764 - Sri Ranganathar Institute of Polytechnic College
1/104 A, Athipalayam, Thudiyalur to Kovilpalayam Road,
Coimbatore – 641110
Tamil Nadu
Phone No: (0422)2982999, 2983099
E-mail: sripoly@yahoo.co.in

CONTENT

SUBJECT CODE &SUBJECT: 40023, ENGINEERING PHYSICS-II

1. NOTES OF LESSON INDEX PAGE

2. NOTES OF LESSON (VEDIO LINK AND PPT LINK ATTACHED TO INDEX PAGE)

PREPARED BY :

All physics staffs

1. Mr. SENTHAMIL SELVAM A

2. Miss. KAVIYA GAYATHIRI R

3. Mrs.P.PARIMALAM

4. Mrs.D.BOWYA

NOTES OF LESSON – INDEX PAGE

YEAR:	FIRST YEAR	SEMESTER:	IInd SEMESTER
SUBJECT&SUBJECT CODE:	40023, ENGINEERING PHYSICS-II	SCHEME:	N SCHEME

UNIT: 1 HEAT

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1.	**1.1 TRANSFER OF HEAT** Concept of Heat and Temperature - Centigrade, Fahrenheit and Kelvin scales of Temperature measurement.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
2.	Conduction, convection and radiation - Definitions and explanations - Good and poor conductors- Examples.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
3.	Coefficient of thermal conductivity-Definition and SI unit	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
4.	Properties of thermal radiation.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
5.	**1.2 KINETIC THEORY OF GASES** Postulates –Mean square velocity and Root Mean Square(RMS)velocity of Molecules	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
6.	Definitions and expressions – Expression for the pressure of a gas on the basis of postulates of kinetic theory of gases	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	

7.	Relation between pressure and kinetic energy and Relation between pressure and absolute temperature of the gas	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
8.	Simple problems based on the expression for the pressure of a gas.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
9.	**SPECIFIC HEAT CAPACITY** Specific heat capacity of a substance (solids and liquids) – Definition – Specific heat capacity of a gas at constant volume	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
10.	Specific heat capacity of a gas at constant pressure Ratio of specific heat capacities	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
11.	Explanation for Cp is greater than Cv - Derivation of Mayer's relation - calculation of Universal gasconstant R from the gas equation PV= RT.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	
12.	Simple problems based on Mayer's Relation – Solved Problems	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	_	-	

UNIT: 2 THERMODYNAMICS, LIQUEFACTION OF GASES – AND NONCONVENTIONAL ENERGY

S.NO	**TOPIC**	**REFER TEXT BOOK NAME**	**VIDEO PRESENTATION**	PPT	**ANY OTHER**

1.	**THERMODYNAMICS** First law of thermodynamics – Statement-Isothermal and Adiabatic changes	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
2.	Explanation – Equations for isothermal and adiabatic changes (No derivation) Simple problems..based on equations $P_1V_1 = P_2V_2$ and $P_1V_1^{\gamma}=P_2V_2^{\gamma}$	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
3.	Second law of thermodynamics – Clausius statement and Kelvin's statement	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
4.	Working of Carnot's reversible engine with indicator diagram and its efficiency.		**Vedio Attached**	**-**	
5.	Application of heat and thermodynamics.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
6.	**LIQUEFACTION OF GASES** Critical temperature, critical pressure and critical volume - Definitions –Principle used in cascade process	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
7.	Cascade process of liquefaction of oxygen - Disadvantages of cascade process	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**-**	**-**	
8.	Joule Thomson effect – Temperature of inversion		**Vedio Attached**	**-**	
9.	Liquefaction of air by Linde's process		**Vedio Attached**	**-**	
10.	**NON – CONVENTIONAL ENERGY**	**E book,Fundamentals of Physics – Brijilal &**	**-**	**PPT Attached**	

	Introduction – Non-renewable and Renewable (Alternate) energy sources - Examples	**Subramaniyam,Non Coventional Energy Sources – G.D. Rai , Khanna Publishers**			
11.	Solar energy, wind energy	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Non Coventional Energy Sources – G.D. Rai , Khanna Publishers**	-	**PPT Attached**	
12.	Advantages and disadvantages of renewable energy.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Non Coventional Energy Sources – G.D. Rai , Khanna Publishers**	-	**PPT Attached**	

UNIT: 3 LIGHT AND REMOTE SENSING

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1.	**OPTICS** Refraction – Laws of refraction – Refractive index of a medium Definition – Spectrometer - Derivation of refractive index of glass prism using minimum deviation	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	-	**PPT Attached**	
2.	Experimental determination of refractive index using spectrometer	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	-	-	
3.	Introduction –Phenomenon of total internal reflection - Fiber optics –introduction – Optical	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**Vedio Attached**	-	

	fiber cable as a wave guide – advantages of OFC - Simple problems using the refractive index.				
4.	Application of total internal reflection	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	-	**-**	
5.	**LASER** LASER – Characteristics of LASER – principle of LASER , Spontaneous emission – Stimulated emission – population inversion	**E book,Fundamentals of Physics – Brijilal & Subramaniyam**	**Vedio Attached**	**PPT Attached**	
6.	Ruby laser- Construction and working, Uses of LASER.		**Vedio Attached**	**PPT Attached**	
7.	**REMOTE SENSING** Remote sensing – Introduction	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Text book of Remote sensing & Geographical Information System – M.Anji reddy BS Publications.**	-	-	
8.	Active and passive remote sensing , Explanation and examples	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Text book of Remote sensing & Geographical Information System – M.Anji reddy BS Publications.**	-	-	
9.	Components of remote sensing - Data acquisition, data analysis and reference data	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Text book of Remote sensing & Geographical Information System – M.Anji reddy BS**	-	-	

		Publications.			
10.	RADAR – principle and working with block Diagram.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Text book of Remote sensing & Geographical Information System – M.Anji reddy BS Publications.**	**Vedio Attached**	**PPT Attached**	

UNIT: 4 ELECTRICITY

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1.	**ELECTRICAL CIRCUITS** Ohm's law – Laws of resistances – Resistivity, Conductivity,Super conductivity and Meissner effect- Definitions	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	**Vedio Attached**	**PPT Attached**	
2.	Kirchhoff's current and voltage laws – Definitions, Condition for balancing the Wheatstone's bridge - Simple problems based on expression for resistivity.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	**PPT Attached**	
3.	Capacitance of a capacitor – Definition – ' farad '– Definition– expressions for effective capacitance when capacitors are connected in series and in parallel	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	**PPT Attached**	
4.	Simple problems based on expressions for e.c.e., effective capacitance	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals**	-	-	

	for series and parallel connections of capacitors.	**of Electricity – DN Vasudeva & S Chand & Co**			
5.	**4.2 EFFECTS OF CURRENT** Joule's law of heating – Experimental determination of specific heat capacity of a liquid using Joule's calorimeter	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	**Vedio Attached**	-	
6.	Faraday's laws on electrolysis – Electro chemical equivalent(e.c.e) of an element – Definition – Experimental determination of e.c.e. of copper	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	**Vedio Attached**	-	
7.	Simple problems based on expression for ece – application of heating effect of electric current.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	-	
8.	**MEASURING INSTRUMENTS** Expression for the force acting on a current carrying straight conductor placed in a uniform magnetic field – Fleming's Left Hand rule	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	-	
9.	Expression for the torque experienced by a rectangular current carrying coil placed inside a uniform magnetic field - Working of a moving coil galvanometer and its merits	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	**Vedio Attached**	-	
10.	Conversion of galvanometer into an Ammeter and	**E book,Fundamentals of Physics – Brijilal &**	-	-	

	Voltmeter	Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co			
11.	Simple problems based on conversion of galvanometer into ammeter and voltmeter	E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co	-	-	

UNIT: 5 ELECTRONICS

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1.	**SEMI CONDUCTORS** Semi conductors - Intrinsic semiconductors -Concept of holes - Doping – Extrinsic semiconductors	E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co	-	PPT Attached	
2.	Energy bands in solids – Energy band diagram of good conductors, insulators and semi conductors	E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co	-	PPT Attached	
3.	Concept of Fermi level - P type, N type semiconductors.	E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co	-	PPT Attached	
4.	P type and N type Semiconductors	E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co	Vedio Attached	PPT Attached	
5.	**DIODES AND TRANSISTORS**	E book,Fundamentals of	Vedio Attached	-	

	Rectification action of diode – Working of full wave rectifier using P N junction diodes	**Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**			
6.	PNP and NPN transistors	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	-	
7.	Three different configurations	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	-	
8.	Working of NPN transistor as an amplifier in common emitter configuration.		**Vedio Attached**	-	
9.	**DIGITAL ELECTRONICS** Digital electronics – Introduction – Logic levels – Basic logic gates: OR, AND ,NOT gates		**Vedio Attached**	-	
10.	Universal logic gates:NAND and NOR gates – Symbolic representation, Boolean expression and Truth table for all above logic gates		**Vedio Attached**	-	
11.	Integrated circuits– Levels of integration – SSI, MSI, LSI and VLSI - Advantages of ICs.Application of transistors,gates and IC's solved Problems.	**E book,Fundamentals of Physics – Brijilal & Subramaniyam,Fundamentals of Electricity – DN Vasudeva & S Chand & Co**	-	-	

Prepared by: SENTHAMILSELVAM A & KAAVYAGAYATHRI R	**Verified by:**
Submitted by IQAC on: 25.05.2021	**Checked and Approval by IQAC on:**

Sign of IQAC coordinator

UNIT-I

HEAT

TRANSFER OF HEAT

Introduction:

Heat:

- Heat is a form of energy. It is measured in 'joule' with symbol 'J'.
- We can realize the hotness or coldness of a body by our sense of touch. But there should be a method to determine the degree of hotness or coldness.
- Temperature is a measure of the relative degree of hotness or coldness of the body. Generally, we take the melting point of ice as lower fixed point and the boiling point of water (steam point) as upper fixed point.

To measure the temperature, different scales are in use:

1. Centigrade scale :

In this scale, the temperature is measured in 'degree Celsius' with symbol °C. In this scale, the lower fixed point is taken as 0 °C for ice point and the upper fixed point is taken a 100° C for steampoint.

2. Fahrenheit scale:

In this scale, the temperature is measured in 'degree Fahrenheit' with symbol °F. Here, the lower fixed point (ice point) is taken as 32 °F and the upper fixed point (steam point) is taken as 212 °F.

3. Absolute scale or Kelvin scale:

In this scale, the temperature is measured by the unit 'kelvin' with symbol 'K'. Usually, the temperatures are measured in centigrade scale in laboratories. To convert the temperature from centigrade scale to Kelvin scale, we have to add 273.15, because 0 K corresponds to -273.15 °C.

Ex: The room temperature = 32° C

= (32 + 273.15) K = 305.15 K

The relation between Celsius 'C', Kelvin 'K' and Fahrenheit 'F' is

$$\frac{C}{100} = \frac{F - 32}{180} = \frac{K - 273}{100}$$

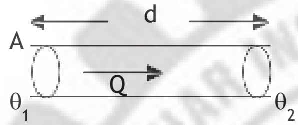
Heat Transfer:

- There are three methods of transfer of heat from one place to another.
- They are **Conduction, Convection and Radiation.**
- Conduction **takes place both in solids and fluids.**
- Convection **cannot occur in solids.**
- Radiation **does not require the presence of any medium**

- **<u>Conduction:-</u>**
  Transfer of heat from one point to the other through a body without the actual movement of Particles are called conduction.
  Example: when one end of the metal rod is heated
- **<u>Convention:-</u>**
  Transfer of heat from one point to the other through a body with the actual movement of particles is called Convention.
  Example: when water is heated in vessel
- **<u>Radiation:-</u>**
  Transfer of heat from one place to other without the help of material medium is called Radiation.
  Example: We get heat radiations directly from the sun.

<u>Coefficient of thermal conductivity:</u>

Let us consider a metallic rod of cross sectional area A. Let the two ends be separated by a distance d, maintained at temperatures θ_1 and θ_2. Let θ_1 be greater than θ_2. Heat flows from the end at the higher temperature to the end at the lower temperature.



When the steady state is reached, the quantity of heat Q conducted is

i) directly proportional to the area of cross section A

ii) directly proportional to the difference in temperature between the ends $(\theta_1 - \theta_2)$

iii) directly proportional to the time for which the heat is conducted (t)

iv) and inversely proportional to the distance between the two ends.

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

or

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

where λ is a constant known as the coefficient of thermal conductivity of the material and $(\theta_1 - \theta_2) / d$ is known as temperature gradient.

when $A = 1$, $\frac{(\theta_1 - \theta_2)}{d} = 1$ and $t = 1$, then $Q = \lambda$

Hence, Coefficient of thermal conductivity (λ) of the material of a conductor is defined as the quantity of heat conducted per second per unit area per unit temperature gradient at the steady state.
unit of λ :

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

or

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

Substituting the units,

$$\text{Unit of } \lambda = \frac{Jm}{m^2Ks}$$

$= Js^{-1}\ m^{-1}\ K^{-1} = Wm^{-1}\ K^{-1}$ (as Js^{-1} is W)

Good conductor :

They conduct more heat very easily is called good conductor

Example: copper, Aluminum, steel, silver, etc.,

Poor (bad) conductor:

They do not conduct heat easily. it is called poor conductor

Example: rubber, glass, wood, etc.,

Uses of thermal conductors(good and bad):-

1. Handles made of wood or ebonite is provided for cookers and hot water vessels.
2. Hot water bottles made of rubber are able to keep hot water at high temperature for a considerable period of time.
3. Use of double windows with a thin layer of air enclosed in between them keep the room warm in cold countries.
4. Wool, cork and ebonite are used for the purpose of heat insulation in refrigeration.
5. Woolen clothes are used in winter to keep the body warm.
6. Sawdust and jute sheet is used to cover ice to prevent it from melting.
7. Vessels made of copper, aluminum, etc., are used for cooking purpose as they easily conduct heat.
8. Copper is used in boilers and radiators, because of its good conductivity.

Good and poor thermal conductors:-

Substance	λ ($Wm^{-1}\ K^{-1}$)	Substance	λ ($Wm^{-1}\ K^{-1}$)
Silver	420	Water	0.6
Copper	390	Red brick	0.6
Aluminium	240	Rubber	0.5
Steel	14	Wood	0.04 to 0.1
Lead	35	Glass	0.8
Concrete	1.1	Ebonite	0.2

Applications of Convection.

1. The wind flow is due to the convection currents in the atmosphere. During day time, parts of earth get heated by the Sun. As the air expands, it rises up and its place is taken by the flow of air from colder areas.
2. The land breeze and sea breeze are due to the convection in the atmosphere. During day time, land mass is heated to a higher level than the sea. So, the warm air over the land rises giving place to the cool air flow from the ocean. This gives the sea breeze. During night time, the land mass cools quickly than the water in the sea. So, cool air flows from land mass towards sea which gives the land breeze.

Applications of Radiation.

1. White coloured dresses are used in hot countries to keep the inside cool.
2. In some countries, shining aluminium sheets are used to cover the roof of the house to reflect back the radiant heat and to keep the inside cool.
3. A cooking vessel is painted black at the bottom for greater absorption of heat, but polished at the top to minimize radiation losses.
4. In cold countries, hot air or water runs through the pipes along the walls inside a building and the radiant heat energy keeps the occupants warm by 'Central Heating'.

Properties of thermal radiation :

The nature of thermal radiation is similar to that of light. Following are some of the properties of thermal radiation.

1. Thermal radiation travels with the velocity of light, which is 3×10^8 ms^{-1}.
2. Thermal radiation obeys the same laws of reflection, refraction etc., as light.
3. Thermal radiation travels through vaccum.
4. It obeys the law of inverse square, as light.
5. It travels in straight lines.
6. When thermal radiation falls on any body, which can absorb it, then converted into ordinary heat, which raises its temperature.
7. It is absorbed by dark rough surfaces and reflected by light smooth surface.

HEAT CONVERSIONS

1. Celsius to Fahrenheit

$$^\circ F = \left(\frac{9}{5} \times {}^\circ C\right) + 32$$

2. Fahrenheit to Celsius

$$^\circ C = \left(\frac{5}{9}\right) \times ({}^\circ F - 32)$$

3. Celsius to Kelvin

$$K = {}^\circ C + 273$$

4. Kelvin to Celsius

$$^\circ C = K - 273$$

KINETIC THEORY OF GASES

- A gas consists of a large number of particles called molecules.
- The molecules are in the state of continuous motion.
- The pressure of a gas is due to the collision of individual molecules on the walls of the container.
- The behaviour of the gas can be explained on the basis of kinetic theory of gases. The kinetic theory of gases has found better applications to explain various properties of gases.
- This theory was developed by Clausius, Boltzmann and Maxwell

Postulates of Kinetic Theory of gases:-

1. A gas consists of large number of tiny, rigid particles called molecules.
2. The gas molecules are identical in all respects, like mass, size, etc.
3. The molecules are perfectly elastic spheres.
4. The molecules are in random motion and travel with all possible velocities in all possible directions.
5. The molecules collide with each other and also with the walls of the container.
6. Between two successive collisions, the molecules travel in the straight line.
7. The average distance between two successive collisions is called the mean free path.
8. The time of collision is negligible when compared to the time taken by the molecule to travel its mean free path.
9. The volume of the molecules is negligible when compared to the volume of the gas.
10. The force of attraction between the molecules is negligible.

Mean square velocity and Root Mean Square velocity (R.M.S. velocity) :-

Let C_1, C_2, C_3, C_4 be the velocities of 1st, 2nd, 3rd …..nth molecule present in the gas, then the mean square velocity is,

$$\overline{C^2} = \frac{C_1^2 + C_2^2 + C_3^2 + \dots\dots\dots + C_n^2}{n}$$

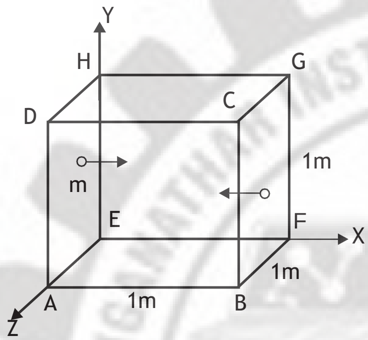
The mean square velocity is defined as the average of the square of velocities of all the molecules.

Now R.M.S. velocity is obtained by taking square root of the mean square velocity of the molecules.R.M.S velocity is

$$\sqrt{\overline{C^2}} = \sqrt{\frac{C_1^2 + C_2^2 + C_3^2 + \dots\dots\dots + C_n^2}{n}}$$

The R.M.S. velocity is defined as the square root of the average of squares of velocities of all molecules

Expression for the pressure of a gas:-



- **Consider a perfect gas inside a cubical vessel of side 1 meter.**
- **m- mass of molecule**
- **n-number of molecule**
- **momentum of molecule before collision= mv**
- **momentum of molecule after collision= -mv**
- **change in momentum =mv - (-mv) = mv+mv=2mv -------(1)**
- **v=$\frac{d}{t}$**
-
- **t=$\frac{d}{v}$== $\frac{1+1}{v} = \frac{2}{v}$ ---------------(2)**
- **Rate of change of momentum=$\frac{2mv}{\frac{2}{v}}$ ----------------------(3)**

<u>By Newton's II^nd law</u>

- **F=mv^2 ------------(4)**
- **On an avarge $\frac{n}{3}$ molecule move in x-direction**
- **F=$\frac{n}{3}mv^2$**
- **Pressure on the wall= $\frac{F}{A} = \frac{\frac{n}{3}mv^2}{1}$**
- **P=$\frac{n}{3}mv^2$ = $\frac{1}{3}nmv^2$ (substituting nm=ρ , $v^2 = c^2$)**

P=$\frac{1}{3}\rho c^2$-----------(5)

Drive the Relation between Pressure and kinetic Energy of a Gas:

P=$\frac{1}{3}\rho c^2$ $\quad (\rho = \frac{m}{V})$

P=$\frac{1}{3}\frac{m}{V}c^2$ **(V=1)**

P=$\frac{1}{3}mc^2$

Multiply and devide by 2

P=$\frac{2}{3}\times\frac{1}{2}mc^2$

P = $\frac{2}{3}\times kinetic\ energy$ $\quad$ **(KE=**$\frac{1}{2}mc^2$**)**

P = $\frac{2}{3}\times$ **KE**

Derive the relation between kinetic energy and absolute temperature:

P=$\frac{1}{3}\rho c^2$ $\quad (\rho = \frac{m}{V})$

P=$\frac{1}{3}\frac{m}{V}c^2$

Pv= $\frac{1}{3}mc^2$ **-------(1)**

Gas equation,

PV=RT ----------(2)

Substituting equation(1) in(2)

RT =$\frac{1}{3}mc^2$ **----------(2)**

Both side multiplying $\frac{1}{2}$

$$\frac{1}{2}RT = \frac{1}{2}\times\frac{1}{3}mc^2$$

$\frac{3}{2}RT = \frac{1}{2}mc^2$

--------(3)

Derive mean kinetic energy of the molecule of gas:

P=$\frac{1}{3}\rho c^2$ $\quad (\rho = \frac{M}{V})$

P=$\frac{1}{3}\frac{M}{V}c^2$

Pv= $\frac{1}{3}mc^2$ **-------(1)**

Gas equation,

PV=RT ----------(2)

Substituting equation(1) in(2)

RT =$\frac{1}{3}Mc^2$ **----------(2) (M=Nm)**

RT =$\frac{1}{3}$**N**mc^2

$mc^2 = 3\frac{R}{N}T$

Both side multiplying $\frac{1}{2}$

$$\frac{1}{2}mc^2 = \frac{3}{2}\frac{R}{N}T$$

mean kinetic energy $= \frac{3}{2}\frac{R}{N}T$

mean kinetic energy $= \frac{3}{2}KT$

$$\boxed{KE \alpha T}$$

Worked Problems:

1. Find the r.m.s. velocity of hydrogen molecule at S.T.P. if density of hydrogen is 0.0899 kgm^{-3} at S.T.P.

   Given: $\rho = 0.0899\ kgm^{-3}$; $P = h\rho g$

   Known: At S.T.P, P = 0.76m of Hg = $0.76 \times 13.6 \times 10^3 \times 9.8$

   $P = \frac{1}{3}\rho C^2$, R.M.S. Velocity, $C = \sqrt{3P/\rho}$

   R.M.S. Velocity, $C = \sqrt{\frac{3 \times 0.76 \times 13.6 \times 10^3 \times 9.8}{0.0899}} = 1.838 \times 10^3\ ms^{-1}$

2. The root mean square velocity of argon gas molecule at S.T.P. is $434 ms^{-1}$. Find the density of argon gas at S.T.P.

   Given: R.M.S. Velocity, $c = 434\ ms^{-1}$

   Known At S.T.P P = 0.76m of Hg

   $$P = \frac{1}{3}\rho C^2$$

   $$\rho = \frac{3 \times 0.76 \times 13.6 \times 10^3 \times 9.8}{434 \times 434}$$

   $= 1.6133 kgm^{-3}$

SPECIFIC HEAT CAPACITY

Specific heat capacity:

When a substance is heated, it gains heat and its temperature increases. The quantity of heat gained by different substances is specified in terms of the value known as specific heat capacity.

Specific heat of solid and liquid :

1. Specific heat capacity of solid:

It is the quantity of heat required to raise the temperature of one kilogram of solid through 1k is called specific heat at solid.

It is unit: $JKg^{-1}\ k^{-1}$

2.Specific heat capacity of Liquid:

It is the quantity of heat required to raise the temperature of one kilogram of Liquid through 1k is called specific heat at Liquid.

It is unit: $JKg^{-1}\ k^{-1}$

- **For example, the specific heat capacity of water is 4190 J kg^{-1} K^{-1}. It means, to increase the temperature of 1 kg of water through 1 K, 4190 J of heat energy is required.**
- **Similarly, the specific heat capacity of copper is 385 J kg^{-1} K^{-1}. It means, to increase the temperature of 1 kg of copper through 1 K, 385 J of heat energy is required.**

Specific heat capacities of a gas:

- **When a solid or liquid is heated, its temperature alone is increased, neglecting the little increase in its volume.**
- **But, when a gas is heated, its pressure and volume change in addition to its temperature.**
- **So, to study the effect of heating on a gas, we have to keep either the pressure or volume of the gas as constant.**
- **Accordingly, for each and every gas, there are two specific heat capacities.**

1. Specific heat capacity at constant pressure (C_p):

The specific heat capacity of a gas at constant pressure is the quantity of heat energy required to increase the temperature of one mole of the gas through 1K, when the pressure is kept constant.

2. Specific heat at constant volume (C_v):

The specific heat capacity of a gas at constant volume is the quantity of heat energy required to increase the temperature of one mole of the gas through 1K, when the volume is kept constant.

The unit for C_p and C_v is J K^{-1} mol^{-1}

Ratio of specific heat capacities (γ) :

For a gas, the ratio of the specific heat capacity at constant pressure to the specific heat capacity at constant volume is a constant. i.e.

$$\frac{c_p}{c_v} = \gamma,$$

$$c_p > c_v$$

Since C_p is always greater than C_v, the value of γ is always greater than one for any gas.

3. Ratio between C_p and C_v

The ratio of the specific heat capacity of gas at constant pressure to the specific heat capacity of gas at constant volume is a constant and is denoted by the letter (γ)

$$\text{Then, } \gamma = \frac{C_p}{C_v}$$

When a gas is heated at constant volume the heat supplied to the gas is wholly used to raise the temperature of the gas whereas when the gas is heated at constant pressure, a part is used to external work to keep the pressure constant.

For monoatomic gases γ = 5/3 for diatomic gases, γ = 7/5 and for triatomic gases γ = 4/3

Explanation for C_p greater than C_v :

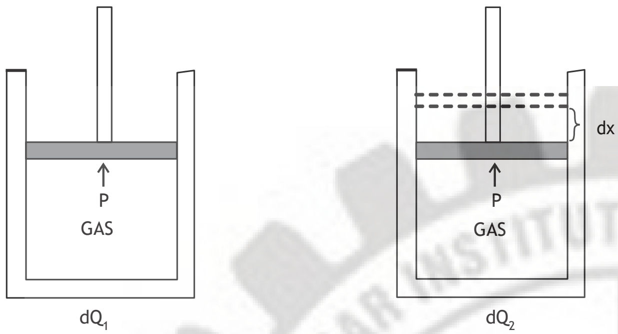
The Specific heat capacity of a gas at constant pressure (C_p) is the heat energy required to increase the temperature of 1 mole of a gas through 1K, at constant pressure.

The Specific heat capacity of a gas at constant volume (C_v) is the heat energy required to increase the temperature of 1 mole of a gas through 1K, at constant volume.

When a gas is heated, keeping the volume of the gas as constant, the entire heat energy supplied is used only to increase its internal energy i.e. temperature.

Mayer's relation $C_p - C_v = R$ (Relation between C_p and C_v)

- Consider 1 mole of a perfect gas inside a cylinder in which there is a tight piston moving without any friction.
- The internal energy of the gas is directly proportional to its absolute temperature.
- Let dQ_1 be the heat energy supplied to the gas at constant volume. Consequently, the temperature increases by dT.
- We know, quantity of heat supplied =mass × specific heat capacity × increase intemperature



- **Consider a 1 mole of gas in a cylinder with frictionless piston**

(i) At constant volume

$dQ_1 = C_V dT$ ------------(1)

(ii) At constant pressure

$dQ_2 = C_p\, dT$ -----------(2)

$dQ_2 = dQ_1 + W$----------(3)

pressure $(P) = \frac{F}{A}$

F=P X A

W=F x (dx)

W= P X (A x dx)

W= P dv------------------(4)

Substituting equation(1),(2)in (3)

$C_p\, dT = C_V dT + P\, dv$ --------------(5)

PV=RT

PdV=RdT ----------(6)

Substituting equation(6)in (5)

$C_p\, dT = C_V dT + RdT$

$C_p\, dT = (C_V + R)dT$

$C_p = C_V + R$

$C_p - C_V = R$

PROBLEMS

1.Calculate the value of universal gas constant R from the gas equation PV=RT.

PV=RT

$R=\frac{PV}{T}$

P= $h\rho g$ **=** $76\times10^{-2}\times13.6\times10^{3}\times9.8$

$V=22.4\times10^{-3}\ m^3$

T=273k

$R=\frac{76\times10^{-2}\times13.6\times10^{3}\times9.8\times22.4\times10^{-3}}{273}$

$R=\frac{226895.8\times10^{-2}}{273}$

$R=8.314\times10^{-2}$

$R=8314\ Jk^{-1}Kg^{-1}\ mol^{-1}$

2. The ratio between two specific heat of a gas is 1.346. The specific heat capacity of the gas at constant volume is 23094 $Jk^{-1}Kg^{-1}\ mol^{-1}$**. Find the value of universal gas constant.**

$\frac{c_p}{c_v}=\gamma$

$c_p=c_v\gamma$

$\gamma=1.36$

$c_v=23094\ Jk^{-1}Kg^{-1}\ mol^{-1}.$

$c_p=23094\times1.36$

$c_p=31407.8\ Jk^{-1}Kg^{-1}\ mol^{-1}.$

$c_p-c_v=R$

3. The ratio of two specific heat of helium 1.667 and value of gas constant $8314\, Jk^{-1}Kg^{-1}\, mol^{-1}$. Calculate the specific heat capacity of constant pressure and volume.

R=8314 $Jk^{-1}Kg^{-1}\, mol^{-1}$

$\gamma = 1.667$

$\frac{c_p}{c_v} = \gamma$

$c_p = c_v\gamma$-----(1)

C_p - C_V =R-----(2)

Sub/.(1)in(2)

$c_v\gamma$- C_V =R

$c_{v(}\gamma - 1) = R$

$$c_v = \frac{R}{\gamma - 1}$$

$c_v = \frac{8314}{1.667-1} = \frac{8314}{0.667}$= 12464.76

C_p - C_V =R

C_p =R+ C_V

C_p =8314+ 12464.76

C_p =20778.76 $Jk^{-1}Kg^{-1}\, mol^{-1}$

R =31407.8 -23094

R=8311 $Jk^{-1}Kg^{-1}\, mol^{-1}$

4. A gas at 1.5 atmospheres occupies a volume of 2m^3 at 25^o C. What will be the volume of gas at 40^o C and at 3 atmospheres?

Gas equation, PV $= RT$ (or) $\frac{PV}{T} = R$

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

P_1 = 1.5 Atm.pre., T_1 = 25°C + 273 = 298K

P_2 = 3 Atm.pre., T_2 = 40°C + 273 = 313K

And V_1 = 2 m^3

V_2 = $(P_1 V_1 T_2)/P_2 T_1 = (1.5 \times 2 \times 313) / (3 \times 298)$

= 1.05^3

5. The ratio between two specific heats of a gas is 1.36. The specific heat capacity of the gas at constant volume is 23094 JK^{-1} per k. mole. Find the value of Universal gas constant.

C_p / C_v = 1.36 and C_v = 23094 JK^{-1} per k.mole C_P = 1.36 × C_v = 1.36 × 23094

= 31407.84 JK^{-1} per k mole.

By Mayers relation $C_P - C_V = R$

i.e., R = 31407.84 - 23094

R = 8313.84 JK^{-1} per k. mole

6. Find the specific heat capacity at constant pressure of helium if C_V = 12525 JK^{-1} per k. mole. One gram molecule of the gas occupies 22.42 litres at NTP Given g = 9.8ms^{-2} and density of mercury = 13600 kgm^{-3}

Given: C_V = 12525 JK^{-1} per k. mole

V = 22.42 litres 22.42 × 10^{-3} m^3

At. N.T.P. P = 0.76 × 136000 × 9.8 and T = 273 K

Gas equation PV = RT

$$R = \frac{PV}{T} = \frac{0.76 \times 136000 \times 9.8 \times 22.42 \times 10^{-3}}{273}$$

= 8.313JK^{-1} permole

= 8313 JK^{-1} k mole^{-}

[1] By Meyer's relation, $C_p - C_v = R$

$C_P = R + C_V$

= 8313 + 12525

i.e., C_P = 20838 JK^{-1} per k. mole

7. The ratio of two specific heats of Ammonia is 1.31 and universal gas constant is 8314 JK^{-1} per k.mole. Calculate the specific heat of the gas at constant pressure and at constant volume.

The ratio, $C_p / C_v = \gamma$, $C_P = \gamma C_V$

By Meyer's Relation, $C_P - C_V = R$, $C_P = R + C_V$

Then $R + C_V = \gamma C_V$

$R = \gamma C_V - C_V = C_V (\gamma - 1)$

$$C_V = \frac{R}{(\gamma - 1)} = 8314 / (1.31 - 1)$$

i.e., $C_V = 26819$ JK^{-1} per k. mole

$C_P = R + C_V = 8314 + 26819$

i.e., $C_p = 35133$ JK^{-1} per k. mole

UNIT 2

THERMODYNAMICS, LIQUEFACTION OF GASES & NON-CONVENTIONAL ENERGY

1.1 THERMODYNAMICS

INTRODUCTION:

- Energy exists in various forms in nature. They are mechanical energy (kinetic and potential), heat energy, electrical energy, radiant energy, chemical energy, etc.
- In a hydroelectric power station, mechanical energy is converted into electrical energy. In a steam engine, heat energy is converted into mechanical energy. When a metal piece is hammered mechanical energy is converted into heat energy.
- Thermodynamics deals with the conversion of heat energy into mechanical energy and vice versa. But in a mere general sense, it includes the relation of heat to other forms of energy like electrical energy, chemical energy, etc. In our discussions we will be concerned mainly about the conversion of heat energy into mechanical energy.
- The science of thermodynamics is guided by the three laws of thermodynamics.

FIRST LAW OF THERMODYNAMICS:-

- Heat and work are two form energy. Heat can be converted into work. Work can be converted into Heat.

$$\Delta Q = \Delta W + \Delta U$$

- Hence the first law of thermodynamics states that the amount of heat energy supplied to a system is equal to the sum of the change in internal energy of the system and the work done by the system.
- According to First Law of Thermodynamics, heat energy can be converted into mechanical work and vice versa.

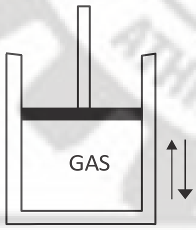
ISOTHERMAL AND ADIABATIC CHANGES:

In general, when a quantity of heat is given to the gas a part of the heat is used to increase the internal energy of the gas and the rest is used to do external work by the gas. Let dQ be the quantity of heat given to the gas, dE the increase in internal energy and W the external workdone by the gas. Then

$$dQ = dE + W$$

This equation is called Gas - energy equation.

ISOTHERMAL CHANGE:

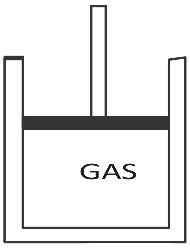


- Any change in pressure and volume of a gas at constant temperature is called isothermal change.

$$PV = constant$$

- When pressure and volume of gas changes, temperature also changes.
- This is called adiabatic change.
- Here, no heat is allowed to enter or leave the gas
- Its equation is PV^{γ} =constant

ADIABATIC CHANGE :



- When pressure and volume of gas changes, temperature also changes. This is called adiabatic change.
- Any Consider one mole of gas in a cylinder fitted with frictionless piston
- Piston, cylinder are made up of non conducting material.
- When the gas compressed (piston moves down)suddenly, pressure increases volume decreases temperature increases.
- Since the cylinder are made up of non conducting material, no heat is allowed to escape from gas.
- Hence when P ,V changes, T is changes.
- When the gas expand suddenly, pressure decreases, volume increases, Temperature decreases.
- Here, no heat is allowed to enter or leave the gas
- Its equation is PV^{γ} =constant
- When P,V changes, T also changes

APPLICATIONS OF HEAT & THERMDYNAMICS

1. Heat engines convert heat into useful work. Gasoline and diesel engines, jet engines, steam turbines that convert heat energy into electrical energy are the examples of heat engines.
2. The working of refrigerator and air conditioners are based on the second law of thermodynamics.
3. They do not create cold, instead, they simply transfer heat from inside to the outside.
4. Heating and cooling system in our homes and other buildings, engine used in our motor vehicles are based on thermodynamics.

WORKED PROBLEMS:

1. A gas at 2 ATP is compressed to half of its original volume. Calculate the final pressure, if the compression is (i) isothermal and (ii) adiabatic ($\gamma = 1.4$)

Let V be the original volume

Given; $P_1 = 2$ atmosphere, $V_1 = V$ and $V_2 = ½ V$

1) For Isothermal change, the equation is $P_1V_1 = P_2V_2$

$$\therefore P_2 = \frac{P_1V_1}{V_2} = \frac{2 \times V}{(1/2)V} = 4 \text{ atmospheric pressure}$$

ii) Adiabatic equation is $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$$\therefore P_2 = \frac{P_1 V_1^{\gamma}}{V_2^{\gamma}} = \frac{2 \times V^{\gamma}}{\left(\frac{V}{2}\right)^{\gamma}} = \frac{2 \times V^{\gamma} \times 2^{\gamma}}{V^{\gamma}}$$

$$= 2 \times 2^{\gamma} = 2 \times 2^{1.4}$$

$$= 2 \times 2^{1.4} = 5.278 \text{ Atmospheric Pressure.}$$

2. Air at a pressure of 0.75 m of mercury and of volume 1 litre is compressed to a pressure of 1.5 m of mercury under isothermal process. Calculate the resulting volume.

The equation for Isothermal change is $P_1V_1 = P_2V_2$ Given; $P_1 = 0.75$m of Hg

$P_2 = 1.5$m of Hg $V_1 = 1$ litre

$\therefore V_2 = (P_1V_1) / P_2 = (0.75 \times 1) / 1.5 = 0.5$ litre

3. A certain mass of gas at 3 atmosphere is compressed adiabatically to half of its volume. Calculate the resulting pressure if $\gamma = 1.4$

Given; $V_1 = V$, $V_2 = ½ V$ and $P_1 = 3$ atmosphere pressure $P_2 = P_1 V_1^{\gamma} / V_2^{\gamma}$

$P_2 = P_1 V^{\gamma} / (½V)^{\gamma}$

$P_2 = (3 \times V^{1.4}) / (½ V)^{1.4} = 3 \times 2^{1.4} = 7.92$ atmosphere pressure

SECOND LAW OF THERMODYNAMICS:-

A heat engine is mainly used for the conversion of heat energy into mechanical work. A refrigerator is a device used to cool a certain space below the temperature of its surroundings. The first law does not contradict the existence of 100% efficient heat engine or a refrigerator, which are not attainable in practice. These phenomena led to the formulation of second law of thermodynamics. There are two versions of this second law of thermodynamics.

a. CLAUSIUS STATEMENT :

It is impossible for a self acting mechanism working in a cyclic process unaided by an external agency to transfer heat from a body at a lower temperature to the body at a higher temperature.

This part of the law is applicable in the case of ice plants and refrigerators. i.e., Heat itself cannot flow from a body at a lower temperature to a body at a higher temperature, on its own.

b. KELVIN'S STATEMENT:

It is impossible to derive a continuous supply of work from a body by cooling it to a temperature lower than that of its surroundings. This part of the law is applicable in the case of Heat engines. In a heat engine the working substance does some work and rejects the remaining heat to the sink. The temperature of the source must be higher than the surroundings. The engine will not work when the temperatures of the source and the sink are same.

2.2. LIQUEFACTION OF GASES

- The work on the liquefaction of gases started in 1823 by Faraday. Gases like chlorine, hydrogen chloride, hydrogen sulphide, sulphur dioxide, ammonia and carbon dioxide were liquefied under high pressure with the aid of simple freezing mixtures. But this method cannot be used to liquefy oxygen, nitrogen, hydrogen and helium.
- In 1863, Andrews had discovered the phenomenon of critical state of the gas. According to Andrew's discovery, a gas cannot be liquefied when it is at above a particular temperature. That particular temperature is called critical temperature. The pressure and volume of the gas corresponding to that temperature are called the critical pressure and critical volume. After Andrew's discovery, the liquefaction was done easily by cooling the gas below its critical temperature, even though the process is difficult to liquefy oxygen, nitrogen, hydrogen and helium since they have very low critical temperatures. For example, the critical temperature for oxygen is - 119°C and for hydrogen is - 240°C.
- Then in 1877, Pictet liquefied the oxygen by cascade (step by step) process in which low temperatures are obtained in step by step by the evaporation of suitable liquids. In 1896, Linde performed a process to liquefy air by using Joule - Thomson effect.

CRITICAL CONSTANTS:

The critical temperature, critical pressure and critical volume are called critical constants T_C

1. CRITICAL TEMPERATURE (T_C) : The critical temperature of gas is defined as that temperature above which the gas cannot be liquefied however great the pressure applied may be.

2. CRITICAL PRESSURE (P_C) : The critical pressure is the minimum pressure required to liquefy a gas when it is at its critical temperature.

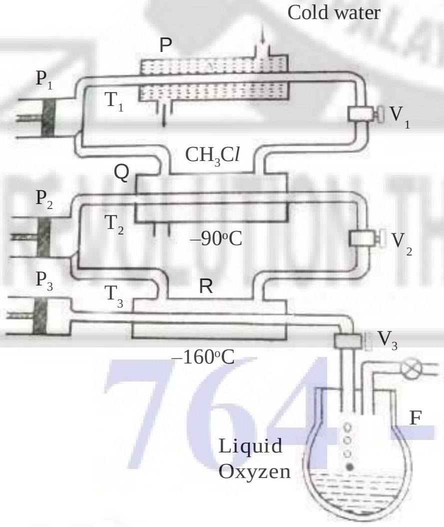
3. CRITICAL VOLUME (V_C) : The critical volume is the volume of unit mass of a gas when it is at its critical temperature and critical pressure.

Note: Below the critical temperature the gas is termed as vapour and above the critical temperature it is termed as gas. The gas can be liquefied easily when it is in the state of vapour. Gases like oxygen, nitrogen, hydrogen and helium are termed as permanent gases since they have very low critical temperatures.

2. CASCADE PROCESS - LIQUEFACTION OF OXYGEN:

PRINCIPAL:

- A gas can be liquefied by cooling it below its critical temperature and applying high pressure greater than critical pressure.
- The apparatus consists of compression pumps P1, P2 and P3. T1, T2 and T3 are the three tubes which are surrounded by outer jackets A, B and C. 'D' is a Dewar's flask which collects liquid oxygen.



STAGE I:

- Critical temperature of methyl chloride is 143^{o}c is compressed by the pump P1 through the tube T1.
- It is cooled by the cold water circulating in jacket A to reduce the temperature to 25^{o}c.
- Due to high pressure methyl chloride gas is converted into liquid and collected in the jacket B and its temperature is reduced to -90^{o}c.

STAGE II:

- The critical temperature of ethylene gas is 10^{o}c is compressed by pump P_2 through the tube T_2.
- It is cooled by liquid methyl chloride in jacket B. Since -90^{o}c ethylene gas is converted into liquid and collected in the jacket C and its temperature reduced to -160^{o}c

STAGE III:

- Critical temperature of oxygen is -118^{o}c is compressed by the pump p_3 through the tube T_3.
- It is cooled by Liquid ethylene at –160^{o}C in the jacket C surrounds the tube T_3.
- Since this temperature is well below the critical temperature of oxygen (-118^{o}C) and the pressure is high, oxygen gets liquefied.
- The liquid oxygen is collected in the Dewar’s flask.
- It is circulated back to the pump P3 and the process is repeated.

DISADVANTAGE: The lowest temperature obtained in this process is -160° C. Therefore the cascade process cannot be used to liquefy hydrogen and helium whose critical temperatures are lower than
- 160° C.

3. JOULE - THOMPSON EFFECT:

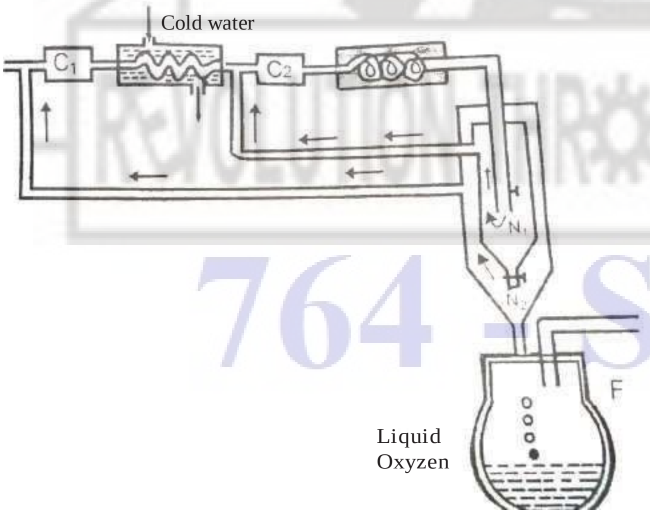
- Using the principle of Joule - Thompson effect, air, hydrogen and helium were also liquefied. Joule performed an experiment to study the effect of change in the temperature of a gas when it is allowed to pass through a porous plug from the high pressure side to the low pressure side.

JOULE - THOMPSON EFFECT : When a gas is allowed to expand from a high pressure side to a low pressure side through a porous or nozzle or jet then it produces intense cooling, if the temperature of the gas is less than the temperature of inversion. This effect is called Joule - Thompson effect.

TEMPERATURE OF INVERSION : If a gas is at a particular temperature no cooling or heating is observed when it is passed through the porous plug. If the temperature of the gas on the high pressure side is more than that temperature, heating will takes place instead of cooling. That particular temperature is called the temperature of inversion.

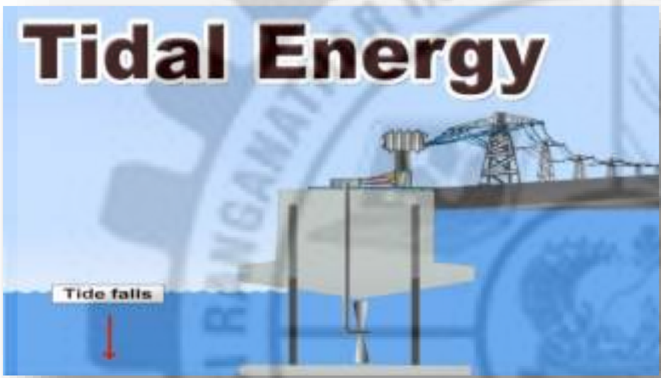
Temperature of inversion may be defined as the temperature at which there neither cooling nor heating due to Joule Thomson effect.

4. LINDE'S PROCESS - LIQUEFACTION OF AIR:



- The compressor C_1 air is compressed to 25 atmosphere and is cooled by cold water .
- This compressed air is passed through KOH solution to remove CO_2 and water vapour.
- The air is compressed to 200 atmospheres using compressor C_2.
- This air passes through a spiral tube surrounded by a jacket containing a freezing mixture and the temperature is reduced to -20^{o}C .
- This cooled air at high pressure is allowed to come out of the nozzle N1.
- At N1, Joule – Thomson effect takes place and the incoming air is cooled to -70^{o}C.
- This cooled air is circulated back into the compressor C_2 and is compressed.
- It passes through the nozzle N1 and is further cooled.
- Then it is allowed to pass through the nozzle N2 from high pressure to low pressure, and is further cooled.
- As the process continues, after a few cycles, air gets cooled to a sufficiently low temperature well below its critical temperature of -140^{o}C through nozzle N_2
- Finally the air is converted into liquid collected in the Dewar's Flask.
- The unliquefied air is again circulated back to the pump c1 and the process is repeated.
- The whole apparatus is packed with cotton wool to avoid any conduction or radiation.
- By applying the principle of Joule – Thomson effect and regenerative cooling, Hydrogen and Helium can also be liquefied.

TIDAL ENERGY



- The tides in the sea are the result of the universal gravitational effect of heavenly bodies like the sun and moon on the earth.
- Due to fluidity of water mass, the effect of this force becomes apparent in the motion of water. his shows a periodic size and fall in levels which is in rhythm with daily cycle of raising and setting of the sun and moon.
- This periodic rise and fall of the water level of sea is called tide. These tides can be used to produce electric power which is known as tidal power.

UNIT 3

LIGHT AND REMOTE SENSING

LIGHT

- Light is a form of energy radiated by luminous bodies. When it enters our eyes, it stimulates the retina to a sense of vision. An object is visible only by the scattering of light from the object reaches the eyes.
- The objects which emit light rays (energy) are called light sources. For example, Sun, Stars, lamp etc are the light sources. Light can pass through the transparent medium like glass, air, water etc. Light rays undergo reflection, refraction interference, diffraction, polarization, etc. Light is propagated with a finite velocity 3×10^8 ms^{-1}. Light plays dual role. In some places it behaves like particles and in some places it behaves like waves, traveling in a straight line.

3.1 OPTICS

Refraction

When a ray of light travels from one transparent medium into another medium, it bends while crossing the interface, separating the media. This phenomenon is called refraction.

Laws of Refraction

I Law : The incident ray, the refracted ray and the normal to the refracting surface at the point of incidence are in the same plane.

II law : The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for any two given medium for one particular colour of light. This is known as Snell's law.

Refractive index of a medium

When a ray of light passes from air or vacuum to the given medium, the ratio between the sine of the angle of incidence and the sine of the angle of refraction is called the refractive index of the given medium. If 'i' is the angle of incidence and 'r' is the angle of refraction,

Refractive index of the medium $\mu = \frac{\text{Sin i}}{\text{Sin r}}$

According to wave theory of light, if 'c' is the velocity of light in air or vacuum and 'v' is the velocity of light in the medium, then

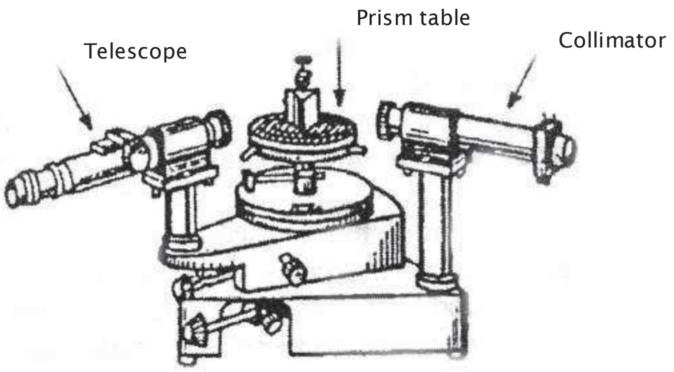
Refractive Index of the medium

$$\mu = \frac{\text{Velocity of light in air (or) vacuum (c)}}{\text{Velocity of light in the medium (v)}}$$

SPECTROMETER

Spectrometer is used to determine the refractive index of the material of the prism and to study spectra.

The three main parts of the spectrometer are Collimator, Prism table and Telescope.



Collimator

The collimator consists of two co-axial brass tubes, one is capable of sliding into the other. An adjustable slit is provided at one end and a convex lens is fixed at the other end of the collimator. The distance between the slit and the convex lens can be changed using the screw provided. The width of the slit can also be changed. The collimator is rigidly fixed to the instrument. It is used to get parallel rays of light.

Prism table

It consists of two circular metal discs with three leveling screws. The prism table can be rotated about an axis passing through its centre. The prism table can be raised or lowered and can be fixed at any desired height. The prism table can be made horizontal by adjusting the levelling screws with the help of a spirit level.

Telescope

It consists of two co-axial brass tubes, one is capable of sliding into the other. An eye-piece is provided at one end and an objective lens is fixed at the other end of the telescope. The telescope can be rotated about the central axis of the instrument. A circular scale graduated in half degree is attached to the telescope. Therefore when the telescope rotates, the circular graduated scale also rotates. The telescope can be fixed in any position using the clamping screw. For fine adjustment of the telescope, the tangential screw is used.

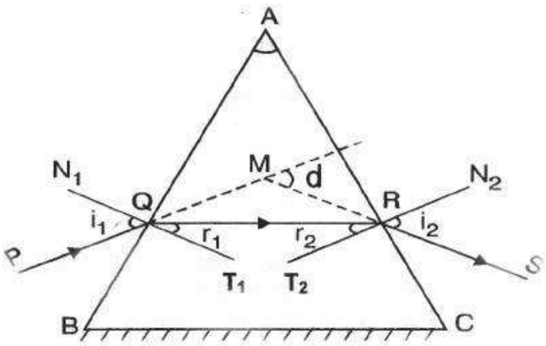
Initial adjustments of a spectroimeter

1. The eye-piece in the telescope is gently pulled out or pushed in, till the cross wires are seen clearly.
2. The telescope is turned towards a distant object. Then the distance between the eye-piece and the objective lens of the telescope is adjusted, till the clear image of the object is seen in the field of view of the telescope.
3. The slit is illuminated by a monochromatic source of light. The width of the slit is adjusted suitably by viewing through the convex lens in the collimator. Then the telescope is brought in line with the collimator. Clear image of the slit is obtained by using the screws in the collimator and telescope. Using the tangential screws, the vertical cross wire is made to coincide with the left edge of the image of the slit.
4. The prism table is made horizontal by adjusting the leveling screws in it using a spirit level.

Refraction

When a ray of light passes from one medium to the second its direction changes at the point where it enters the second medium. This phenomenon is known as refraction.

Expression for the refractive index of the material of the prism



- ABC is an equilateral glass prism, AB, AC are the refracting faces. BC is the base of the prism
- PQ- incident ray at an angle of incidence i_1
- QR- refracted ray at an angle of refraction r_1
- RS- Emergent ray
- r_2-angle of incidence on the face AC
- i_2-angle of emergence
- d-angle of deviation
- A-angle of prism
- In ΔAQR

$A + \angle AQR + \angle ARQ = 180°$

$A + (90 - r_1) + (90 - r_2) = 180°$

$A + 180° - r_1 - r_2) = 180°$

$A - (r_1 + r_2) + 180° = 180°$

$A - (r_1 + r_2) = 180° - 180° = 0$

$A - (r_1 + r_2) = 0$

$A = (r_1 + r_2)$ -----------------(1)

ΔEQR

$< EQR + < ERQ + < QER = 180°$

$(i_1 - r_1) + (i_2 - r_2) + (180° - d) = 180°$

$(i_1 + i_2) - (r_1 + r_2) = 180° - 180° + d$

$(i_1 + i_2) = d + (r_1 + r_2)$---------------(2)

Sub/. Equation(1) in equation(2)

$(i_1 + i_2) = d + A$---------------(3)

$i_1 = i_2 = i$

$r_1 = r_2 = r$, d=D

From equation (1)

$A = (r + r)$

2r=A

$r = \frac{A}{2}$ -------(4)

From equation (3)

$(i_1 + i_2) = d + A$

$(i + i) = D + A$

$2i = A + D$

$i = \frac{A+D}{2}$---------(5)

$The\ refractive\ index\ of\ the\ glass\ prism \mu = \frac{\sin i}{\sin r}$

$$\boldsymbol{\mu = \frac{\sin(\frac{A+D}{2})}{\sin(\frac{A}{2})}}$$

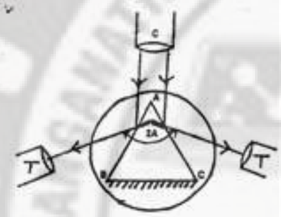
Experiment to determine the refractive index of the material of the prism:

The refractive index of the material of prism is determined by measuring the angle of prism and the angle of minimum deviated ray by using Spectrometer.

Before, starting the experiment the following initial adjustment is made for the spectrometer

1. The telescope is kept in focus by capturing the clear image of distance object.
2. The prism table is kept horizontal by levelling screws in it using sprite level.
3. The slit is illuminated by monochromatic source of light. The collimator screw is adjusted to produce narrow slit. Then, the clear image of the slit is viewed through the telescope and coincide with vertical cross wire of the telescope. Now, the vernier table is adjusted to $0^o – 180^o$.

Determination of angle of prism A:



After making initial adjustments, the least count of the spectrometer is determined (as in Vernier Calipers).

Having a very fine slit, the telescope is adjusted for direct ray. A prism is placed on the prism table as shown in the figure. The telescope is turned to catch the reflected image from one polished face AB of the prism. Fixing in that position, the tangential screw is adjusted till the vertical cross wire is made to coincide with the fixed edge of the image of the slit. The readings in the scales I and II are noted.

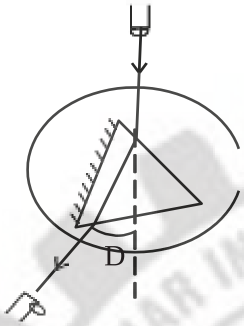
The telescope is then turned to the other polished face AC of the prism. The readings in the scales I and II are noted when the vertical cross wire coincides with the fixed edge of the image of the slit. The difference between both the scale I readings is 2A. Similarly the difference between both the scale II readings is 2A. Then the average of the angle of the prism A is calculated.

Tabular column I:

To determine the angle of the prism A LC =

Ray	Spectrometer readings in degree							
	Scale I				Scale II			
	MSR	VSC	VSR= VSC × LC	OR= MSR+VSR	MSR	VSC	VSR= VSC ´LC	OR= MSR+VSR
Reading of the reflected ray (left)				x_1 =				x_3 =
Reading of the reflected ray (right)				x_2 =				x_4 =

Determination of angle of minimum deviation:



Tabular column II:

To determine the angle of the minimum deviation D LC =

Ray	Spectrometer readings in degree							
	Scale I				Scale II			
	MSR	VSC	VSR= VSC × LC	OR= MSR+VSR	MSR	VSC	VSR= VSC ´LC	OR= MSR+VSR
Reading of minimum deviated ray				d =				d =
Reading of Direct ray				d =				d =

The prism is placed on the prism table as shown in the figure. The ray of light from the collimator incident on one polished face of the prism gets refracted and emerges out of the other polished face. Viewing the image of the slit through the telescope, the prism table and telescope are rotated simultane- ously through small angle such that the image of the slit moves towards the direct ray. At one stage, it is found that the image of the slit is stationary for a moment and on rotating the prism table further in the same direction the image begins to retrace its path. The telescope is fixed at that position, the cross wire is made to coincide with the fixed edge of the image of the slit. At this minimum deviation position, the readings of scales I and II are noted.

The prism is removed from the prism table. The telescope is brought in line with the collimator and the image of the slit is seen through the telescope. The vertical cross wire is made to coincide with the fixed edge of the image of the slit. The readings in the scales I and II are noted.

The difference between the two readings of scale I or scale II gives the angle of minimum deviation D. Hence there fractive index of the material of the prism is calculated using the formula. The refractive index of the prism is determined by using the formula,

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

WORKED PROBLEMS

The angle of a glass prism is 60° and angle of minimum deviation is 40°. Calculate the refractive index of the prism.

A=60°

D=40°

μ =?

$$\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\mu = \frac{\sin\left(\frac{60^\circ + 40^\circ}{2}\right)}{\sin\left(\frac{60^\circ}{2}\right)}$$

$$\mu = \frac{\sin 50^\circ}{\sin 30^\circ} = \frac{0.7660}{0.5}$$

$$\mu = 1.532$$

The angle of a glass prism is 59° and refractive index of the prism is 1.642. Calculate the minimum deviation.

A=59°

μ =1.642

D=?

$$\mu = \frac{\sin\left(\frac{A+D}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$sin\left(\frac{A+D}{2}\right) = \mu \times sin\left(\frac{A}{2}\right)$$

$$sin\left(\frac{59+D}{2}\right) = 1.64 \times sin\left(\frac{59}{2}\right)$$

$$sin\left(\frac{59+D}{2}\right) = 1.64 \times sin(29° \, 30')$$

$$sin\left(\frac{59+D}{2}\right) = 0.8083$$

$$\left(\frac{59+D}{2}\right) = \sin^{-1}(0.8083)$$

$$\left(\frac{59+D}{2}\right) = 53.93$$

$$59 + D = 53.93 \times 2$$

$$59 + D = 107°52'$$

$$D = 107°52' - 59°$$

$$D = 48°52'$$

APPLICATIONS OF TOTAL INTERNAL REFLECTION:

1. The phenomenon of total internal reflection is used in many optical instruments like telescope, Microscope, binoculars, spectroscopes, periscopes etc...
2. The glittering of diamond is due to total internal reflection.
3. Mirage (appearance of water layer at short distances in a desert or one the road) is caused due to total internal reflection.
4. Endoscopes work on the phenomenon of total internal reflection optical fibres are inserted into the body through mouth, nose or special hole made in the body. even operations could be carried out with the endoscope cable with suitable instruments attached at their ends.
5. When a electric bulb is kept inside a water tank, the light from the source travels in all directions inside the water.the light incident on the water surface at an angle less than the critical angle will undergo refraction and comes out from water.the light incident at angle greater than critical angle will undergo total internal reflction.
6. The principle of total internal reflection is used in fibre optic communication.

REMOTE SENSING

- Remote sensing is the process of sensing and measuring the objects in a long distance without physical contact with them. A device used for the above purpose is called remote sensor.
- Remote sensors are mounted on the aircraft or satellite platforms. The sensors receive the reflected or emitted radiations from a particular place on the earth's surface and measure the energy. These measurements are being made at a large number of points from the image of the earth's surfaces. The sensed images are interpreted in terms of geographical variations. The active power of the remote sensors depends upon the detection of energy emitted or reflected by the object.

Types of remote sensing (Active and Passive) :

The system of remote sensing is classified into two types. They are

1) Active remote sensing

2) Passive remote sensing

(1) Active remote sensing is the process of sensing the distant target in which the sensors direct their own generated radiations towards the target and then it detect the amount of energy reflected by the target.

Examples: Radar, Radar Altimeter, Wind scatterometer, Synthetic Aperture Radar (SAR) and Camera with flash.

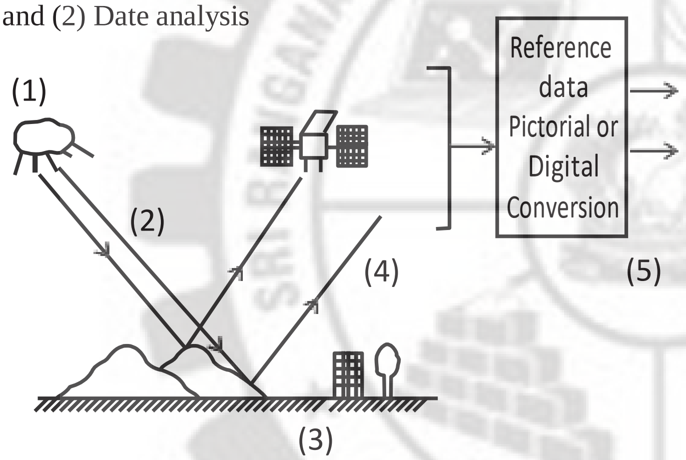
(2) Passive remote sensing is the process of sensing the distant object in which the sensors detect only the amount of energy radiated by the object.

Examples: Aerial photography, Camera without flash and Microwave radiometer.

Components of remote sensing:

The electromagnetic remote sensing process is divided into two components namely

(1) Date acquisition and (2) Date analysis

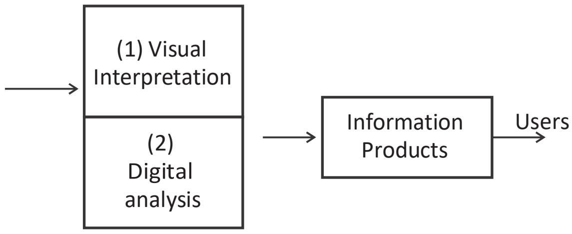


Date acquisition : The schematic diagram of data acquisition is shown in the figure. In this process, five distinct elements are involved.

They are

1. Energy Sources.
2. Propagation of energy through the atmosphere.
3. Energy interaction on earth surface.
4. Space borne sensors record the reflected energy.
5. Conversion of sensors data in the form of pictures or digital information.

The electromagnetic radiations emitted by the energy source are propagated through the atmosphere and incident on the surface of the earth. Then the radiations are reflected back towards the space borne remote sensors. The sensors generate the receiving data into picture or digital forms.



Data analysis: The schematic diagram of data analysis is shown in the figure. The data analysis is divided into two separate processes.

They are

1) visual interpretation technique

2) Digital analysis

In visual interpretation techniques, various viewing instruments are used for examining and analysing the pictorial data. In digital analysis the computers are used to analyse the digital data. All analyzing data are viewed in the information products by users. The data analysis can be carried only with the help of reference data.

The process that involves examination and analysis of pictorial data is called visual image interpretation techniques. This process involves the use of fundamental picture elements like tone, texture, pattern, shape and size in order to identify the various objects. Stereoscopic instruments are used for this purpose.

Use of computers to analyse digital data is known as digital image processing techniques. If the data is available in digital form, it can be analysed on interactive computer systems for getting statistical data. This statistical data is analysed using computers by comparing with the actual “signatures” of the objects collected through field visits. This system of classification of objects is quite accurate.

Reference data:

Whether it is pictorial data analysis or digital data analysis, reference data should be generated as supporting data. Reference data is called ground truth or field check. The reference data is used to analyse and interpret remotely sensed data and also to verify information obtained from remote sensing data. The acquisition of reference data is through actual field visits.

The collection of reference data may depends upon time-critical or time-stable measurements. The time-critical measurements are those vegetation conditions, water pollutants and climatic conditions. The time- stable are other geological measurements.

UNIT 4 ELECTRICITY

INTRODUCTION

- The flow of free electrons in a conductor constitutes electric current. The current is defined as the rate of flow of charges across any cross sectional area of a conductor. The current is expressed in ampere and it is a scalar quantity. The direction of current is the direction of flow of positive charges or opposite to the direction of flow of electrons. The electric current is the flow of positive charge from a point at a higher potential to a point at a lower potential. Current flows only if there are charge carriers present in a conductor which can move freely when an electric field source is connected between the ends of the conductor. When charges are in motion, they produce magnetic effects. The current flowing through a conductor is one ampere if a charge of one coulomb flows through any section of it per second.

4.1 ELECTRICAL CIRCUITS

- In an electrical circuit there must be a source of energy which provides energy to electrons so that they can move and constitute an electric current. For easy flow of current, the connecting wires must be made of conductor material. The energy source creates a potential difference across the circuit and therefore it forces electric charges to move along the conductor. When a voltage (V) is applied across a conductor, a current (I) flows in the conductor. The magnitude of current in a conductor depends on its resistance and the resistance plays an important part in the conduction.

Resistivity

The resistance of a conductor is directly proportional to the length of the conductor and inversely proportional to the area of cross section of the conductor.

$$R \propto l$$

$$R \propto \frac{1}{A}$$

$$\text{i.e., } R \propto \frac{l}{A}$$

$$R = (\rho)\frac{l}{A}$$

$$\therefore \rho = \frac{RA}{l}$$

ρ is called the resistivity or specific resistance of the material of the conductor.

The resistivity or specific resistance of a material is defined as the resistance offered by a conductor of unit length having unit area of cross section. The unit of resistivity is ohm metre (Ω m).

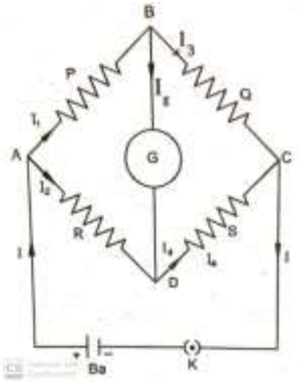
CONDUCTIVITY

The reciprocal of resistivity of the material of a conductor is called as its conductivity. It is denoted by σ Based on the above expression of conductivity, the unit of conductivity is mho/m.

$$\sigma = \frac{1}{\rho}$$

$$o = \frac{l}{RA}$$

CONDITION FOR BALANCING THE WHEAT STONE'S BRIDGE



- Wheat stone's bridge consists of four resistances P, Q, R, S.
- A galvanometer, battery, key are connected as shown in figure.
- Current I_1, I_2, I_3, I_4

Apply Kirchhoff's first law:

Junction 'B':

$I_1 = I_2 + I_g$ ----------------(1)

Junction 'D':

$I_3 = I_4 - I_g$ ----------------(2)

Here, $I_g = 0$

$I_1 = I_2$ --------------------(3)

$I_3 = I_4$ ----------------(4)

Apply Kirchhoff's second law:

From ABDA

$I_1 P + I_g G - I_3 R = 0$ ----------(5)

From BCDB:

$I_2 Q - I_4 S + I_g G = 0$ ----------(6)

Here, $I_g = 0$

$I_1 P - I_3 R = 0$ ----------(7)

$I_2 Q - I_4 S = 0$ ----------(8)

Equation $\frac{(7)}{(8)}$

$$\frac{I_1 P}{I_2 Q} = \frac{I_3 R}{I_4 S}$$

Sub/. $I_1 = I_2, I_3 = I_4$ ***in above equation***

$$\frac{I_1 P}{I_1 Q} = \frac{I_3 R}{I_3 S}$$

$$\boxed{\frac{P}{Q} = \frac{R}{S}}$$

SOLVED EXAMPLES

1. Calculate the resistance of a wire of length 1.5 m and diameter 0.8 mm.

The specific resistance of the material of the wire is 45×10^{-8} ohm m Given

l = 1.5 m

d = 0.8 mm   r = 0.4 mm

= 0.4×10^{-3} m

$\rho = 45 \times 10^{-8}$ ohm m

We know specific resistance $\rho = \frac{RA}{l}$

Resistance $R = \frac{\rho l}{A}$

ie $R = \frac{\rho l}{\pi r^2}$

$$\frac{45 \times 10^{-8} \times 1.5}{3.14 \times (0.4 \times 10^{-3})^2} = 1.343 \text{ ohm.}$$

2. Calculate the resistivity of a material of a wire whose resistance is 1.5 ohm with a diameter of 0.32 cm and length 80 cm.

Given

R = 1.5 ohm

Diameter = 0.32 cm

r = 0.16 cm r = 0.16×10^{-2} m

l = 80 cm

= 80×10^{-2} m.

We know specific resistance $\rho = \frac{RA}{l}$

$$= \frac{R\pi r^2}{l}$$

$$= \frac{1.5 \times 3.14 \times (0.16 \times 10^{-2})^2}{80 \times 10^{-2}}$$

$$= 15.07 \times 10^{-6} \text{ ohm m}$$

4.2 EFFECTS OF CURRENT

- If a positive charge is moved from a point at a higher potential to a point at a lower potential, energy is liberated. When current flows in a conductor, the electrons collide with the ions because of the acceleration of electrons and energy is transferred to the ions. Therefore, there is increase in the energy of the ions and the temperature of the conductor rises and thereby it is heated. This is called heating effect of electric current. This heating effect was studied by Joule.

JOULE'S LAW OF HEATING

The quantity of heat developed (H) in a conductor is

(i) directly proportional to the square of the current passing through the conductor ie $H \alpha I^2$

(ii) directly proportional to the resistance of the conductor ie $H \alpha R$

(iii) directly proportional to the time of flow of current ie $H \alpha t$ ie $H \alpha I^2 Rt$

$$H = I^2 Rt$$

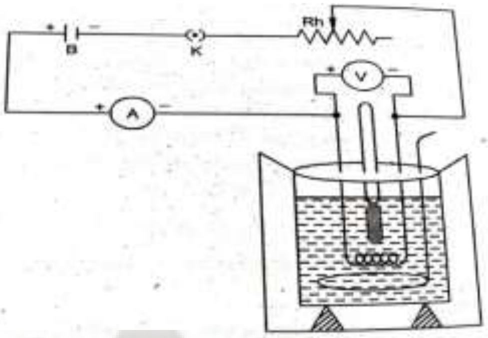
where I is in ampere ,R is in ohm and t is in second But R = E/I

$\because \quad H = I^2 \frac{E}{I} t$

$H = EI\,t$ joule

The heating effect of electric current is applied in the working principle of electric fuse wire, electric heater, electric welding and electric furnace.

EXPERIMENTAL DETERMINATION OF SPECIFIC HEAT CAPACITY OF A LIQUID USING JOULE'S CALORIMETER



- It is consists of a calorimeter containing a heating coil with a stirrer
- To avoid conduction, radiation the full apparatus placed in cotton wool in wooden box.

Experiment:

- The mass of empty calorimeter with stirrer m_1 is found
- The calorimeter ,stirrer with liquid(water) mass m_2 is found
- The calorimeter is kept in the wooden box and connate the ammeter, voltmeter, key, rheostat are as shown in figure.
- The initial temperature T_1 is found
- A current and voltage is applied
- The time taken to raise 5 c is noted using stop watch
- The final temperature T_2
- S_1 specific heat capacity of calorimeter,
- S specific heat capacity of liquid can be found.
- Heat energy produced by coil= VIT
- Heat energy gained by calorimeter= $m_1 s_1 (T_2 - T_1)$
- Heat energy gained by Liquid =$(m_2 - m_1) S(T_2 - T_1)$
- $VIT = m_1 s_1 (T_2 - T_1) + (m_2 - m_1) S(T_2 - T_1)$
- $(m_2 - m_1) S(T_2 - T_1) = VIT - m_1 s_1 (T_2 - T_1)$
- $S = \frac{VIT}{(m_2 - m_1)(T_2 - T_1)} - \frac{(m_1 s_1)(T_2 - T_1)}{(m_2 - m_1)(T_2 - T_1)}$

$$S = \frac{VIT}{(m_2 - m_1)(T_2 - T_1)} - \frac{(m_1 s_1)}{(m_2 - m_1)}$$

CHEMICAL EFFECT OF CURRENT

- The phenomenon of conduction of electricity through liquid was first studied by Faraday in 1833. Pure liquid does not conduct electricity, but the conductivity of a liquid increases if the solution contains an acid. The molecules of a salt in solution are supposed to break up into two parts, positive and negative ions and this process is called dissociation.
- When an electric field is applied between two electrodes dipping in the solution, the positively charged ions move towards the negative electrode (cathode) and they are called as Cations. The negatively charged ions move towards the positive electrode (anode) and they are called as Anions.
- The process of chemical decomposition of an electrolyte by the passage of electric current through it is called electrolysis.
- The liquid containing the compound is called an electrolyte and the vessel containing the electrolyte is called a voltameter.

FARADAY'S LAWS OF ELECTROLYSIS

The two laws of electrolysis are stated as follows.

FIRST LAW

The mass of an element liberated at cathode from an electrolyte by passing of electric current is directly proportional to

(I) The strength of the current (I)

(ii)The time for which the current is passed through the electrolyte (t) ie $m \propto I$

and $m \propto t$ ie $m \propto It$ or

$m = ZIt$

Here, the constant Z is known as the electrochemical equivalent (e.c.e) of the element.

SECOND LAW

If the same current passes through different electrolytes for the same time then the masses of the elements liberated from electrolytes are directly proportional to their respective chemical equivalent weights.

Let m_1, m_2 and m_3 be the masses of the elements liberated by the passage of the same current through the electrolytes for the same time whose chemical equivalent weights are E_1, E_2 and E_3, then according to second law,

$m_1 \propto E_1$; $m_2 \propto E_2$ and $m_3 \propto E_3$

or $$\frac{m_1}{E_1} = \frac{m_2}{E_2} = \frac{m_3}{E_3}$$

ELECRO-CHEMICAL EQUIVALENT (E.C.E) OF AN ELEMENT

According to Faraday's First law of electrolysis

$m \propto It$ or $m = ZIt$

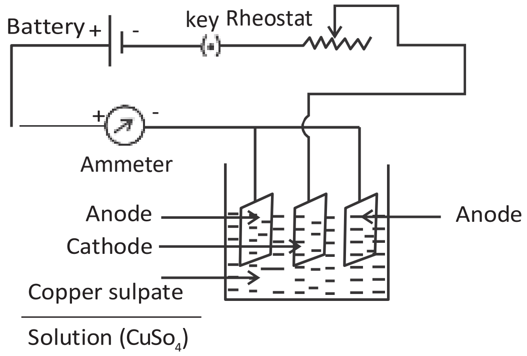
Where Z is a constant called electrochemical equivalent of the given element When I = 1

ampere and t = 1 second, then Z = m

Therefore the electro-chemical equivalent of an element is defined as the mass of the element liberated from an electrolyte when one ampere current is passed through it for one second.

Sinc $Z = m/It$ the unit of e.c.e is kilogram per ampere second or kg C^{-1} (ampere second = coulomb).

EXPERIMENTAL DETERMINATION OF E.C.E OF COPPER



- The copper voltmeter is connected to an ammeter, battery, key rheostat as shown in figure.
- The key is closed and the rheostat is adjusted to one ampere current.
- Then the key is opened
- Then the cathode is kept in copper voltmeter.
- The key is closed. The current is passed for 30 minutes.
- Mass of the cathode before passing current=m_1
- Mass of the cathode after passing current=m_2
- $m=m_2-m_1$
- Current=I
- Time=t
- electro chemical equivalent (e.c.e) of copper

$$e = \frac{m}{It} \text{ kg } c^{-1}$$

APPLICATIONS OF HEATING EFFECT OF ELECTRIC CURRENT:

Electric heating elements:

Heating elements are used in electric iron, electric heater, electric stove, electric immersion heater etc.. The heating element material should have high melting point it should not get oxidised easily. usually it is made up of Nichrome (nikel-80% &chromium 20%).it has high resistivity.

electric fuse wire:

Electric fuse is a piece of wire of material having a very low melting point. Whenever a large current flows, it melts and breaks the circuit. it protects the electrical appliances from over current. fuse wires are usually made up of tin, lead or zinc alloy.

Electric furnaces:

In this molybdenum-nickel coil is used to produce up to 1500˚C heat.

Solved Examples:

1. Calculate the electro-chemical equivalent of copper when a current of one ampere passing through a coppervoltmeter for one hour liberates 1.2 g of copper.

Given,

m = 1.2 g

= 1.2×10^{-3} kg

t = 1 hour

= 3600 s

I = 1 ampere

ECE of copper Z $= \frac{m}{It}$

$= \frac{1.2 \times 10^{-3}}{1 \times 3600}$

$= 3.33 \times 10^{-7}$ kg C^{-1}

2. Calculate the mass of copper deposited when a current of one ampere flows for 30 minutes in a copper voltameter. e.c.e of copper = 3.33×10^{-7} kg C^{-1}.

Given,

I = 1 ampere

t = 30minutes

= 30×60

= 1800 s

Z = 3.33×10^{-7} kg C^{-1}

We know $Z = \frac{m}{It}$

m = Z I t

m = $3.33 \times 10^{-7} \times 1 \times 1800$

m = 5.994×10^{-4} kg.

3. Calculate the current required to deposit 3.3 g of silver in 45 minutes. e.c.e of silver = 1.118×10^{-6} kg C^{-1}

Given,

m = 3.3g

= 3.3×10^{-3} kg

t = 45 minutes

= 45×60

= 2700 s

Z = 1.118×10^{-6} kg C^{-1}

We know,

$Z = \frac{m}{It}$

$I = \frac{m}{Zt}$

$= \frac{3.3 \times 10^{-3}}{1.118 \times 10^{-6} \times 2700}$

I = 1.093 ampere

4. 2×10^{-3} kg of gold is to be deposited electrolytically by passing a current of 1.2 ampere. What will be the time tarken ? e.c.e of gold is 68×10^{-6} kg C^{-1}

Given,

m = 2×10^{-3} kg I = 1.2 ampere

Z = 0.68×10^{-6} kg C^{-1}

We know,

$$Z = \frac{m}{It}$$

$$\therefore t = \frac{m}{ZI}$$

$$t = \frac{2 \times 10^{-3}}{0.68 \times 10^{-6} \times 1.2}$$

t = 2451 s.

5. Three capacitors of capacitances 4μf, 8μf,12μf are connected in (i) series (ii) parallel. Calculate the equivalent capacitance in both the cases.

C_1=4μf, C_2=8μf, C_3=12μf

(1)Series:

$$\frac{1}{C_s}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$$

$$\frac{1}{C_s}=\frac{1}{4}+\frac{1}{8}+\frac{1}{12}$$

$$\frac{1}{C_s}=\frac{6+3+2}{24}=\frac{11}{24}$$

$$C_s=\frac{24}{11}=2.18\ \mu f$$

(ii) parallel:

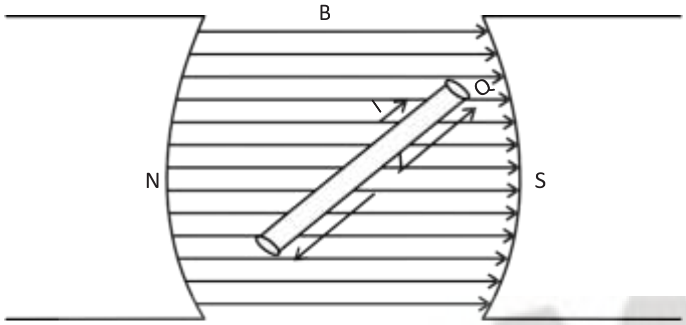
$$C_P = C_1 + C_2 + C_3 = 4+8+12$$

$$C_P = 24\mu f$$

4.3 MEASURING INSTRUMENTS

When charges are in motion they produce magnetic effect. An electric current produces magnetic field. Therefore moving charged particles in magnetic field experience force.

EXPRESSION FOR THE FORCE ACTING ON A CURRENT CARRYING STRAIGHT CONDUCTOR PLACED IN A UNIFORM MAGNETIC FIELD:



- When a charge q is moving in an uniform magnetic induction B.
- A velocity v at an angleθ.

F$\alpha qv\sin\theta$

F= $Bqv\sin\theta$ ---------(1)

(i)When the charge is moving perpendicular to magnetic field

$\theta = 90°$

F= F $= Bqv\sin 90°$

F $= Bqv$---------------(2)

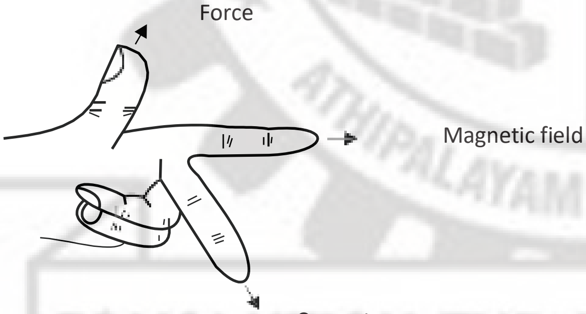
(i)When the charge is moving parallel to magnetic field

$\theta = 0°$

F $= Bqv\sin 0°$

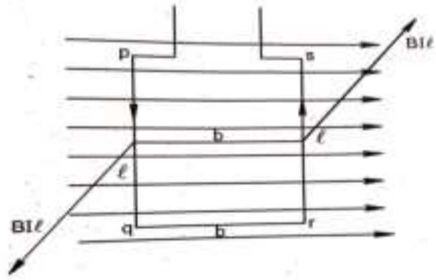
F $=$ 0° --------------(3)

FLEMING'S LEFT HAND RULE



The direction of motion of current carrying conductor placed in a uniform magnetic field is given by Fleming's Left Hand rule. According to this rule, when the forefinger, middle finger and thumb of the left hand are stretched mutually perpendicular to each other and if the forefinger represents the direction of magnetic field, the middle finger represents the direction of current in the conductor, then the thumb gives the direction of motion of the conductor.

Expression for the torque experienced by a rectangular current carrying coil placed in a uniform magnetic field



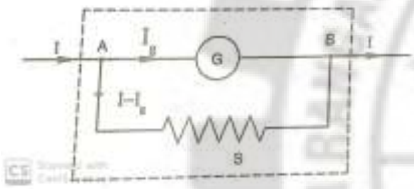
- ABCD is a rectangular coil having length l and breadth b.
- The coil carries a current of I is place in an uniform magnetic field B.
- The sides AB and CD are perpendicular to magnetic field.
- Force n AB =BIL
- Force n CD =BIL
- There the two forces are equal and opposite in direction. They constitute a couple.
- Moment of a couple=Fxq
- $\tau =$ BIL xb
- $\tau =$ BIA
- If the coil has n turns, then $\tau =$ nBIA

MERITS OF MOVING COIL GALVANOMETER

(i) The external magnetic fields do not alter the deflection of the coil since there is a strong magnetic field between the pole pieces, and the galvanometer can be placed in any position.

(ii) Since the deflection of the coil is directly proportional to the current, a uniformly divided scale can be used to measure the current.

CONVERSION OF A GALVANOMETER IN TO AN AMMETER



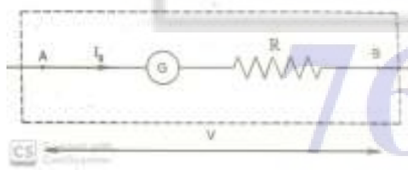
- A galvanometer can be converted into an ammeter by connecting a low resistance in parallel with the galvanometer.
- I-current
- Ig- current through galvanometer.
- G-resistance of galvanometer
- S- low resistance

(I- Ig)s = Ig G

.

$$S = \frac{Ig\,G}{(I - Ig)}$$

CONVERSION OF A GALVANOMETER INTO A VOLTMETER



- Voltmeter is used to voltage.
- A galvanometer can be converted into voltmeter by connecting a high resistance in series with galvanometer.
- V-voltage
- Ig- current through galvanometer.
- G-resistance of galvanometer
- R- high resistance
- Total resistance =G+R
- V= Ig (G+R)
- G+R=$\frac{V}{Ig}$

$$\mathbf{R=\frac{V}{Ig} - G}$$

SOLVED EXAMPLES

1. A galvanometer of resistance 20 ohm gives full scale deflection for a current of 10mA.How will you convert it into a voltmeter to read upto 100v.

   $G = 20\Omega$
   $Ig = 10mA = 10 \times 10^{-3}A$
   V=100v
   R=?
   R=$\frac{V}{Ig} - G$
   R=$\frac{100}{10\times10^{-3}} - 20$

   R=$\frac{100\times10^{3}}{10} - 20$
   R=$\frac{100000}{10} - 20$
   R=10000-20
   R =9980 Ω

2. A galvanometer of resistance 100 ohm gives full scale deflection when a current of 100mA flows through it.How will you convert it into an ammeter to read upto 10A.

   $G = 100\Omega$
   $Ig = 100mA = 100 \times 10^{-3}A$
   I=10A
   S=?
   S=$\frac{Ig\ G}{(I - Ig)}$
   S=$\frac{100\times10^{-3}\times 100}{(10 - 100\times10^{-3})}$

   S=$\frac{100\times10^{-3}\times 100}{(10 - 0.1)}$

   S=$\frac{0.1\times 100}{(10 - 0.1)}$
   S=$\frac{10}{9.99}$=1.01Ω

UNIT 5

ELECTRONICS

SEMICONDUCTORS

Semiconductors are materials that essentially can be conditioned to act as good conductors or insulators, or anything in between.

FERMI LEVEL:-

- At 0 K, the electrons start filling the energy levels in valence band, from bottom to top level. Few electrons fill the bottom level and other electrons above this level. So filling of energy starts from bottom of the band to top of the band.
- The highest energy level, which an electron can occupy in the valence band at 0 K, is named as Fermi level.
- Fermi level is also defined as the energy level corresponding to the average energy of electrons and holes present in the crystal.

CONCEPT OF HOLES:

The vacant place created in the valence band due to the jumping of electron from the valence band to conduction band is called 'hole', which is having positive charge.

DOPING:-

The process of addition impurity added in an Intrinsic semiconductor and increase conductivity is Called doping.

EXTRINSIC SEMICONDUCTOR:-

Add the some impurity in pure semiconductor is called the extrinsic semiconductor.

5.2. DIODES AND TRANSISTORS

INTRODUCTION:-

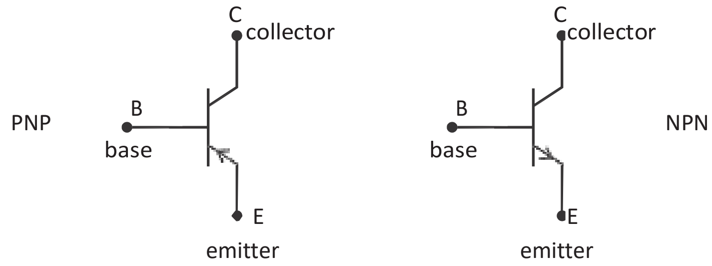
To understand electronic devices and circuits, brief idea about semiconductor diodes is must. The semi conductor diode is a fundamental two terminal electronic device, similar to a resistor. The volt–ampere (V-I) relationship of a resistor is linear. However, the V-I characteristic of a diode is not only non linear but also depends on the operating condition. That is resistor allow the charge carriers at any condition and behaves like passive element. A diode allows current to pass through it in one direction and acts as a switch in electronic circuits.

TRANSISTOR:

A junction diode cannot be used for amplifying a signal. For amplification another type of semiconductor device called 'transistor' is used. Transistor is a three sectioned semiconductor. Transistor is a solid state device. Two P-N junction diode placed back to back form a three layer transistors.

The three sections of the transistors are called emitter [E], base [B] and collector [C]. In a transistor the emitter is heavily doped, since emitter has to supply majority carriers. The base is lightly doped. Two type of transistors are available, namely N-P-N and P-N-P transistor.

SYMBOL FOR TRANSISTORS:-



In the symbolic representation for a transistor, the arrow mark is placed on the emitter in the direction of conventional current flow, i.e., from P to N direction.

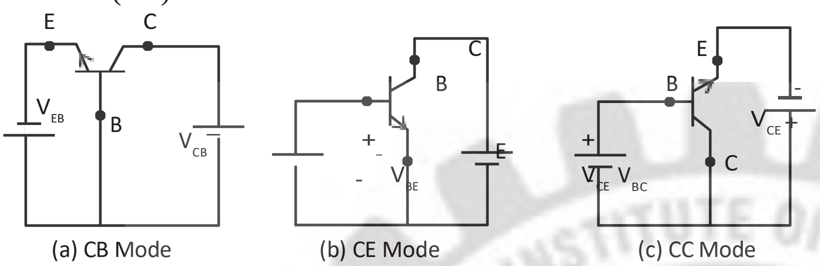
THREE DIFFERENT CONFIGURATIONS :-

In an electronic circuit a transistor can be connected in three different ways. They are,

(I) Common base (CB)

(ii) Common emitter (CE)

(iii) Common Collector (CC)



The term common is used to denote the lead that is common to the input and output circuits. The three different modes are shown above for NPN transistor .

For proper working of a transistor, the input junction should be forward biased and the output junction should be reverse biased.

WHY DO WE NEED AMPLIFICATION?

- When we cannot hear a stereo system, we have to increase the volume, when picture in our television is too dark, we should increase the brightness control. In both of these cases, we are taking a relatively weak signal and making its stronger (i.e., increasing of its power). The process of increasing the power of an a.c. signal is called amplification.
- The circuit used to perform this function is called amplifier. An amplifier may also be defined as a device, which amplifies the input weak signal. The input signal may be obtained from a phonograph, tape head or a transducer such as thermocouple, pressure gauge etc.

ADVANTAGES OF COMMON EMITTER CONFIGURATION:

On comparing the three different configurations of an amplifier, with help of their characteristics like input impedance, output impedance, current gain, voltage gain, power gain and phase reversal the following are the major advantages of common emitter configuration when compared with other configurations.

(a) High input impedance

(b) Low output resistance

(c) Moderate current gain

(d) High voltage gain

(e) High Power gain

(f) Phase reversal

In common emitter amplifier, the output signal is 180^0 out of phase with input signal.

5.3 DIGITAL ELECTRONICS

INTRODUCTION

With the invention of the transistor in 1948 by W.H.Brattain and I.Bardeen, the electronic circuits became considerably reduced in size. It was due to the fact that a transistor is cheaper, easily available, smaller compare to vacuum tube, less power consuming. It is widely used in many electronic circuits.

With the development of printed circuit board (PCB) which further reduced the size of electronic equipments in the early 1960's a new field of "microelectrics" was born primarily to meet the requirements of the military, which wanted to reduce the size of its electronic equipment. The drive for extremely small size of microelectronic circuits ends up with an invention of integrated circuits (ICs). Integrated circuits can contain anything from one to millions of logic gates, flip-flops, multiplexers, and other circuits in a few square millimetre. The small size of these circuits allows high speed, low power dissipation and reduced manufacturing cost compared with board-level integration (PCB).

This increased capacity per unit area can be used to decrease cost and increase functionality.

In electronics, an integrated circuit (also known as IC chip, or microchip) is a miniaturized electronic circuit (consisting mainly of semiconductor devices, as well as passive components) that has been manufactured on the surface of a thin substrate of semiconductor material. Integrated circuits are used in almost all electronic equipment in use today and have revolutionized the world of electronics.

The integrated circuit was invented by Jack Kilby and Robert Noyce. This invention is a boon for digital technologies like computer, mobile phones, MP3 and DVD's. This list could be almost infinite.

Digital electronics :

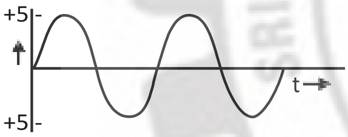
In the modern electronic world, signal processing plays vital role. Different types of signals with different shapes are generated by different devices. Two shapes of signals or waves are considered here.

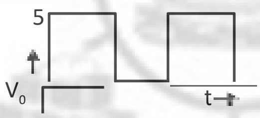
Analog signal and Digital signal :

The voltage signals which vary continuously with time are called continuous or analog voltage signals. The Fig (a) below shows a typical voltage signal, varying as a sinusoidal wave of 0 to 5 v.

In general, symmetrical square wave forms a digital signal. Fig (b) below shows a digital voltage signal, which does not vary continually with time. The values will be equal to 0V or 5V. By representing these two voltage levels as a binary numbers, 0 and 1 can be formed.

Digital signal processing is familiar and formed a digital world. The counters, computers, etc are outcome of digital electronics.





Positive and Negative Logic:

In computing system, the binary number symbols "0" and "1" represent two possible states of a circuit or an electronic device.

In positive logic, the "1" represents

1. an "ON" circuit 2. a "CLOSED" switch 3.a "HIGH" voltage

4. a "PLUS" sign 5. a "TRUE" statement.

Consequently, the "0" represents

1. an "OFF" circuit 2. an "OPEN" switch 3. a "LOW" voltage

4 a "MINUS" sign 5. a "FALSE" statement.

In Negative logic, just opposite conditions prevail.

Suppose, a digital system has two voltage levels like 0V and 5V.

If we say that value 1 stands for 5V and value 0 for 0V, then we have positive logic system.

If on the other hand, we decide that"1" should represent 0V (low voltage) and 0 should represent 5V (high voltage), then we have negative logic system.

Logic gates :

The logic gates are building blocks of digital electronics. They are used in digital electronics to change one voltage level (input voltage) into another (output voltage) according to some logical statement relating them.

Thus, logic gate is a digital circuit, which works according to some logical relationship between input and output voltage.

The logic gate may have one or more inputs, but only one output.

Truth table of a logic gate is a table that shows all possible input combinations and the corresponding output for the logic gate.

The logical statements that logic gates follow are called "Boolean expressions".

1. In Boolean algebra, the addition sign (+) is referred as OR. The Boolean expression is

   $$y = A + B$$

   This Boolean expression is read as y is equal to A 'OR' B.

2. The multiplication sign (.) is referred as AND in Boolean algebra. The Boolean expression is y = A.B

   This Boolean expression is read as y is equal to A 'AND' B.

3. The bar sign (-) is referred to as NOT in Boolean algebra. The Boolean expression is

   $$y = \overline{A}$$

   This expression Is read as y is equal to 'NOT' A.

SCALE OF INTEGRATION:-

INTEGRATED CIRCUITS:

It is an electronic circuit in which a number of active components (diode, transistors) and passive components (resistors, capacitors, and inductors) are made on a single small silicon chip.

Two types of Ic:

(i) Digital Ic , (ii) Linear Ic

Digital Ic:

- They process digital signals in calculators, computers.

Linear Ic :

- They process analog signals in communication electronics.

Types of scales of integrated:

- SSI –Small Scale Integration
- MSI-Medium scale Integration
- LSI-Large scale Integration
- VLSI- very large scale Integration

SSI:

- In this case, the number of circuits contained in one chip is less than 30 and components is less than 50.
- The chip area is 1 mm^2

MSI:

- In this, the number of circuits contained in one chip between 30to 100. The number of components is 50 to 500.
- Its chip area is 16 mm2.They are used in encoders, decoders, calculators, counters.

LSI:

- In this the number of circuits contained in one chip is between 1000 to 100000. Its chip area is $100mm^2$.
- They are used in memories and micro processors

VLSI:

- In this the number of circuits contained in one chip is greater than 100000. Its chip area is $100mm^2$ and more They are used in large memories and large micro processors.

ADVANTAGE OF ICS:-

ICs have the following advantages:-

1. Extremely small physical size. Often the size is thousands of times smaller than discrete circuit.
2. Weightless when compared with a discrete circuit. Since many circuit functions can be packed into a small area, in many applications where weight and space are critical, such as in air craft, space shuttle, satellite, etc., the IC invention and application brought a very big change in the satellite communication and satellite launching.
3. Life time of ICs is long which is most important from both military and consumer application point of view. Most significant factor is the absence of soldered connections.
   Extremely high reliability. IC damages are less under proper usage.
4. In signal processing, the signal transfer from one circuit to another circuit or from one device to another device is fast when we use ICs. Moreover, because of short distance between the internal circuits, the stray signal pick is less and nil in many ICs. Response time and speed are more, on the other hand.
5. Low power consumption.
6. Easy replacement
7. Cost effective due to mass production of IC and less failure rate in mass production.

<u>Applications of transistors, logic gates and ICs</u>

Transistors:

- Used as an inverter(NOT gate) in computer logic circuits.
- Used in amplifier, oscillator, modulator and detector circuits.
- Used in digital and analog circuits

Logic gates:

- NAND gates are used in burglar alarms and buzzers,push button switches and in the
- functioning of street light system.
- AND gates are used to enable or inhibit the data transfer function
- Used in microprocessors, microcontroller and embedded systems.

ICs:

- Every electronic device uses ICs. they are used as timers, amplifier, rectifiers,logic units,
- counters, calculators, temperature sensor, radio and TV receivers etc...