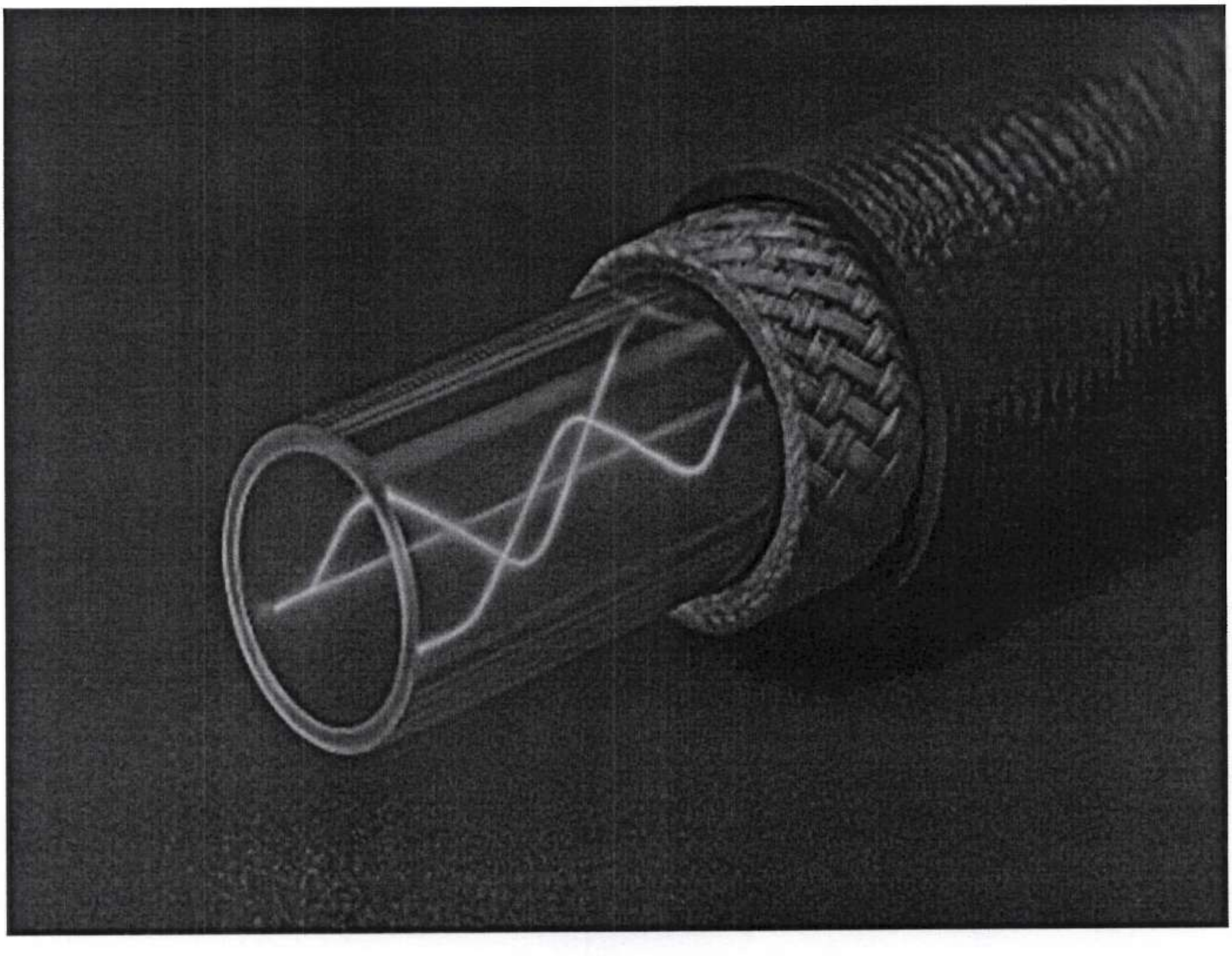
R.C.Patel College Of Engineering & Polytechnic, Shirpur

Department of Applied Sciences and Humanities

Course Title- Basic Science
Department Name – Applied Sciences
Course Code - 311305
Semester- First

Subject Teacher: Prof Praful. C. Mundake

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
3	Thermometry and Optical Fibre	CO3	10	02	04	06	12



Unit – 03

Thermometry & Fiber Optics.

(12 M, 10 Hr)

- Heat, Temperature, temperature Scales.
- Modes of transfer of heat, Good & bad conductors of heat, law of thermal conductivity.
- Boyles law, Charle's law, Gay Lussac's law, perfect gas equations.
- Specific heat of gas at const pressure & const volume (C_p & C_v), ratio of specific heats
- Reflections, Refractions, law of refraction, T.I.R. (Total internal reflections.)
- optical fiber – Principle, Construction & path of light through optical fiber, Applications of optical fibers.

* Introduction :-

- Heat is one form of energy.
- Heat energy possessed by a body due to the kinetic energy of ~~diff~~ its molecules.
- Heat energy flows from a body at higher temperature to a body at lower

temperature.

- Heat is an extensive property.

Sources of heat

i) Sun ii) Electrical heaters iii) fuels.
iv) Gases etc.

* Defination of Heat :→

Heat is a form of energy possessed by a body due to the kinetic energy of its molecule.

or

The energy transfered from one body to another due to temp difference between them is called heat

or

Heat is the form of energy which produces sensation of hotness or warmness.

Units of Heat :→

S.I unit → Joule (J)
C.G.S. unit → Calorie (Cal)
MKS. unit → Kilocalorie (kcal)

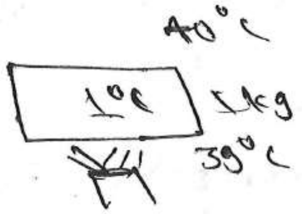
Dimension of heat - $[L^2 M^1 T^{-2}]$

Calorie :→

1 Cal = 4.186 J ≃ 4.2 J.

One Kilocalorie :→

The amount of heat energy required to increase the temperature of 1kg of water through 1°C is called as one Kilocalorie.



$1\ KCal = 4186\ J \approx 4200\ J.$

One Joule :→

The amount of heat energy required the increase the temperature of 1/4.186 gm of water through 1°C is called as one Joule.

Temperature :→

The degree of hotness or coldness of the body is known as its temperature.

This temperature is measured using thermometer.

S.I unit of temp. is °K (kelvin)

* Defference betⁿ Heat & temperature.

	Heat	Temperature.
(1)	Heat is froom of energy which prod−ucess sensetn of hotness or warmness.	Temperature is measure of degree of hotness or coldness of a body.
(2)	Heat is sum of energies of all molecules in the body or system.	temperature is measure of average K.E. of molecules of the body or system.
(3)	Heat flows from higher temperature to lower temperature	(3) Temperature is the condition that determines the direction of flow of heat.
(4)	It is an extensive property.	It is an intensive property.
(5)	It is the couse	Temperature is the effect
(6)	Heat is measured in calorimeter	Temperature is measured in thermometer.
(7)	S.I unit → Joule. Kilo calorie, calories are other units.	S.I unit → Kelvin K °C, °F are other units.

* Absolute Zero Temperature :-

The temperature at which pressure & volume of gas theoretically becomes zero. i.e. $-273°C$

$$\boxed{-273°C = 0°A = 0°K.}$$

* Temperature Scales :-

Thermometer is a device that measures temperature dependent properties of matter.

e.g. In a clinical thermometer, expansions of mercury is measured.

There are different temperature scales.

1. Celsius Scale (°c) of temperature.
2. Fahrenhiet Scale (°F) of temp.
3. Kelvin Scale (°K) of temp.

(1) Celsius Scale (°c) of temperature :-

The Celsius Scale is a temperature scale used to measured how hot or cold something. It is also called Centigrade Scale.

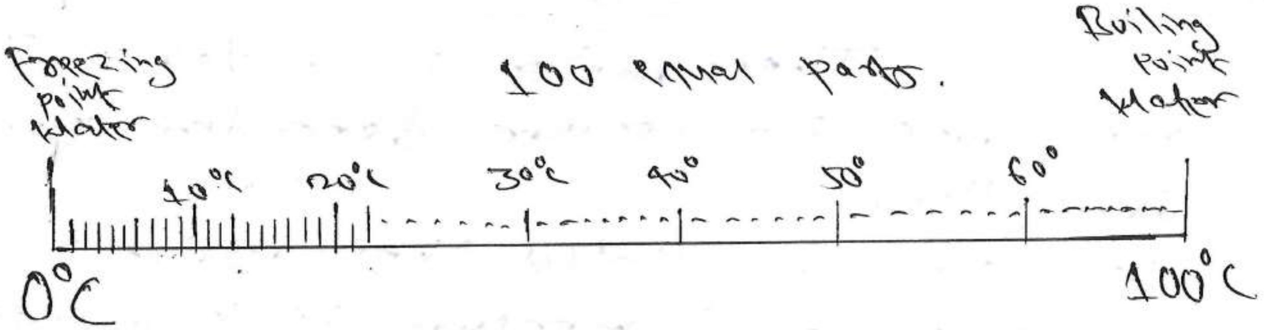
The scale is devided into 100 equal parts and each part is called 1 degree celsius (1°c)

Each division is called 1 degree celsius (1°C). It is commonly used in weather report, laboratories & household.

It is developed by Anders celsius. Symbol is °C.

Lower fixed point = 0°C

Upper fixed point = 100°C.



② Fahrenheit Scale (°F) of temperature:-

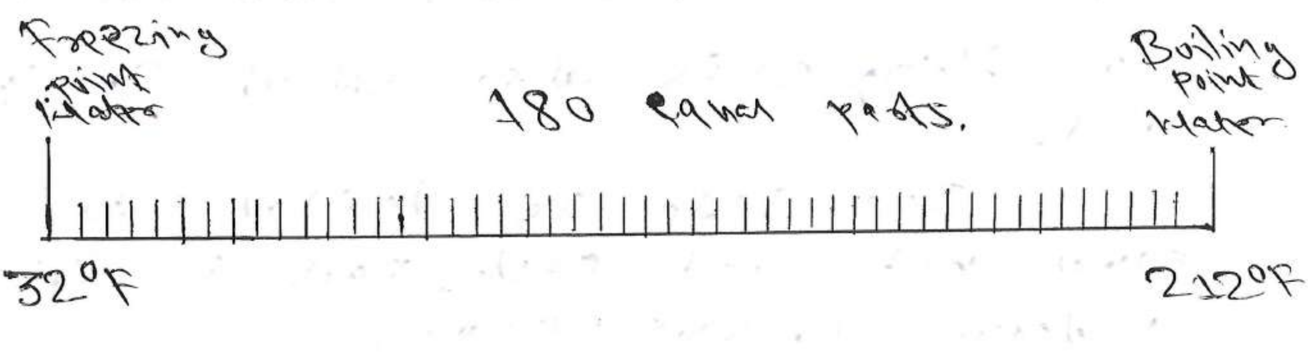
Fahrenheit Scale is a temperature measurment Scale mainly used in the United States & few other Countries.

It was developed by Daniel Gabriel fahrenheit. Symbol is °F

In this Scale lower fixed point = 32°F

Upper fixed point = 212°F

The Scale divided into 180 equal parts



Kelvin Scale (°K) of temperature:→

The Kelvin Scale is the S.I unit of temperature used in mainly Science & physics. It was developed by William Thomson.

Symbol → K (Kelvin)

Degree Symbol is not used in Kelvin Scale. ✓K ×°K

Kelvin Scale is Called the absolute temperature Scale

It Starts from absolute zero, the lowest possible temperature.

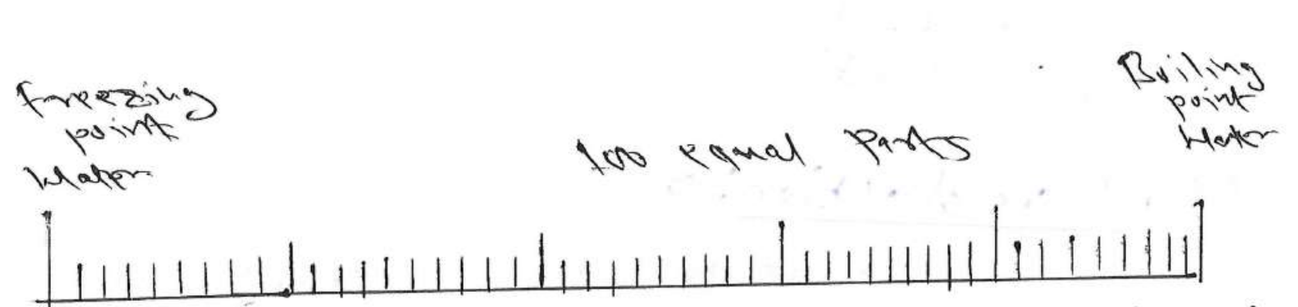
$$0K = -273°C.$$

In this scale

lower fixed point = 273°K

Upper fixed point = 373°K

The Scale is divided into 100 equal parts.



* Relation between °C °F & K.

$$\boxed{C = \frac{F-32}{1.8} = K-273}$$

3.2 Modes of transmission of heat Conduction, Convection, Radiation Application in daily life:→

The transmission of heat takes place from region of higher temperature to a region of lower temperature So we can conclude that transmission of heat is the process by which heat is transferred from a body at a higher temperature to the body at lower temperature.

Modes of transmission of heat is.....

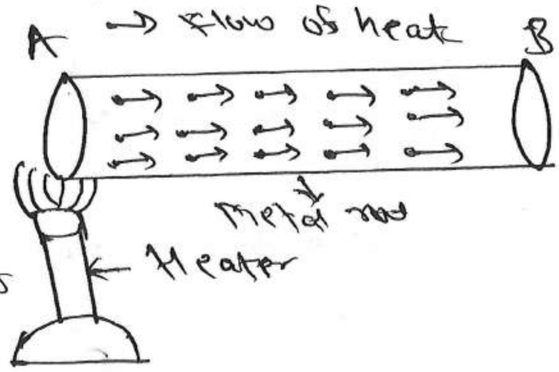
1. Conduction
2. Convection
3. Radiation.

1. Conduction:→

Conduction is mode of transfer of heat in which heat transfer from hot part of the body to its cold part without any actual motion of heated particles.

e.g. heating of metal rod.

Generally it takes place in solids

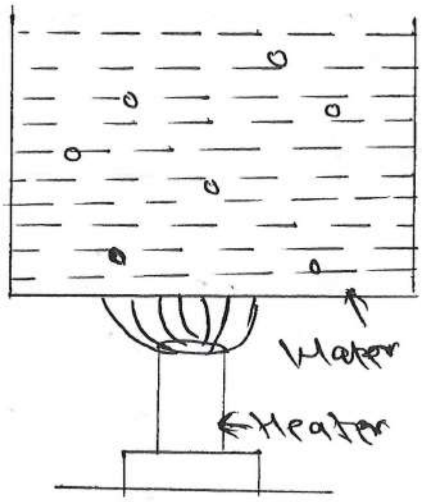


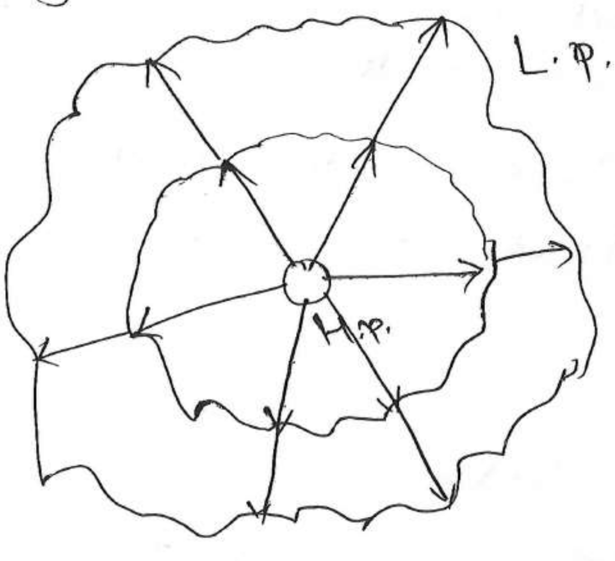
② Convection :→

It is defined as a process of transmission of heat from one part of the medium to another by bodily (actual) motion of the heated particles.

e.g. Boiling of water.

Generally it takes places in liquids & gases.

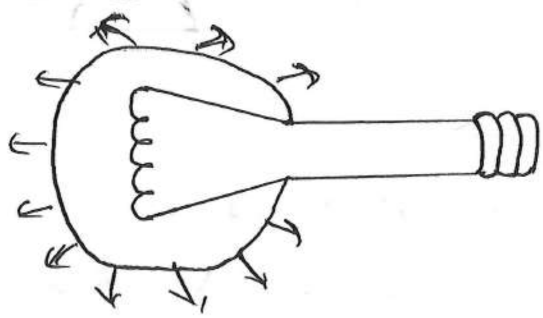




③ Radiation :→

The radiation is the process by which heat is transmitted from one body to another without necessity of material medium.

e.g. Heating radiation from sun or electric bulb.



Radiation is the process of transfer of heat in the form of electromagnetic waves from one place to another.

* Variable State :-> Defn

The State in which temperature of the (body) rod goes on increasing is called as variable state.

In variable state, Heat absorbed by material > Heat given out by material.

* Steady State :-> Defn

The Steady in which temperature of the rod remains constant & will not increase further is called Steady State.

Heat absorbed by material = Heat given out by material.

* Good & Bad Conductor of heat :→

① Good Conductor of heat :→

The substances which conduct heat easily are called good conductors of heat. e.g. Copper, Silver, aluminium, steel etc.

② Bad Conductors of heat :→

The substances which do not conduct heat easily are called bad conductor of heat or insulator of heat.

e.g. Glass, wood, air, thermocol, wool, paper etc.

* Difference between Good Conductor & Bad Conductors :→

Good Conductor	Bad Conductor.
① the material which conduct (pass) of heat easily are called good conductors.	The material which does not conduct (pass) of heat easily are called bad conductors.
② The thermal conductivity is very high.	The thermal conductivity is very low.
③ They stand at very high temperature.	③ They cannot stand at very high temperature.
④ Used in cooking utensils.	④ Used in handles of utensils & insulation.
⑤ e.g. Copper, Aluminium Iron, Silver, Gold etc.	⑤ e.g - Wood, plastic, rubber, Air, glass, wool etc.

* Applications of Conduction :→

A) Good Conductors :→

1) Good Conducting materials is used as a heat sink in electronic circuits

2) Condenser coil in refrigerator is ideally made up of Copper (good Conductor) for better Conduction.

3) Cooling of electrical machines by blowing hydrogen gas through machines cools speedily.

B) Bad Conductors :→

1) Ice box - A bad Conducting materials like thermocole is used in ice box because of which ice melts very slowly. (Fig ①)

2) Use of insulation in Refrigerator :→

The pipeline connection between expansion valve outlet & evaporator inlet is thermally insulated to avoid thermal loss.

3) Use of doubled walled flask or thermos flask :→

Flasks having double layers and air gap in between avoid thermal loss. Hence warm food or liquid inside the flasks remains warm for longer time. (fig ②)

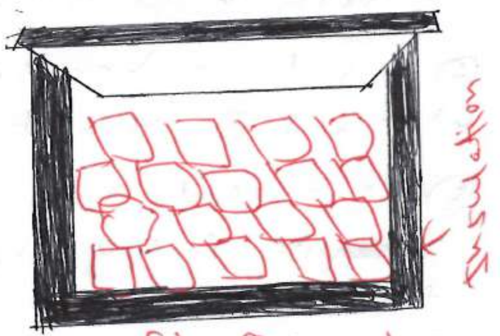


fig ① Ice box.

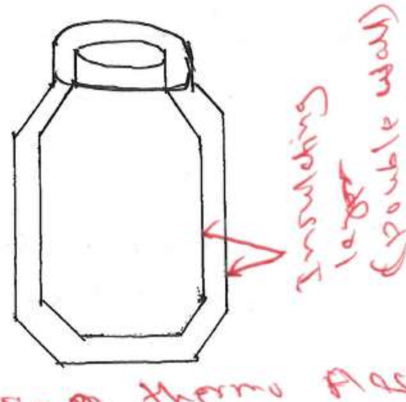


fig ② thermo flask

* Application of Convection:→

1) Room Ventilation:→

Ventilators are provided at high position in the room, warm air and Carbon dioxide go out through ventilators fresh & Cool air ~~come~~ Come in through doors & windows.

2) Formation of sea breeze and land breeze:→

It is happen near the seaside location, in the day time land surface gets heated more strongly than the sea water. Thus hot air at land surface goes up & forms low pressure region at land surfaces rushes towards the land surface & forms Sea breeze and air circulation take-place.

On the other hand, at ~~high~~ night the land surfaces cool more rapidly then the sea surfaces, thus wind blows to sea from land. which forms land breeze and air circulation take-place.

3) Gas filled Coiled electric lamps:→

Gas filled coiled electric lamps reduce convection current and increase life of the lamp.

* Applications of Radiations :→

1) White or light Coloured Cloths are preferred in Summer - becouse they are good reflector & poor absorber of heat, which keep our body cool. Coloured cloths are preferred in winter becouse they absorbs most of heat from Sun & which keep our body warm

2) Heat radiations in Cars, machines are painted black —
which radiates most of the heat & maintain cooling effect.

3) Aeroplanes & Ships are painted white → to maintain absorption of heat from Surronding.

④ The polished Surfaces of Space Craft reflect most of the heat radiation from Sun.

* Law of Thermal Conduction :→

Suppose 'AB' is bar of metal of cross - Section area 'A' as shown in figure.

Consider the bar to be in steady State no amount of heat is lost to be the surroundings by means of radiations.

Consider the bar to be in Steady State no amount of heat is lost to be the Surroundings by means of i.e. $Q \propto A(\theta_1-\theta_2)t$ — (I)

& inversely proportional to distance between two planes or thermometer

Thus $Q \propto \frac{1}{d}$ — (II)

∴ Combining equation I & II we get.

$$\therefore Q \propto \frac{A(\theta_1-\theta_2)t}{d}$$

$$\therefore Q = \frac{KA(\theta_1-\theta_2)t}{d}$$

K = Const of proportionality. Which is called Co-efficient of thermal conductivity 'K' depends on material of bar.

* Coefficient of thermal Conductivity :→ It is defined as amount of heat conducted in one second in steady state of temperature through unit cross-sectional area of an element of material of unit thickness with unit temperature different between it's apposite faces.

radiations.

Consider two planes ~~of~~ 'C & D' in the bar, Let

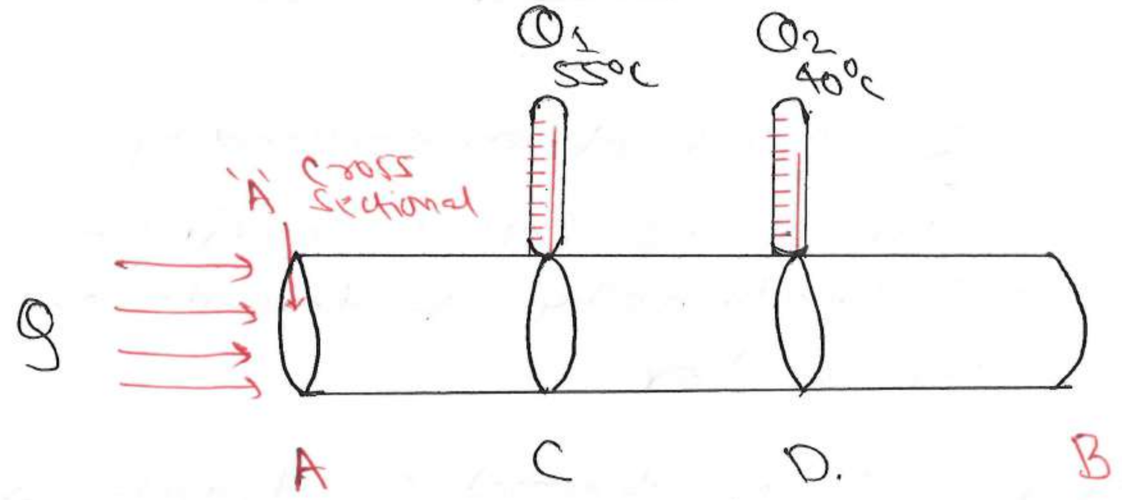
Q = amount of heat betn planes C to D $(C \to D)$

d = distance between C & D.

θ_1 = Temp of plane 'C'

θ_2 = Temp of plane 'D'.

$\theta_1 > \theta_2$



The amount of heat flowing (Q) from C to D at steady state is directly proportional to.

- Cross-Sectional Area 'A' of rod
- temp diff betn two planes $(\theta_1 - \theta_2)$
- Time 't' for which heat flows (t)

$$K = \frac{Q \cdot d}{A(\theta_1 - \theta_2)t}$$

$$K = \frac{Cal \times m}{m^2 \times {}^\circ C \times Sec} = \frac{Cal}{m^\circ C\ Sec}$$

Unit of $K = Cal / cm\ {}^\circ C \cdot Sec \rightarrow$ C.G.S.

$= KCal / m\ {}^\circ K\ Sec \rightarrow$ M.K.S.

$= Watt / m^\circ K \rightarrow$ S.I $\left(Watt = \frac{KCal}{Sec}\right)$

* Temperature Gradient :-

It is defined as change in temperature per unit length of rod.

Units are ${}^\circ C / cm$ - C.G.S.

${}^\circ K / m$ - S.I.

$\therefore$ Temperature Gradient $= \frac{(\theta_1 - \theta_2)}{d}$

Where $\theta_1 - \theta_2$ = Change in temp.

d = distance betn θ_1 & θ_2.

* Newton's law of Cooling :→

Statement :→

The rate of loss of heat of the body is directly proportional to the difference of temperature of body and the Surrounding provided the difference in temperature is Small.

Let $\frac{dT}{dt}$ = Rate of loss of heat of body.

T = temp of the body.

T_0 = Temperature of the Surrounding.

$(T - T_0)$ = temp diff betn the body & its Surrounding.

According to Statement,

$$\frac{dT}{dt} \propto (T - T_0)$$

$$\frac{dT}{dt} = \text{Const}\ (T - T_0)$$

$$\boxed{\therefore\ \frac{dT}{dt} = K\,(T - T_0)}$$

K = proportionality Const.

Or

Statement :→

The rate of fall of temperature of the body is directly proportional to the difference of temperature of the body and surroundings provided the difference in temperature is small.

* Gas Laws :→

Introduction:→

There are five states of matter solid, liquid, gas plasma & B.E Condensation.

When solids or liquid heated they are expands without change in pressure.

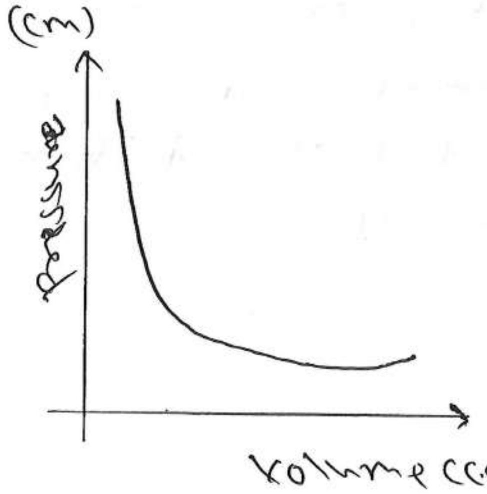
But when gas is heated there is change in pressure (P) volume (V) & temperature (T).

A gas molecule consists of large no of extremly small particles called molecules.

The gas molecules are rigid & perfectly elastic spheres. The intermolecular forces of attractions are ~~negibi~~ negligible as compared to solids & liquids they can move the random state with all possible directions & velocities.

• Boyle's Law, Charle's Law, Gay Lussac's Law & perfect Gas Equations:→

1) Boyle's Law:→



It state that at Const temperature (T). Volume of gas (V) inversely proportional to pressure (P).

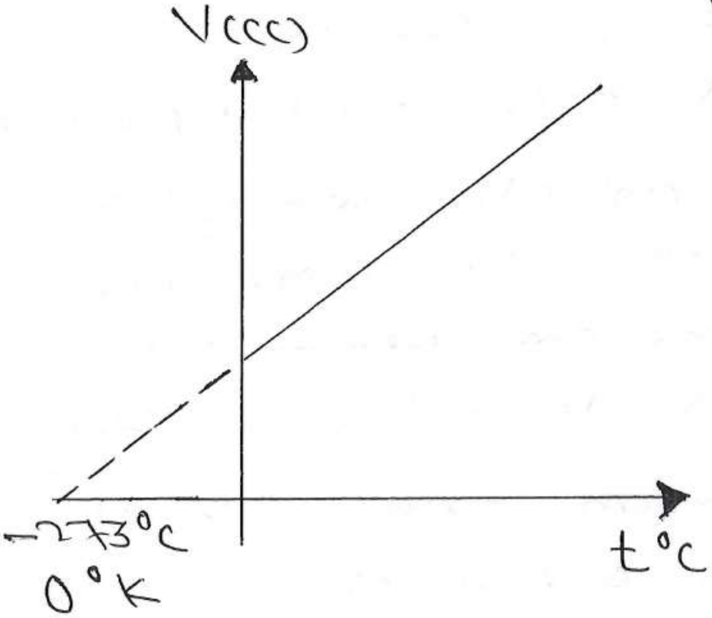
i.e. $V \propto \frac{1}{P}$ at Const (T)

$V = \frac{K}{P}$

$PV = K$ (K = Const)

Examples:→ ① Syringe ② Bicycle pump. ③ Breathing process. ④ Ballon squeezing. ⑤ Air Compressors. ⑥ Scuba Diving Cylinders ⑦ Aerosol spray Cans ⑧ Pnematic machine.

2) Charle's Law:→



It states that at Constant pressure (P) Volume of gas is directly proportional to its temperature (T)

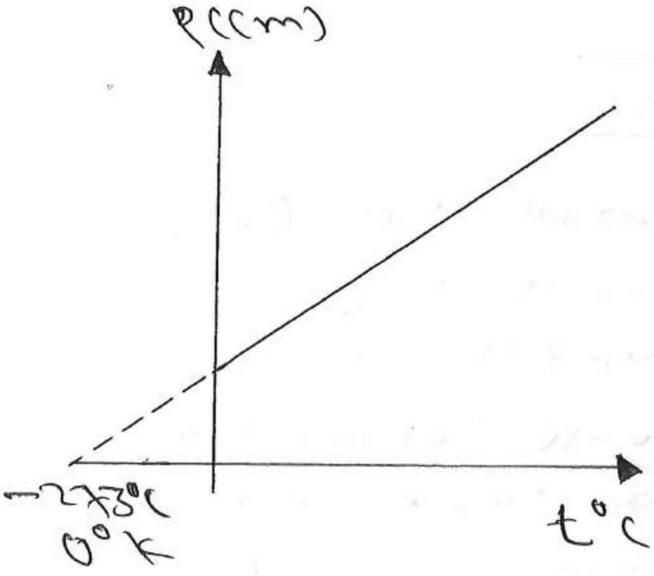
i.e $V \propto T$ at Const (P)

$V = K.T.$

$\frac{V}{T} = K$ Const.

Examples :→ ① Hot air Ballon ② Vehicle tire pressure ③ Ballon in summer & winter ④ LPG and Gas storage. ⑤ Hot air Engines & turbines ⑥ Plastic Bottle manufacturing.

3) Gay Lussac's Law :→



It states that at constant volume (V), pressure (P) is directly proportional to temp (T)

i.e. $P \propto T$

$P = K \cdot T.$

$\frac{P}{T} = K$ (const)

Examples :→ ① pressure Cooker ② Car tire in summer ③ Aerosol spray cans. ④ football or Basketball in sunlight ⑤ Steam boilers ⑥ Gas welding cylinders ⑦ Automobile Engine ⑧ Industrial Autoclaves.

* General Gas Equations or perfect Gas Equations :→

According to Boyle's law.

$V \propto \frac{1}{P}$ — (I)

According to Charle's law.

$V \propto T$ — (II)

Combining of Equation I & II we get

$$V \propto \frac{T}{P}$$

i.e. $PV \propto T$

$PV = \text{Const} \times T.$

$PV = RT$

$\boxed{\therefore PV = nRT}$

Where R = Universal gas Const
P = Pressure of gas.
V = Volume of gas.
T = Absolute temperature.
n = no of gas molecules

1) B.L. $V \propto \frac{1}{P}$ at Const T.
2) C.L. $V \propto T$ at Const P.
3) G.L.L. $P \propto T$ at Const V.

- Specific heat of gas at Const pressure & Volume (C_P & C_V), ratio of specific heats.

1) Specific heats of Substances :-

Specific heat of a Substances is defined as the quantity of heat energy required to increase the temperature of 1kg Substances by 1°C

$$Cp = \frac{q}{m(\theta_1 - \theta_2)} = \frac{J}{mole\,(K)}$$

S.I unit is J / mole K.
or $J \cdot mole^{-1} K^{-1}$

1) Specific heat of gas at Constant volume:→
It is defined as amount of heat required to increase the temperature of 1kg of mass of gas by 1°c at Const volume.

It S.I unit is J/kg°c

$$CV = \frac{q}{m(\theta_1 - \theta_2)}$$

2) Specific heat of gas at Const pressure:→
It is defined the amount of heat required to increase the temperature of 1kg mass of gas by 1°c at Const pressure.

S.I unit is J/kg°c.

$$Cp = \frac{q}{m(\theta_1 - \theta_2)}$$

Ratio of specific heat:→

$$\boxed{Cp - CV = \frac{R}{J}}$$

∴ R = universal gas Const
J = Joules Const.

* Important formulea :→

1) Temp Conversion $C = \frac{F-32}{1.8} = K - 273.$

2) $Q = \frac{KA(\theta_1 - \theta_2)t}{d}$ Kcal.

3) $K = \frac{Q \times d}{A(\theta_1 - \theta_2)t} = \frac{Kcal}{m^\circ K\, sec}$ or $\frac{Watt}{m^\circ K}$

4) Temperature Gradient $T.G. = \frac{(\theta_2 - \theta_1)}{d} = \frac{^\circ K}{m}$

• Examples :→

① Convert 80°c temp into °F.

We have $C = \frac{F-32}{1.8}$

$F = (1.8 \times C) + 32$

$F = (1.8 \times 80) + 32.$

$\boxed{80^\circ F = 176^\circ C.}$

H.W.
30°C ⇒ F = ? → 86°F

② Convert 50°c temp into °K.

We have

$C = K - 273.$

$C + 273 = K.$

$K = 50 + 273 = 323.$

$\boxed{50^\circ c = 323^\circ K}$

H.W.
35°C ⇒ K = ? K = 308K

③ Convert 186° F into °c.

We have

$$C = \frac{F-32}{1.8} = \frac{186-32}{1.8}$$

$$\boxed{186^\circ F = 85.55^\circ c}$$

H.W.

108.8 °F, °C = ? → 42.66°C.

④ Convert 350 °k into °c

We have

$$C = K - 273.$$

$$= 350 - 273$$

$$\boxed{350^\circ K = 77^\circ c}$$

H.W.

390 °K C = ? → 117°C.

⑤ Convert 500°K into °F

We have

$$\frac{F-32}{1.8} = K - 273$$

$$\therefore F = [(K-273) \times 1.8] + 32$$

$$F = [(500-273) \times 1.8] + 32$$

$$F = 440.6^\circ F$$

$$\boxed{\therefore 500^\circ K = 440.6^\circ F}$$

H.W. 350°K, °F = ? → 170.6°F

(6) Find the quantity of heat conducted in 6 minutes across a silver sheet of size 40 cm × 30 cm of thickness 3 mm, if two faces are at temperature of 40°c & 20°c. (K for silver = 0.1 kcal/m °c sec)

→ Given.

$t = 6\ min = 6 \times 60 = 360\ sec.$

$A = 40\ cm \times 30\ cm = 1200\ cm^2$

$= 1200 \times 10^{-4}\ m^2$

$= 0.12\ m^2$

$d = 3\ mm = 3 \times 10^{-3}\ m.$

$(\theta_1 - \theta_2) = 40 - 20 = 20°c$

to find $Q = ?$

$K = 0.1\ kcal/m°c\ sec.$

$\therefore Q = \dfrac{KA(\theta_1 - \theta_2)t}{d}$

$= \dfrac{(0.1 \times 0.12 \times 20 \times 360)}{(3 \times 10^{-3})}$

$\boxed{Q = 28{,}800\ kcal.}$

H.W. $t = 8\ min = 480\ sec.$ $d = 6\ mm = 6 \times 10^{-3}\ m.$

$A = 50\ cm \times 60\ cm = 3000\ cm^2 = 0.3\ m^2$

$\theta_1 - \theta_2 = 55 - 20 = 35°c$

$K = 0.1\ kcal/m°c\ sec.$

$Q = ?$

$\boxed{Q = 84000\ kcal}$

(7) A nickel plate of thickness 6mm has temperature difference of 40°c between its faces. It transmits 200 Kcal per hour through an area of 8 cm². Calculate the conductivity of nickel.

→ Given :- $d = 6mm = 6 \times 10^{-3} m$

$\theta_1 - \theta_2 = 40°c$

$Q = 200$ K cal

$t = 1 hr = 3600$ sec.

$A = 8 \; cm^2 = 8 \times 10^{-4} m^2$

$K = ?$

$$Q = \frac{K . A (\theta_1 - \theta_2) t}{d.}$$

$$\therefore K = \frac{Q \times d}{A (\theta_1 - \theta_2) t}$$

$$= \frac{(200 \times 6 \times 10^{-3})}{(8 \times 10^{-4} \times 40 \times 3600)}$$

$$\boxed{K = 0.104 \text{ Kcal/m°C Sec}}$$

(8) A Copper rod 19 cm long and area of cross - sectional 0.99 cm^2. which is thermally insulated is heated at one end to a temperature of 130°c. While other end kept at 50°c. Calculate the amount of heat which will flow in 8min along the rod. if (K = 480 W/m°K)

→ Given $d = 19$ cm $= 0.19$ m

$A = 0.99\ cm^2 = 0.99 \times 10^{-4}\ m^2$

$\theta_1 = 130°c \quad \theta_2 = 50°c$

$t = 8$ min $= 480$ sec.

$K = 480$ W/m°K.

to find $Q = ?$

$$Q = \frac{K \cdot A\,(\theta_1 - \theta_2)t}{d}$$

$$= \frac{(480 \times 0.99 \times 10^{-4} \times (130-50) \times 480)}{(0.19)}$$

$$\boxed{Q = 9604.042\ J.}$$

(9) A metal rod of length 0.30m has one of its ends at 40°c, while the other is at 80°c. find temperature gradient.

→ Given $d = 0.3$ m

$\theta_1 = 40°c \quad \theta_2 = 80°c$

to find T.G = ?

We have.

$$T.G = \frac{(\theta_2 - \theta_1)}{d} = \frac{80-40}{0.3}$$

$$\boxed{T.G = 133.33\ {}^\circ c/m.}$$

H.W. $\theta_2 - \theta_1 = 120^\circ c$ $d = 10\,cm.$

$T.G = ?$ $\rightarrow 1200\,{}^\circ c/m.$

(10) Find the quantity of heat Conducted in 5 min across a silver sheet of size 40 cm × 30 cm of thickness 3 mm. If its two faces are at temperatures of 40°c & 25°c ($K = 0.1$ KCal/m°c sec.)

→ Given $t = 5\,min = 300\,sec$

$A = 40\,cm \times 30\,cm = 1200\,cm^2$
$= 0.12\,m^2$

$d = 3\,mm = 3\times 10^{-3}\,m.$

$\theta_1 - \theta_2 = 40 - 25 = 15^\circ c$

$$Q = \frac{K.A(\theta_1 - \theta_2)t}{d}$$

$$= \frac{(0.1 \times 0.12 \times 15 \times 300)}{(3\times 10^{-3})}$$

$$\boxed{Q = 18000\ KCal}$$

Gas law:→

Important formulas:→

① $P_1V_1 = P_2V_2$ → Boyles law

② $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ → Charle's law

③ $\frac{P_1}{P_2} = \frac{T_1}{T_2}$ → Gay Lussac's law.

④ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ → General Gas Eqn.

⑤ $C_p - C_v = R$ S.I unit $J/kg\,°K$.

Examples:→

① A flask containing dry air is corked upto at 37°C, the pressure is 75cm of Hg. The cork blows up when the pressure becomes 100 cm of mercury. Find the temperature at which cork blows up.

→ Given - $P_1 = 75$ cm of Hg
$t_1 = 37°C$
$T_1 = (273+37)°K$
$= 310°K$

Find
$P_2 = 100$ cm of Hg
$t_2 = ?$
$T_2 = ?$

Here volume of gas is const.

∴ We can use Gay lussac's law.

$\frac{P_1}{P_2} = \frac{T_1}{T_2}$ ∴ $T_2 = \frac{T_1 \times P_2}{P_1}$

$$= \frac{(310 \times 100)}{(75)}$$

$T_2 = 413.33^\circ k.$

$t_2 = 413.33 - 273$

$$\boxed{t_2 = 140.33^\circ C}$$

H.W. $P_1 = 80$ cm $\quad P_2 = 108$ cm

$t_1 = 45^\circ C \quad t_2 = ?\ 60.75^\circ c$

$T_1 = 318^\circ k \quad T_2 = ?^\circ k$

(2) Certain mass of gas occupies $30 cm^3$ at $27^\circ c$ & 780 mm of pressure. Find its volume at $57^\circ c$ & 690 mm of pressure.

→ Given

$P_1 = 780$ mm $\quad P_2 = 690$ mm

$V_1 = 30 cm^3 \quad V_2 = ?$

$t_1 = 27^\circ c \quad t_2 = 57^\circ c$

$T_1 = (27 + 273) \quad T_2 = 330^\circ k$

$T_1 = 300^\circ k$

We have

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2}$$

$$V_2 = \frac{780 \times 30}{300} \times \frac{330}{690}$$

$$\boxed{V_2 = 37.3 \ cm^3}$$

(2) Certain mass of gas occupies 30 cm^3 at 27°c & 780 mm of pressure. Find its volume at 57°c & 690mm of pressure.

→ Given

$P_1 = 780$ mm $\qquad P_2 = 690$ mm

$V_1 = 30\ cm^3 \qquad V_2 = ?$

$t_1 = 27°c \qquad t_2 = 57°c$

$T_1 = (27+273) \qquad T_2 = 330°k$

$T_1 = 300°k$

We have

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$$

$$\therefore V_2 = \frac{780 \times 30}{300} \times \left(\frac{330}{690}\right)$$

$$\boxed{V_2 = 37.3\ cm^3}$$

(3) A gas at 17°c & pressure of 60 cm of mercury has volume 2 lit. Find its volume at 27°c & pressure of 70 cm of Hg.

→ Given

$P_1 = 60$ cm $\qquad P_2 = 70$ cm

$V_1 = 2$ lit. $\qquad V_2 = ?$

$t_1 = 17°c \qquad t_2 = 27°c$

$T_1 = 17+273 = 290°k \qquad T_2 = 27+273 = 300°k$

$$\therefore \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2}$$

$$\therefore V_2 = \frac{60 \times 2}{290} \times \frac{(300)}{(70)}$$

$$\boxed{V_2 = 1.77 \text{ lit.}}$$

(4) For hydrogen the difference between the principal specific heats Cp & Cv is 4000 J/kg°K If the ratio of specific heats is 1.4 Calculate Cp & Cv.

→ Given $C_p - C_v = 4000$ J/kg°K — (I)

$$\frac{C_p}{C_v} = 1.4 \quad \text{— (II)}$$

from eqn (II) $C_p = 1.4 C_v$.

putting in eqn (I)

$$1.4\, C_v - C_v = 4000.$$

$$C_v(1.4 - 1) = 4000$$

$$C_v = \left(\frac{4000}{0.4}\right) = 10{,}000.$$

$$\boxed{C_v = 10{,}000 \text{ J/kg°K}}$$

Putting in eqn (II)

$$C_p = 1.4 \times 10{,}000$$

$$\boxed{C_p = 14{,}000 \text{ J/kg°K.}}$$

Fiber Optics.

* Introduction :->

- Light is form of energy. Energy can be transfered into two ways. In one way the particles of medium move with finite speed while in other the energy is propagated in the form of waves.

- In homogeneous medium light travels in straight line from a source in a medium appears to be different colour in another medium
- Light passed through a particular sheet of material 'dissappears' when another similler sheet is kept in a crossed position.
- These observations are due to light showing wave nature & specially transverse nature resp.

- Light travels with speed of 3×10^{8} m/sec in vaccum. In order to explain how light is propogated, various theories were put forward by different scientist like Newton's, Huygen's, Maxwell etc.

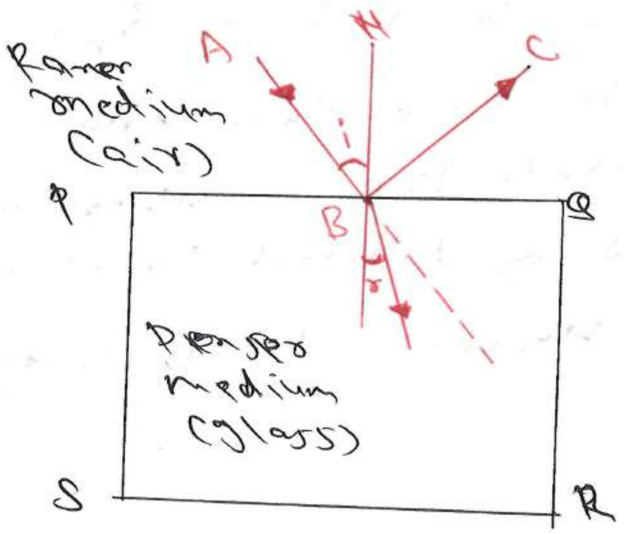
• Natural phenomenon called mirage happen in a hot summer day due to T.I.R. (Total Internal Reflection)

• Reflection, Refraction, Laws of refraction, T.I.R.

*Reflection :→

When light reaches any reflecting media, then it bounces (rebounds) back in the same media. Consider light ray PQ travelling in a part of incident light is reflected in the first medium, while the major part passes into the second medium.

It is observed that in the second medium the ray of light is deviated from its original path and bends towards the normal as shown in figure. This bending of light is known as refraction.



PQRS = medium
$\angle i$ = Angle of incidence
$\angle r$ = Angle of refraction
BN = Normal.

The bent ray in the Second medium is Called refracted ray. The refracted ray bends towards or away from the normal depending upon whether the Second medium is denser or rarer than first. It has been found that the Second medium the velocity of light also changes.

* Snell's Law:→

For any two media the ratio of the Sine of the angle of incidence to the Sine of the angle of refraction is Const for light beam of particular wavelength.

i.e. $$\frac{\sin i}{\sin r} = \text{Constant}$$

$$\frac{\sin i}{\sin r} = \mu.$$

$\therefore$ μ = Refractive index.

If light travells from medium 1 to medium 2.

$$\boxed{\frac{\sin i}{\sin r} = {}_1\mu_2}$$

* Defination Refractive Index :->

Refractive index of any medium is defined as the ratio of velocity of light in vacuum to velocity of light in the medium

It is dimensionless quantity so it has no unit.

$\mu \rightarrow$ has no unit
$\downarrow$
Symbol of refractive Index.

Refractive index of medium depends on i) Nature of two media in contact.
ii) Temperature of media.
iii) Wavelength of light.

Refractive index of two media & wavelength of light in these media are related as.

$$\lambda_1 \mu_1 = \lambda_2 \mu_2$$

* Total Internal Reflection (T.I.R) :->

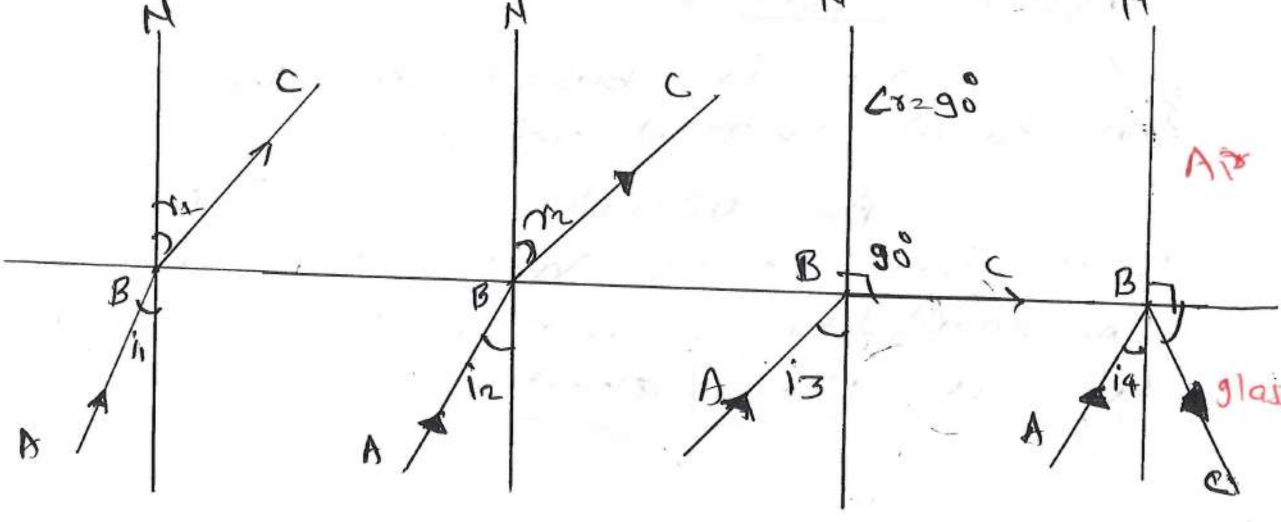
It is the phenomenon in which a ray travelling from denser medium to a rarer medium is reflected into denser medium if angle of incidence is more than the critical angle of medium.

① When light passes from denser medium to rarer medium, then the reflected ray bends away from the normal.

② Consider a ray 'AB' incident at $\angle i_1$ and refracted at $\angle r_1$ as angle of incidence increases, angle of refraction also increases.

③ For a particular value of $\angle i$ the refracted ray travels along the surface of separation between the two media i.e. $\angle r$ becomes 90° then the angle of incidence is called as critical angle (θ_c).

④ For the angle of incidence greater than critical angle ($\angle i > \theta_c$) then the ray can not pass into second medium but completely gets reflected into the same medium.



- Conditions for T.I.R :→

1) The light should incident from denser medium to rarer medium.

2) The total internal reflection occurs when an angle of incidence ($\angle i$) in denser medium is greater than critical angle (θ_c).

Critical Angle :→

The angle of incidence in denser medium for, which the angle of refraction is 90° is called critical angle.

$$\theta_c = \sin^{-1}\left[\frac{\mu_2}{\mu_1}\right]$$

- Optical Fiber :→ Principal, Construction & Path of light through optical fiber, Application of optical fibers.

Optical fiber :→

It is based on the principle of total internal reflection.

An optical fiber like a wire but it is very thin as compared to a wire and it is made up of glass/quartz.

An optical fiber Cable Consists a group of optical fibers packed together.

It is Consist of different parts i.e. Core, cladding primary Coating and Secondary Coating etc. for protection of the ~~electrical~~ optical fibers.

* **Structure of optical fiber :-**

Optical fiber has three regions as follows.

① **Core :-**

It is the innermost region. It guides the light wave. Refractive index of Core is kept more than cladding to achieve T.I.R. Diameter of Core is 5 μm to 600 μm.

② **Cladding :-**

Cladding keeps the light wave within the ~~core~~ Core. The cladding gives some strength to Core.

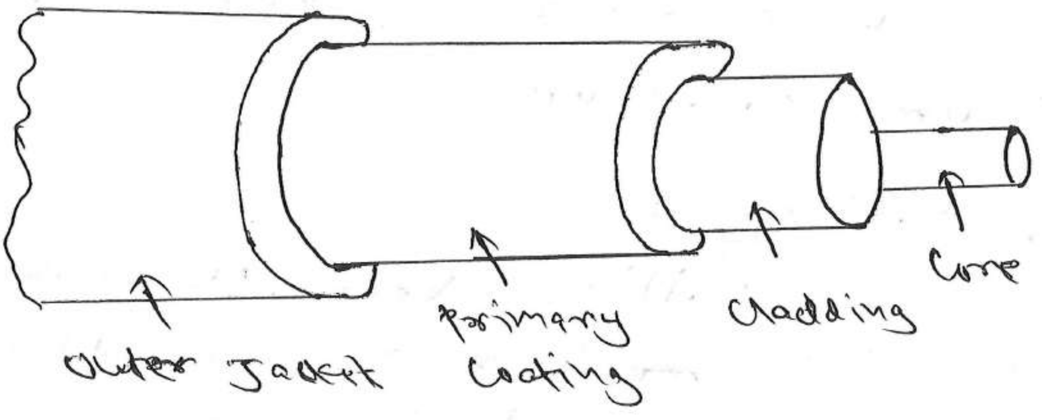
③ **Outer Jacket :-**

It is a protective Jacket called buffer Coating used to protect the fiber from moisture & Contaminamination.

It also gives strength to a fiber.

Practically optical fiber has three coaxial regions - Core, Cladding & outer jacket. The innermost region is called core. Core region guides the light wave.

Core is surrounded by a region called cladding, cladding makes the light confined with core. The outermost layer or outer jacket is called a sheath. It is a protective case of a fiber.



It protect the fiber from moisture & contaminations also it gives strength to the fiber. Refractive index of cladding is always lower than core.

$(\mu_{core} > \mu_{clad})$

fiber is almost parallel to the axis and having angle of incidence ϕ greater than the critical angle. The total internal reflection at the core-cladding interface confines. the light in the core & core acts as a guide to the light; hence the optical fiber is called as optical wave guide.

- Conditions Required for propagation of light through optical fiber :→

i) Light ray should travel from denser medium to rarer medium.

ii) Refractive index of core must be greater than cladding.

iii) When a light ray is incident on core & it strikes core-cladding interface, angle of incidence of the light ray must be greater than critical angle. Due to this reflections will occurs & light ray continuously rebounds and

iv) Collection of light ray depends on core size, acceptance angle & numerical aperture of fiber.

Optical fibers are Constructed as Single fiber or flexible bundle of Cables. A bundle Contains number of fibers in a Single jacket. Each fibers Carries light independent.

The fibers are Covered using Mylar tape & entire assambly fitted in aluminium Sheet. finally polythene Jacket is used to Cover the assambly

* Propagation of light wave through Optical Fiber :-

The ~~ref~~ refractive index of cladding n_2 is less than that of the Core. Hence the light launched into the Core and striking the core-cladding interface at an angle greater than the critical angle is reflected back into the core. The light continueous to rebound and propagated through the Core as Shown in fig. As the Core diameter is very Small ($\sim 10 \mu m$). The light entering the

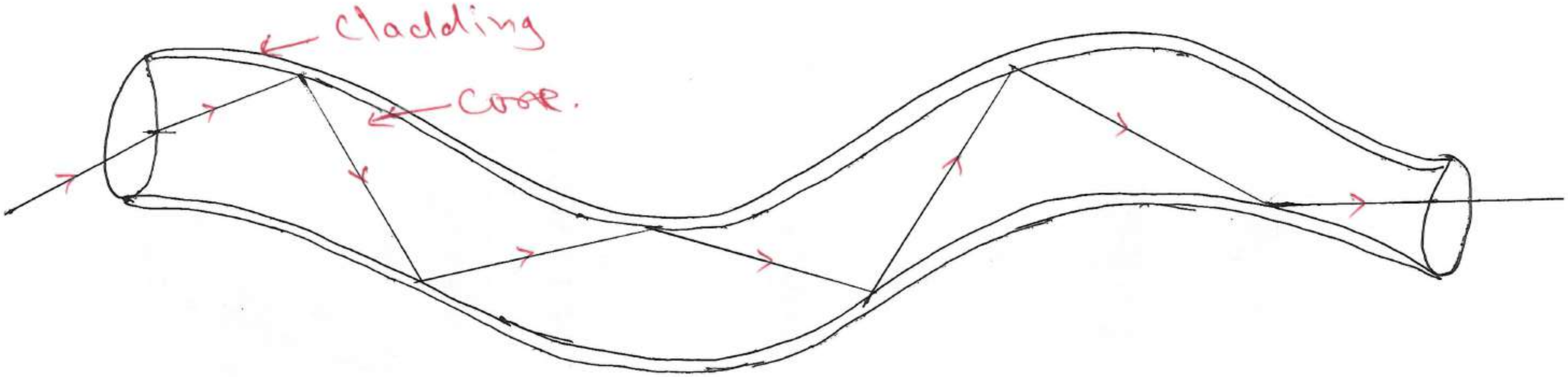


fig. Light wave through optical fiber

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Dhivare Priyal Kiran
ढिवरे प्रियल किरण
Plot No 28,
Dandavate Nagar,
VTC: Shirpur, PO: Shirpur,
Sub District: Shirpur, District: Dhule,
State: Maharashtra, PIN Code: 425405,
Mobile: 7588255394

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आपका आधार क्रमांक / Your Aadhaar No. :

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आधार

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ढिवरे प्रियल किरण
Dhivare Priyal Kiran
जन्म तिथि / DOB: 01/12/2010
महिला / Female

9264 9160 1978

मेरा आधार, मेरी पहचान

- Definations:→

1) Critical Angle (θ_c):→

The critical angle is defined as the angle of incidence at which the angle of refraction is 90^0.

$$\theta_c = \sin^{-1}\left(\frac{\mu_{clad}}{\mu_{core}}\right)$$

2) Angle of Acceptance ($\theta_{a max}$):→

The maximum value of external incidence angle for which light will propagates in the optical fiber is called acceptance angle.

Significance:→

(a) Determines the light-gathering ability of an optical fiber

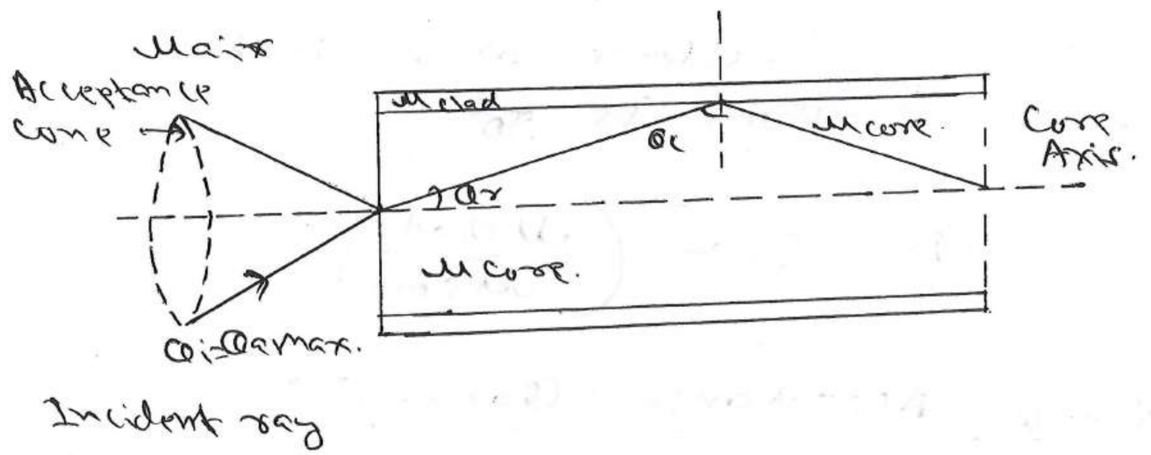
(b) Larger acceptance angle - easier coupling of light into the fiber.

(c) Smaller acceptance angle - more precise aligment required.

3) Acceptance Cone (θ_a):→

If θ_a is rotated around the core axis, then the cone formed which is called acceptance cone.

If light is allowed to fall withine this cone then it will propagates upto the far end.



4) Numerical Apperture :→ (NA) :→

Numerical aperture is defined as the Sine of maximum acceptance angle

i.e. $NA = \sin \theta_a \max$.

It measures the light gathering capacity of the optical fiber, greater the numerical aperture, greater is the amount of external light, the optical fiber will accept.

- Applications of optical fiber :→

Fiber optics cable has outstanding properties; they are lighter in weight, less bulky, flexible and carry large data with high speed. So it has many applications

① Optical fiber in Communications :→

Because of large bandwidth, it can handle number of channels. Hence found large applications in Communications.

② Internet :→

optical fiber Cables pass on huge amount of data that is too with very high speed. This technology is therefore usually used in internet Cables.

③ Telephones :→

Using optical fiber Communi-cations we Can Connect faster and have clear Conversations.

i) Computer Networking → Networking between Computers in a Same buildings is made easier and ~~faster~~ with the use of fiber optic Cables.

ii) Use for Signalling automation System.

iii) Used for industrial automation System.

iv) to observe internal organs of the body in medical field.

v) Use in defence for Confidential Communications.

vi) Used in Cable television.

vii) Used for transmission of digital data.

viii) Sensors :→ Optical fiber sensors are used to control liquid level, temperature, pressure etc. in automation system also used as phase modulated sensors, polarization modulated sensors.

ix) It is used in surgery, endosurgy.

x) It is used in lighting & decorations.

xi) It is used in security & alarm system

xii) Oil & Gas industry :→

Within the oil & gas industry, there are two main areas of use for optical fibers, firstly for sensing and secondly for communications.

Fiber optics sensors offer significant advantages over electrical sensors due to thier small size, ability to operate at high temperature, reduce risk for failure when exposed to ~~water~~ water

Prisms :→ Prisms are disigned to bend light by 90° or by 180° to make use of T.I.R. such prism are used to invert the images without changing thier size.

* Important formulea :→

1) $_a\mu_g = \frac{V_a}{V_g}$ $\quad$ $_g\mu_w = \frac{V_g}{V_w}$.

2) $\mu = \frac{\sin i}{\sin r}$.

3) $\theta_c = \sin^{-1}\left(\frac{\mu_{clad}}{\mu_{core}}\right)$

4) $NA = \mu_{air} \cdot \sin\theta_{a max}$..

$$NA = \sqrt{\mu^2_{core} - \mu^2_{clad}}.$$

5) Acceptance Angle.

$$\theta_{a max} = \sin^{-1}\sqrt{\mu^2_{core} - \mu^2_{clad}}.$$

$$\theta_{a max} = \sin^{-1}(NA).$$

Examples :→

1) Find the velocity of light in a glass whose refractive index is 1.5.

→ Given $\quad _a\mu_g = 1.5$

$V_a = 3\times10^8$ m/sec

$V_g = ?$.

We have.

$$_a\mu_g = \frac{V_a}{V_g} =$$

$$\therefore V_g = \frac{V_a}{_a\mu_g} = \frac{(3\times10^8)}{(1.5)}$$

$$\boxed{V_g = 2\times10^8\ m/sec.}$$

H.W. $_a\mu_g = 2.4$ $V_g = ?$

$\rightarrow 1.25\times10^8\ m/sec.$

2) Speed of light of diamond is $1.4\times10^8\ m/sec$ Calculate refractive index of diamond.

$\rightarrow$ Given $V_d = 1.4\times10^8\ m/sec.$

$V_a = 3\times10^8\ m/sec.$

$_a\mu_d = ?$

We have

$$_a\mu_d = \frac{V_a}{V_d} = \frac{(3\times10^8)}{(1.4\times10^8)}$$

$$\boxed{_a\mu_d = 2.1}$$

3) How long will light take in travelling a distance 600m in water? R.I of water is 4/3 & velocity of light in vaccum is $3\times10^8\ m/sec.$

$\rightarrow$ Given: dist = 600m.

$_a\mu_w = 4/3$

$V_a = 3\times10^8\ m/sec$

$$\therefore\ _a\mu_w = \frac{V_a}{V_w}$$

$$\therefore\ V_w = \frac{V_a}{_a\mu_w} = \frac{(3\times10^8)}{(4/3)}$$

$$= \frac{(9\times10^{8})}{(4)}$$

$$\boxed{V_w = 2.25\times10^{8} \text{ m/sec}}$$

$\therefore V_w = \frac{\text{Distance Covered in water}}{\text{Time}}$

$$= \frac{600}{2.25\times10^{8}}$$

$$\boxed{t = 2.66\times10^{-6} \text{ sec}}$$

4) For silicate glass optical fiber, calculate the critical angle, if refractive index of core is 1.58 & refractive index of cladding is 1.40.

→ Given :→ $\mu_{core} = 1.58$.

$\mu_{clad} = 1.40$.

$\theta_c = ?$.

We have

$$\theta_c = \sin^{-1}\left(\frac{\mu_{clad}}{\mu_{core}}\right)$$

$$= \sin^{-1}\left(\frac{1.40}{1.58}\right)$$

$$\boxed{\theta_c = 62.38^{\circ}}$$

5) Calculate numerical aperture of an optical fiber having refractive index of core as 1.8 & refractive index of cladding as 1.4.

→ Given $NA = ?$

$\mu_{core} = 1.8$

$\mu_{clad} = 1.4$

We have

$$NA = \sqrt{(\mu^2_{core} - \mu^2_{clad})}$$

$$= \sqrt{(1.8^2 - 1.4^2)}$$

$$= \sqrt{1.28}$$

$$\boxed{\therefore NA = 1.13}$$

6) Calculate acceptance angle required in an optical fiber having numerical aperture as 0.85.

→ Given $\theta_a = ?$

$NA = 0.85$

We have $\theta_a = \sin^{-1}(NA)$

$$= \sin^{-1}(0.85)$$

$$\boxed{\theta_a = 58.21^\circ}$$

7) Numerical aperture of a fiber is 0.244 and refractive index of cladding is 1.58. Calculate refractive index of core and acceptance angle.

→ Given:

$$NA = 0.244$$

$$\mu_{clad} = 1.58$$

to find $\mu_{core} = ?$

$$\theta_a = ?$$

We have

$$NA = \sqrt{\mu^2_{core} - \mu^2_{clad}}$$

$$0.244 = \sqrt{\mu^2_{core} - (1.58)^2}$$

Squaring on both sides

$$(0.244)^2 = \mu^2_{core} - (1.58)^2$$

$$\mu^2_{core} = (0.244)^2 + (1.58)^2$$

$$= (2.55)^2$$

$$\mu_{core} = \sqrt{2.55}$$

$$\boxed{\therefore \mu_{core} = 1.59}$$

$$\theta_a = \sin^{-1}(NA)$$

$$\sin^{-1}(0.244)$$

$$\boxed{\theta_a = 14.12^\circ}$$

Assignment No-03
Question Bank.

Q.1. Define following terms.
a) Heat b) Calorie c) Kilo Calorie.
d) Joule. e) temperature f) Absolute zero temperature, State thier units.

Q.2. a) Difference between Heat & temprature
b) Good conductors and bad conductors,
c) Difference between Conduction, Convection & radiations.

Q.3. State the modes of transmission of heat with examples.

Q.4. ⓐ State the applications of Conduction in daily life.
ⓑ State the applications of Convection in daily life.
ⓒ State the applications of radiations in daily life.

Q.5. State the law of thermal Conductivity with its mathematical equation

Q.6. State i) Boyle's Law ii) Charle's law.
iii) Gay lussac's Law.

Q.7. Define the terms.
ⓐ Variable state ⓑ Steady state temp.
ⓒ temperature gradient ⓓ Coefficient of thermal Conductivity.

(8) State Newton's law of cooling with equations.

Q.9 (a) State the properties of light (any four)

(b) State law of refraction of light.

(c) State Snell's law of refraction.

(d) State conditions for total internal reflection (T.I.R.)

Q.10. State principle, construction & working of an optical fiber.

Q.11. Define following terms:

(a) Numerical aperture (NA)

(b) Acceptance angle (θ_a)

(c) Acceptance cone.

(d) Critical Angle. (θ_c).

Q.12. (a) Convert temperature $80^\circ C$ into $^\circ F$.

(b) Convert temperature $186^\circ F$ into $^\circ C$

(c) Convert $500^\circ K$ into $^\circ F$.

(d) Convert $50^\circ C$ temp into $^\circ K$.

Q.13 Find the quantity of heat conducted in 8 minutes across a silver sheet of size $50\,cm \times 60\,cm$ of thickness $6\,mm$. If temperature difference between its faces are kept at $55^\circ C$ & $20^\circ C$. (K for silver $= 0.1\,kcal/m^\circ C\,sec$)

Q.14. A flask containing dry air is corked upto at 37°C, the pressure is 75 cm of Hg. The cork blows up when the pressure becomes 100 cm of mercury. Find temperature at which cork blowsup.

OR

A gas at 17°C & pressure of 60 cm of mercury has volume 2 lit. Find its volume at 27°C & pressure of 70 cm of Hg.

Q.15. (a) Speed of light of diamond is 1.4×10^8 m/sec. Calculate refractive index of diamond.

(b) For silicate glass optical fiber, calculate the critical angle, if refractive index of core is 1.58 & refractive index of cladding is 1.40.

(c) Calculate acceptance angle required in an optical fiber having numerical aperture as 0.85.

——×——×——×—— Best of luck ——

[signature] 4/6/2026.

[signature] 03-06-2026 P. C. Mandake.

[signature] 3/6/26