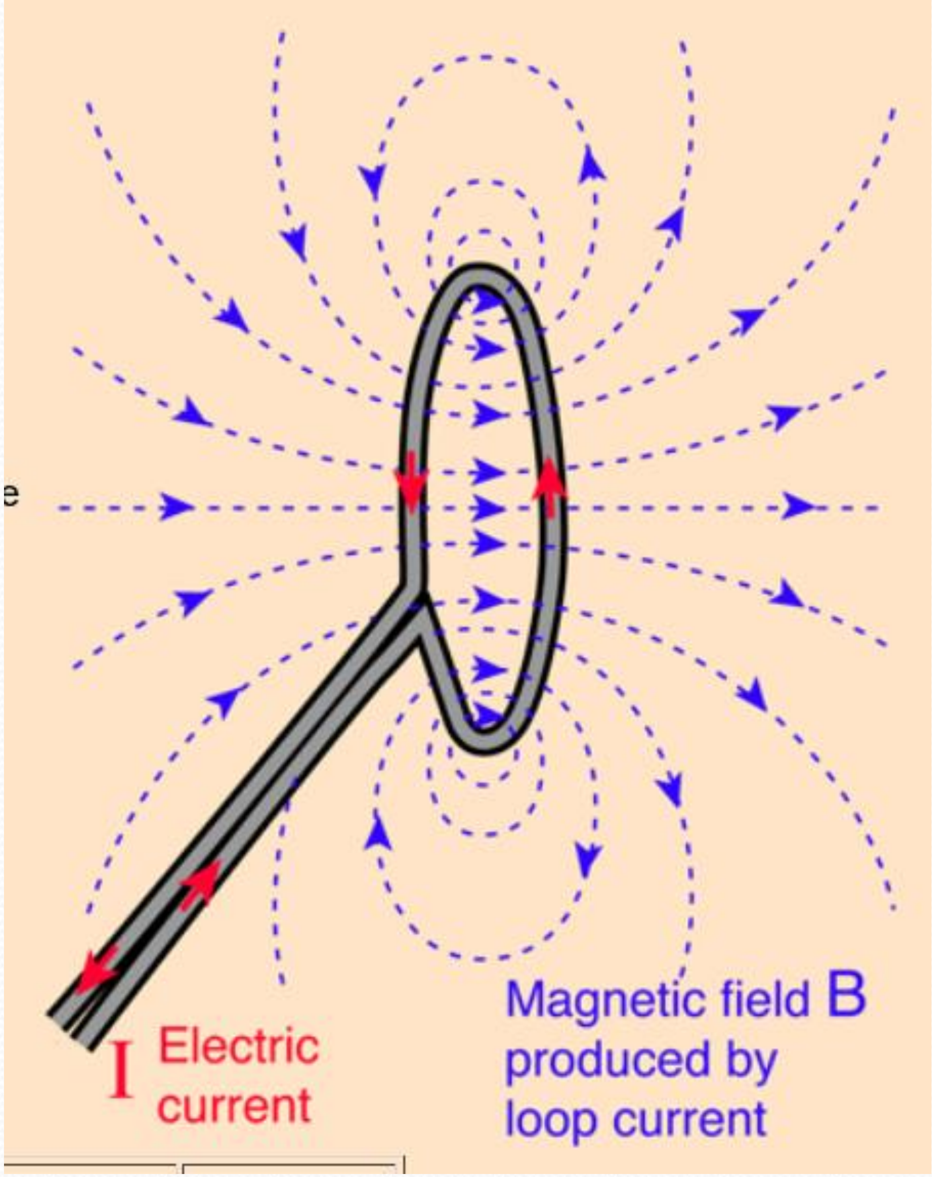
# STEWART-GEE EXPERIMENT




Video

Electric current in a circular loop creates a magnetic field which is more concentrated in the center of the loop than outside the loop.



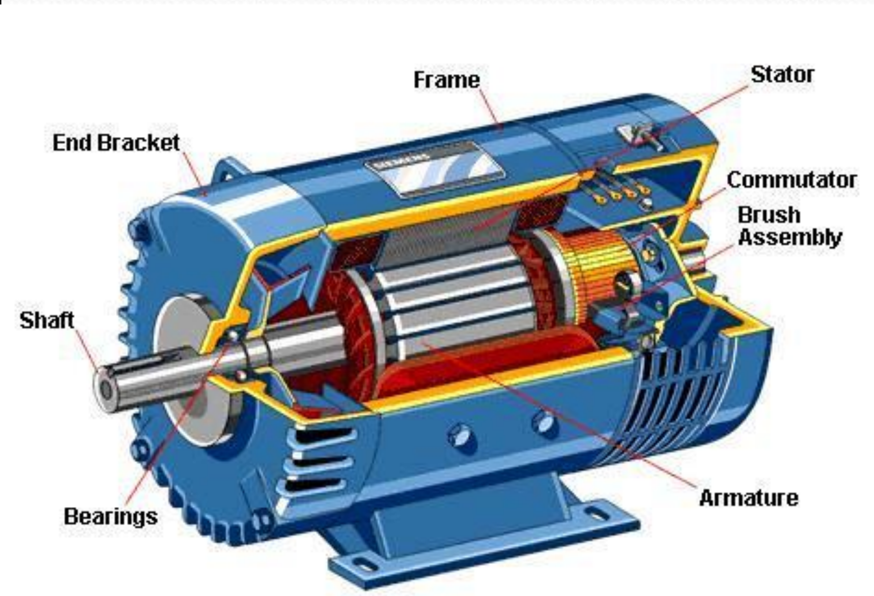
# Applications

- Electro magnets are widely used in electrical devices like,

- Motors, generators , relays, loud speakers, MRI machines, LVDT(Linear Variable Differential Transducers), sensors etc.,

MRI scan

Loud speakers




Electric motor


Electric Generators

# Rules in the Lab

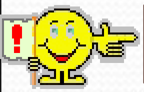
•During each session student is continuously assessed for performance

•For safety reasons, students are requested not to leave their equipment unattended during the lab session. In the case of special circumstances, please seek the support of the class teachers/demonstrators.

•Students must thoroughly read the lab manual and the corresponding theory before starting an experiment.

# Rules in the Lab contd..

- All the original data have to be recorded in observation book during the laboratory sessions. Data recording on rough sheets are not allowed.
- Ensure that recording of the observations are to be signed by the In-charge concerned before leaving the lab.



Click Here

# CONCLUSIONS

After going through this lab course a student's

- Concepts in *physics* strengthened
- Diligence in handling of instruments enhanced
- And a student can confidently apply these concepts in his/her future endeavors of technological improvements, projects and research

# Acknowledgments

- Un Known Virtues for the Videos and Images
- International Music Maestros "Yanni (Music to whole Presentation and A.R.Rehman (For Last 2 Slides) where we used their music to add colour to this presentation


Thank You