Youth Competition Times

RRB JE

2nd Stage (CBT-II)

CAPSULE

ELECTRONICS & ALLIED ENGINEERING

Computer Science, Information Technology, Instrumentation & Control Engineering

Theory + MCQ's

Study Material and Question Bank

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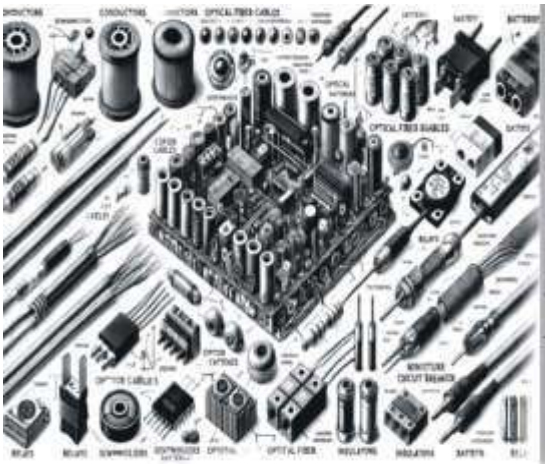
SYLLABUS

RRB JE CBT-2 Electronics Engineering

- **Electronic Components & Materials:** Conductors, Semiconductor& Insulators; magnetic materials; jointing & cleaning materials for U/G copper cable & OFC; Cells and Batteries (Chargeable and non chargeable); Relays, Switches, MCB & Connectors.
- **Electronic Devices and Circuits:** PN Junction diodes, thyristor; Diode and triode circuits; Junction Transistors: Amplifiers; Oscillator; multivibrator, counters; Rectifiers; Inverter and UPS.
- **Digital Electronics:** Number system and Binary codes; Boolean Algebra & Logic gates; Combinational & Sequential logic circuits; A/D & D/A Converter, counters, Memories.
- **Linear Integrated Circuit:** Introduction to operational Amplifier, Linear applications; Non-Linear applications, Voltage regulators, Timers; Phase lock loop.
- **Microprocessor and Microcontroller:** Introduction to microprocessor, 8085 microprocessor working; Assembly Language programming; Peripherals & other microprocessors; Microcontroller.
- **Electronic Measurements:** Measuring systems; Basic principles of measurement, Range Extension methods, Cathode ray oscilloscope, LCD, LED panel, Transducers.
- **Communication Engineering:** Introduction to communication; Modulation techniques; Multiplexing Techniques Wave propagation, Transmission line characteristic, OFC; Fundamentals of Public Address systems, Electronic exchange, Radar, Cellular and Satellite communication.
- **Data communication and Network:** Introduction to data communication, Hardware and interface; Introduction to Networks and Networking devices; Local Area Network and Wide area Network; Internet working.
- **Computer Programming:** Programming concepts; Fundamentals of 'C' and C^{++}; Operators in 'C' and C^{++}; Control Statements; Functions, Array String & Pointers, File Structure; Data Structure and DBMS.
- **Basic Electrical Engg:** DC Circuits; AC fundamentals; Magnetic, Thermal and Chemical effects of Electric current; Earthing-Installation, Maintenance, Testing.



1. Electronic Components and Materials

Content Detailed

■ Conductors, Semi conductor & Insulators ■ Magnetic materials; Jointing & Cleaning materials for U/G copper cable & OFC ■ Cells and Batteries (chargeable and non chargeable) ■ Relays, Switches, MCB & Connectors.

❒ Conductor

Materials with majority of free electrons are called conductors.

Conductors can be classified into three categories-

Solid conductor	Liquid conductor	Gaseous conductor
Solid conductors have a definite shape and size for example- gold, copper, iron etc are solid conductors.	Those conductors which are not stable in shape and have the property of flowing are called liquid conductors for example- Water (H_2O), Silver nitrate etc.	No gas is an ideal gas conductor. To make a gas a conductor, some amount of salt is added to it. So that it gets ionized and behaves like a good gaseous conductor. For example- Helium, Argon, Neon are gaseous conductors.

- **Properties of a good conductor:**

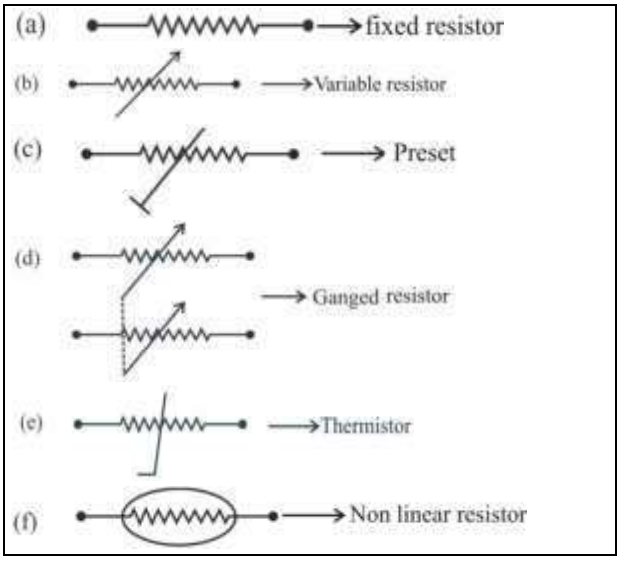
1. The conductor should be cheap and easily available.
2. The conductor should be ductile.
3. The conductor should be malleable.
4. The conductor should be unaffected by atmospheric influences.
5. The conductor material should have more conductivity and low resistivity.

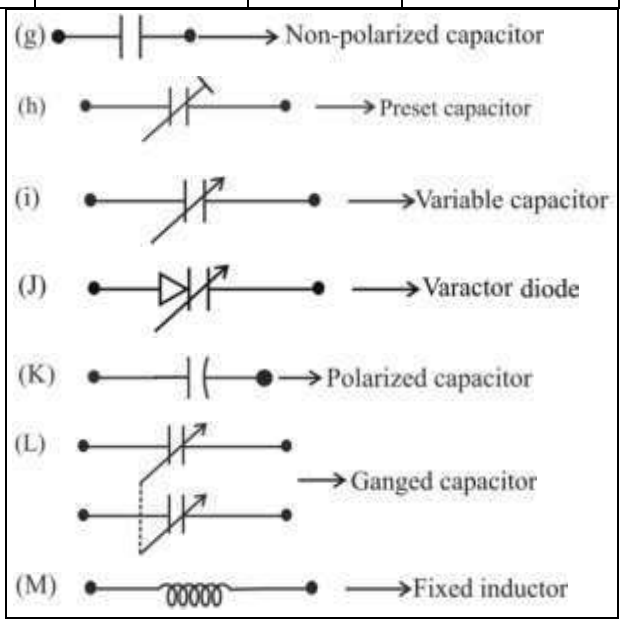
❒ **Some types of conductors and their properties:**

Sr. No.	Name of conductor	Colour or mixture	Resistivity (in ohm-meter (at 20^0C)	Conductivity (at 20^0C)	Melting point in ^{0}C	Temperature coefficient (at 20^0C) per ^{0}C
1.	Silver	White	1.59×10^{-8}	6.289×10^{7}	960	0.0038
2.	Copper	Dull red	1.72×10^{-8}	5.8×10^{7}	1084	0.00428
3.	Aluminium	White	2.82×10^{-8}	3.4×10^{7}	657	0.004013
4.	Gold	Golden yellow	2.44×10^{-8}	4.2×10^{7}	1063	0.0034
5.	Tungsten	Dark grey	5.6×10^{-8}	1.79×10^{7}	3422	0.0051
6.	Zinc	Blue grey	5.9×10^{-8}	1.69×10^{7}	420	0.0037
7.	Brass	Yellow (Cu + Zinc)	6.3×10^{-8}	1.59×10^{7}	930	0.0015
8.	Nickel	White	6.99×10^{-8}	1.43×10^{7}	1453	0.00537
9.	Iron	Silvery-grey	1.0×10^{-7}	1.0×10^{7}	1538	0.0069
10.	Tin	White	1.09×10^{-7}	9.17×10^{6}	232	0.0051

11.	German silver	Mixture Copper→60% Nickel→15% Zinc →25%	3.316×10^{-7}	3.015×10^{6}	960	0.0027
12.	Lead	Grey	2.2×10^{-7}	4.55×10^{6}	327	0.0043
13.	Manganin	Mixture Copper → 84%, Manganese→12% Nickel→4%	4.82×10^{-7}	2.0×10^{6}	960	0.00025
14.	Eureka	55% copper and 45% Nickel	5×10^{-7}	4.04×10^{6}	1270	+0.00001–0.004
15.	Platinum	White-grey	1.06×10^{-7}	9.43×10^{6}	1773	0.00367
16.	Mercury	Silver -White	9.8×10^{-7}	1.02×10^{6}	–38.9	0.0009
17.	Nichrome	80% Nickel + 20% Chromium	1.10×10^{-6}	9.09×10^{5}	1400	0.0014
18.	Carbon	–	3×10^{-5}	1.25 to 2×10^{4}	3500	-0.005

■ Electronics components symbol





☐ Comparison of different types of resisters-

Type of resistor	Resistive material	Range	Power rating	Tolerance	Cost	Noise	High frequency response	Temp. Coefficient
Carbon Composition	Carbon- Clay	upto 20MΩ	upto 2W	+5% to ± 20%	Moderate	Low	Better	Low
Carbon and metal film	carbon or thin layer of metal	upto20 MΩ	More than carbon composition	± 1% to ± 5%	Cheap	High	Normal	More than carbon composition
Wire wound	wire wrapped around an insulating core	upto100 kΩ	upto 200 W	± 1%	Costly	Very Low	Poor	Medium

Comparison of Different types of capacitors-

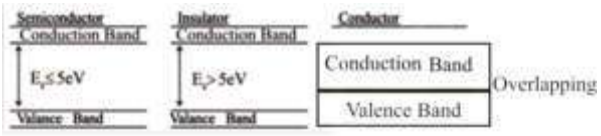
Type of Capacitor	Dielectric (Dielectric constant)	Range	Voltage Rating	Tolerance	Leakage current	Polarity	Application
Paper Capacitor	Impregnated paper (2-6)	0.0005 μF to 10 μF	100V to several thousand volts	± 10%	Low	No	AC, DC, High voltage and High Current
Polyester capacitor	Polyester (2.0)	0.0005μF to 10μF	upto 2000V	± 10%	Low	No	tuned circuit, Digital computer
Ceramic capacitor	Ceramic (80-1200)	3 pf to 2μF	3V to 6000V	± 10% to ± 20%	Low	No	Coupling capacitor, Bypass capacitor
Mica capacitor	Mica (3-8)	1 pf to 1 μF	500 V, 40kV at high frequency	± 0.5%	Low	No	Temperature varying
Electrolyte Capacitor	Aluminium Oxide (7)	1μF to several thousands μF	1V to 500V	± 10%	High	Yes	Filter circuit, coupling capacitor

Energy Bandgap $\boxed{E_g = E_c - E_v}$

E_c = Energy level of conduction band

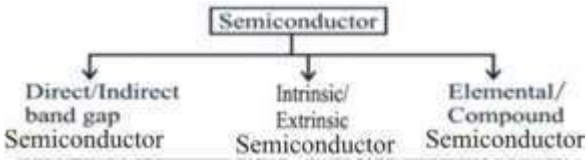
E_v = Energy level of valance band

E_g = Forbidden energy gap



- In metals the conduction band and valance band overlap with each other.
- In insulator energy band gap is very high.
- In semiconductor energy band gap is relatively small.
- Valance band can never be empty.
- $1eV = 1.6\times10^{-19}$ Joule

❒ Semiconductor



Elemental semiconductor

➢only single element ➢ C, Si, Ge, Pb

Compound semiconductor

➢ at least two elements ➢ GaAs, GaN

Direct/Indirect Band gap Semiconductor:

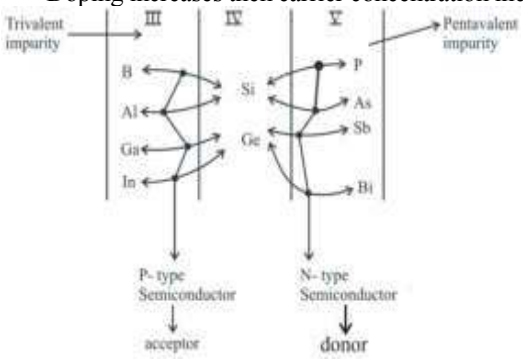
- Light is produced in the direct band gap.
- Heat is produced in the indirect band gap.
- Direct Band gap semiconductor- GaAs, GaN, GaSb, CdS, InGaAs, ZnS
- Indirect Band gap semiconductor- Si, Ge, AlAs, AlSb, PbSe, GaP.

Comparison of intrinsic semiconductor and extrinsic semiconductor

Intrinsic semiconductor	Extrinsic semiconductor
It is pure semiconductor	It is impure semiconductor
Number of free electrons is equal to number of holes.	Number of free electrons and number of holes are unequal.
Conductivity is low.	Conductivity is high.
Conductivity depends only on temperature.	Conductivity depends both on temperature and impurity.
No impurity.	Trivalent and pentavalent impurity.
The order of current in milliamperes.	The order of current in microamperes.

Doping - The process of adding of impurity into pure semiconductor.

- Doping increases then carrier concentration increases.



Standard Doping Level

- $\boxed{\text{Moderate doping}} \Rightarrow 1:\left[10^6 \text{ to } 10^8\right] \rightarrow$ N and P type SC
- $\boxed{\text{Lightly doping}} \Rightarrow 1:10^{11} \rightarrow N^-$ and P^- type SC
- $\boxed{\text{Highly doping}} \Rightarrow 1:10^3 \rightarrow N^+$ and P^+ type SC

➢ Intrinsic SC $\xrightarrow{1:10^8}$ Extrinsic SC

- $1:10^6$ or 1 in 10^6 or $1/10^6$ is read as , 1 impurity atom in 10^6 atoms.
- Conductor ⟶ Metallic Bond
- Semiconductor ⟶ Covalent Bond
- Insulator ⟶ Ionic Bond

Comparison of N-type and P-type Semiconductor-

Parameter	N-type	P-type
Doping	Pentavalent impurities.	Trivalent impurities.
Conductivity	More	Less
Impurities	Extra electrons known as donor atoms.	Extra holes, known as acceptor atoms.
Charge carrier	Majority charge carrier are electrons and minority carrier are holes.	Majority carrier are holes and minority carrier are electrons.
Fermi level	Near to conduction band.	Near to valence band.

Fermi Level

- It indicates carrier concentration.
- Fermi level also gives the information that, at 0^0K above fermi level, all are empty and below fermi level all allowed energy levels are filled.

$$f(E)=\frac{1}{1+e^{\left[(E-E_F)/KT\right]}} \qquad K=1.38\times10^{-23}\,J/K$$

Where, E: given energy level
E_f: fermi-level
K: Boltzmann's constant
T: Absolute temperature

f(E) doesn't gives:
(i) Number of electrons in a given energy level
(ii) Number of energy levels with electrons.

At T = 0K

case (i) : $E << E_f$:

$$f(E)=\frac{1}{1+e^{(E-E_f)/KT}}=\frac{1}{1+e^{-\infty}}=1\Rightarrow 100\%$$

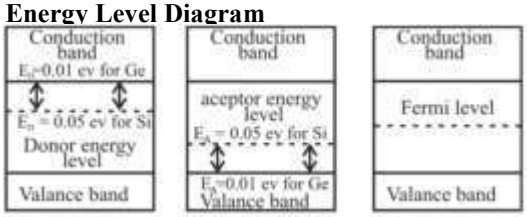
case (ii) : $E = E_f$: at $T \neq 0$

$$f(E)=\frac{1}{1+1}=\frac{1}{2}=0.5\Rightarrow 50\%$$

case (iii) : $E >> E_f$: at T = 0K

$$f(E)=\frac{1}{1+e^{(E-E_f)/KT}}=\frac{1}{1+e^{+\infty}}=0\Rightarrow 0\%$$

Energy Level Diagram



- The Fermi Level in intrinsic semiconductor lies center of the forbidden gap.
- The Fermi Level in P-type semiconductor lies above the valance band
- The Fermi Level in N-type semiconductor lies below the conduction band.

Effect of temperature on Fermi-level:
When temperature goes on increases extrinsic semiconductor gradually gets the intrinsic behaviour when thermally generated e^- concentration dominates the donor electrons, so that Fermi-level to the mid-gap.

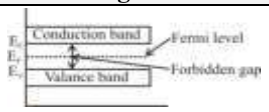
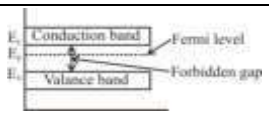
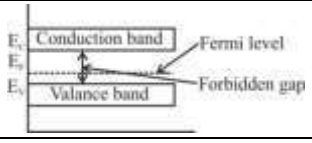
Fermi energy level: The Energy of the electron at 0K is called Fermi energy (Unit → eV)

$$\text{Fermi Energy} = \text{Maximum kinetic energy of electron}$$

$$E_F=\frac{1}{2}mv^2 \qquad V=\sqrt{\frac{2E_F}{m}}$$

- If the Fermi function is f(E) of any electron, then the Fermi function for the hole = 1–f(E)
- $E_g = KT\ell n\left(\frac{N_C.N_V}{n_i^2}\right)$

Fermi level in different type semiconductor

Semiconductor	Fermi formula	Fermi diagram
Intrinsic semiconductor	$E_F=\frac{E_C+E_V}{2}-\frac{KT}{2}\ln\left(\frac{N_C}{N_V}\right)$	
n-type semiconductor	$E_F=E_C-KT\ln\left(\frac{N_C}{N_D}\right)$	
p-type semiconductor	$E_F=E_V+KT\ln\left(\frac{N_V}{N_A}\right)$	

- A semiconductor at absolute zero temperature, behaves as a perfect insulator.
- In a intrinsic semiconductor the resistivity (inverse of conductivity) decreases as the temperature increases. Hence the semiconductors have negative temperature coefficient of resistance.

Electrical Neutrality

- n- type and p- type semiconductors are electrically Neutral.

$$N_D+p=N_A+n$$

Where. $N_D \rightarrow$ Donor, $N_A \rightarrow$ Acceptor
$p \rightarrow$ Positive charge, $n \rightarrow$ Negative charge.

Energy Band gap (E_g): $E_g \propto \frac{1}{\text{temp.}}$

	Ge	Si	GaAs
E_{g0K}	0.785 eV	1.21 eV	1.52 eV
E_{g300K}	0.72eV	1.1 eV	1.42 eV

Mass Action Law: $n \cdot p = n_i^2$

Where, n = concentration of electron
p = Concentration of hole.
n_i = Intrinsic carrier concentration.

- Mass action law mostly used for extrinsic semiconductor to find minority carrier concentration.
- When temperature changes, n_i^2 also changes. So mass-action law not valid when temperature Changes.

$$\text{Minority carrier conc.} = \frac{n_i^2}{\text{majority carrier conc.}}$$

- Minority carriers depend on → Temperature
- Majority carriers depend on → Doping

$$\text{Minority carrier conc.} = \frac{n_i^2}{\text{Doping conc.}}$$

Thermal Voltage $V_T = \frac{KT}{q}$ $V_T = \frac{T}{11600}$

$V_T = 26mV$

Boltzman constant

$\bar{K} = 1.38 \times 10^{-23} J/^oK$ $K = 8.62 \times 10^{-5} eV/^oK$

Diffusion coefficient

Element	Formula	Ge (300K)	Si (300K)
Electron(e^-)	$D_n = \mu_n \times V_T$	99 cm^2/sec	34 cm^2/sec
Hole (H^+)	$D_p = \mu_p \times V_T$	47 cm^2/sec	13 cm^2/sec

$\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \frac{KT}{q} = V_T$ (Einstein relation)

Where,
D_n = diffusion coefficient of electron
D_p = diffusion coefficient of hole
μ_n = mobility of electron
μ_p = mobility of hole
V_T = thermal voltage
T = temperature
K = Boltzman constant

Conductivity

Element	Conductivity formula
Metal	$\sigma = q\mu n = \rho\mu = \frac{J}{E}$
Intrinsic semiconductor	$\sigma = n_i q \mu$
Extrinsic Semiconductor	$n-\text{type} \rightarrow \sigma = n q \mu_n$ $p-\text{type} \rightarrow \sigma = p q \mu_p$
Intrinsic Semiconductor	$\sigma = n_i q(\mu_n + \mu_p)$
For minimum conductivity for P-type: $P = n_i\sqrt{\left(\frac{\mu_n}{\mu_p}\right)}$ for n-type: $n = n_i\sqrt{\left(\frac{\mu_p}{\mu_n}\right)}$ For minimum conductivity condition for p-type semiconductor is $\sigma_{min} = 2n_i\sqrt{\mu_n\mu_p}.q$	
Where, σ = Conductivity, n_i = Carrier Concentration μ_n = Mobility of electrons, μ_p = Mobility of Holes q = Charge	

- In metal when temperature increases mobility of charge carrier decreases therefore conductivity decreases with temperature.
- In metal free electron concentration is independent of temperature.
- In semiconductor conductivity mainly depends on carrier concentration.
- For 1ºC Ge → σ ↑ by 6% : Si σ↑ by 8%.

Electric field intensity

$E = \frac{|dV|}{dt}$ V/m

Where,
dV = Change in voltage, dt = thickness of bar

- Anywhere of the semiconductor bar field intensity is same.

Mobility of charge Carriers

- It is drift velocity per unit electric field.
- unit → $\frac{m^2}{V-s}$ or $\frac{cm^2}{V-s}$
- It defined how fast the charge carrier travels from one place to another and is given by - $\mu = \frac{V_d}{E}$

Where, V_d = drift velocity , E = Electric field

Mobility	Ge	Si	GaAs
e^- mobility (μ_n)	3800 cm^2/Vsec	1300 cm^2/Vsec	4600 cm^2/Vsec
hole mobility (μ_p)	1800 cm^2/Vsec	500 cm^2/Vsec	400 cm^2/Vsec

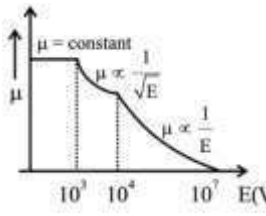
- Mobility of charge carriers decreases with increases temperature and varies as -: $\mu \propto T^{-m}$

  Where, m is constant

  $\text{In Ge} \rightarrow m = 1.66 \text{ for } e^- \text{ and } 2.33 \text{ for hole}$

  $\text{In Si} \rightarrow m = 2.5 \text{ for } e^- \text{ and } 2.7 \text{ for hole}$

- Mobility also varies with applied electric field



μ = constant	$E < 10^3 V/cm$
$\mu \propto \frac{1}{\sqrt{E}}$	$10^3 < E < 10^4$ V/cm
$\mu \propto \frac{1}{E}$	$E < 10^4 V/cm$

- At smaller electric field mobility is constant
- At very high electric field product of mobility and electric field becomes constant and is equal to saturation value of drift velocity.
- Overall mobility-

$$\frac{1}{\mu_T} = \frac{1}{\mu_1} + \frac{1}{\mu_2} + \frac{1}{\mu_3} + ...$$

Where, μ_T = overall mobility

$\mu_1, \mu_2, \mu_3 \rightarrow$ mobility corresponding to different scattering Mechanism.

☐ **Wave length of light (λ) -** $\lambda = \frac{1.24}{E_g(eV)} \mu m$

E_g = Energy gap of the material in Electron Volt

$\text{For visible light } \lambda = 0.38\mu m \text{ to } 0.76\mu m$

$\text{For infrared } \lambda > 0.76\mu m$

☐ **Important point related to Si**

- Si has better thermal stability.
- It is more suitable for used in switching application.
- High power handling capacity.
- Uses in high power device Ex. SCR. DIAC, TRIAC
- Low frequency application, ➢ Low leakage current (nA)
- Atomic Number → 14, ➢ atomic weight → 28.086

☐ **Important point related to Ge**

- It is higher conductivity due to large mobility.
- Relatively more suitable for high frequency applications.
- Higher leakage current (μA), ➢ atomic Number →32
- atomic weight → 72.63
- Large conductivity than, Ge > Si

☐ **Important point related to GaAs**

- It is a direct band gap Semiconductor.
- Covalent bond present, ➢Switching time very small.
- Used in microwave device.

☐ **Used-** LED, LASER, Tunnel diode, varactor diode, PIN diode

☐ **Intrinsic Concentration (n_i)**

$n = p = n_i$ $\quad n_i = \sqrt{A_0} T^{3/2} e^{\frac{-Eg}{2KT}}$

$n_i^2 \propto T^3$, $n_i \propto T^{3/2}$ A_0 = material constant

Hence n_i varies non-linear with temp., At T= 300K

Si-$n_i = 1.5 \times 10^{10}$ atom/cm^3 $\quad$ Ge-$n_i = 2.5 \times 10^{13}$ atom/cm^3

❒ Insulators

The substances in which the number of free electrons is negligible are called insulators.

■ Properties of Good Insulator

1. The value of dielectric strength should be high.
2. The specific resistance should be more than 10^{12} ohm centimeter
3. The material should be able to radiate heat.
4. The insulators should unaffected by moisture and water
5. The insulator material should be strong.

■ Classification of Insulators

Solid Insulator	Liquid Insulator	Gaseous Insulator
Solid dielectrics have definite shape, size and volume. For example- Ebonite, mica, Bakelite, porcelain, glass, marble, slate, dry wood, fiber etc.	Those dielectric which have the property of flowing and do not have any definite shape are called liquid dielectric. For example- mineral oil.	Those dielectric which do not have any definite shape or size are called gaseous dielectrics, For example dry air, nitrogen, hydrogen etc.

■ Different types of Insulators:

Sr. No.	Name of Insulator	Dielectric strength (kV/mm)	Characteristics
1.	Dry air	About 3 kV/mm	It is the best insulation material. Bare metallic wires are used in overhead lines and the air between them acts as a insulator.
2.	Vulcanized rubber	30-50 kV/mm	Vulcanized rubber is prepared by mixing sulphur and zinc oxide in ordinary rubber through heat process. It is used as a dielectric covering in various type of wires and cables.
3.	Polyvinyl chloride, (PVC)	About (14–20) kV/mm	It is good insulating material, which is more durable than vulcanized rubber. At present PVC is increasingly being used in place of rubber.
4.	Ebonite	30–40 kV/mm	It is hard, material-like rubber that starts burning at 180ºC. It is used to make lead acid, storage battery cover, panel boards, machine cover etc.
5.	Mica	20–60 kV/mm	It is only natural and mineral substance that is transparent and unaffected by fire and moisture. It is used as the base of heating elements of electrical heating devices.
6.	Micanite	20–40 kV/mm	Micanite paper or cloth is made by pasting very thin sheets of mica on cloth or paper with the help of varnish. It is used in armature winding work.
7.	Bakelite	17–21 kV/mm	It is used in making switches, Plugs, Tops, Sockets, Bulb holder, Celling roses etc.
8.	Learthroid paper	12–17 kV/mm	It is used as a insulation layer between coil and armature slots in the winding of electrical machines.
9.	Resin	12–14 kV/mm	It is a synthetic substance; it is used in making Bakelite.
10.	Mineral oil	10–16 kV/mm	Non-conductivity of mineral oil is very high. It is obtained from petroleum. It is used in transformer starters, switches with high current carrying capacity, capacitors etc.
11.	Porcelain	8–12 kV/mm	This is a special type of clay. It is used for making overhead lines, kit-kat fuses, switches plates for heating elements.
12.	Glass	8–12 kV/mm	It has property of brittleness, so it is not used in switches. It is used to make the cover of bulbs, fluorescent tube etc.
13.	Asbestos	4–6 kV/mm	It is a white coloured fibrous mineral. It is used as a insulator and heat barrier in electric iron and heater etc.
14.	Marble	2–6 kV/mm	It is a white coloured mineral stone. Its powder is used as a insulator in immersion heating element.
15.	Shellac (Varnish)	2–3 kV/mm	It is a chemical material, which prepared by dissolving it in methylated spirit. It is used in paper, cloth, wood winding etc.
16.	Paper	1–10 kV/mm	It is prepared from grass, cotton etc. It is used as a non-conducting layer in paper capacitors. Leatheroid paper and presspahn paper are two types of paper.

◘ Classification of insulator based on temperature

Class	Maximum safe Temperature	Insulating material
Y	90°C	Cotton, silk, normal paper, wood
A	105°C	Cotton, Silk, oil absorbed paper
E	120°C	Leatheroid paper, empire cloth, fiber
B	130°C	Mica, fiber glass, asbestos
F	155°C	Mica, fiber glass, Asbestos
H	180°C	Material made from mixture of Elastomer and mica, fiber glass, asbestos
C	More than 180°C	Mica, porcelain, glass, quartz.

❑ Magnetic Materials

Materials that can be magnetized are called magnetic materials. Net magnetic field produced by an electron at nucleus is zero.

Magnetization means alignment of dipoles in the direction of applied magnetic field.

■ **Magnetic Dipole :** Two unlike magnetic poles of equal pole strength at a very small distance is known as magnetic dipoles.

☛ **Example :** A small bar magnet, magnetic needle, a current carrying loop etc.

■ **Magnetic Laws:** Magnetic Laws are following –

- **Biot-savart Law–** $\boxed{dB = \frac{\mu_0}{4\pi}\frac{Id\ell\sin\theta}{r^2}}$

  B = Magnetic field, r = Distance , $d\ell$ = Differential length

- **Ampere's circuital Law :**
  Ampere's law is analogous to Gauss's law in electrostatics.

  $\boxed{H = \frac{I_{enc}}{2\pi r}}$ also $\boxed{\oint_C \vec{H}\cdot\vec{dl} = I_{enc}}$

■ **Magnetic Flux-**

- The number of magnetic field lines which pass through a given cross-sectional Area (A).
- SI unit -Weber
- CGS unit- Maxwell
- Formula - $\phi = B\times A$
- 1 Weber = 10^8 Maxwell's

■ **Magnetic flux density:**

$\boxed{B = \frac{\phi}{A} = \mu H}$ (Wb/m^2 or Tesla)

■ **Magnetic susceptibility(χ_m):** Magnetic susceptibility is the degree of magnetization of a material in response to an applied magnetic field.

$\boxed{\chi_m = \frac{M}{H}}$ → Magnetization / → Magnetic field intensity

It is unitless proportionality constant.

■ **Magnetic Moment:** $\boxed{m = I\times A}$ in Amp-m^2

m -Magnetic moment, I - Current, A → Area

$$\text{Magnetization}(M) = \frac{m_{net}}{V} \begin{matrix}\rightarrow \text{Net magnetic moment}\\ \rightarrow \text{Volume}\end{matrix}$$

$$\therefore M = \frac{Am^2}{m^3} = A/m$$

■ **Magnetic Intensity :**

$B = B_0 + B_m = \mu_0(H + M)$

$B = \mu_0 H + \mu_0 M = \mu_0 H + \mu_0\chi_m H$

$= \mu_0 H(1+\chi_m) = \mu_0\mu_r H \quad [\because \mu_r = 1+\chi_m]$

■ **Bohr Magneton:** Smallest unit of magnetic moment is Bohr Magneton.

$\boxed{P_B = \frac{neh}{4\pi m}}$ for n = 1, $P_B = 9.27\times10^{-24}$ Amp-m^2 or J/T

■ **Magnetic Anisotropy:** Different magnetic properties exhibited by ferromagnetic materials in different directions is known as magnetic anisotropy.

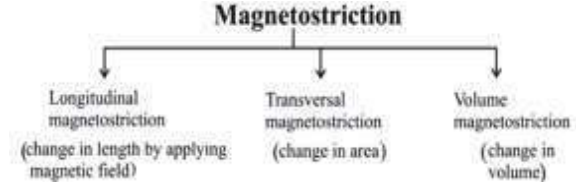
■ **Causes of magnetic anisotropy**

□ **Cold working:** when material is shaped without increasing temperature.

□ **Annealing :** Heat treatment of a material

□ **Quenching :-** Immediate cooling after heating.

■ **Magnetostriction:** Change in dimension of a material when magnetic field is applied is called magnetostriction.

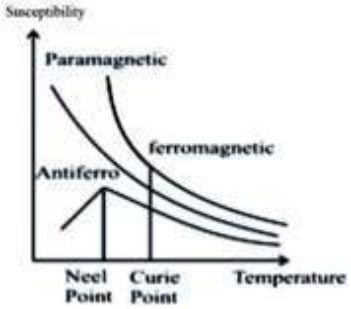


erse of magnetostriction is called "Villari ."

■ **Curie Temperature:** The temperature at which a ferromagnetic material becomes paramagnetic in nature. A magnetic material completely loses its magnetic property at curie's temperature.
According to Curie's law-

i.e. $\boxed{\chi_m = \frac{C}{T}}$ Where, C → Curie's constant

■ **Temperature Vs Susceptibility:**

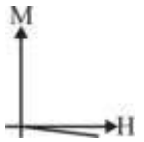
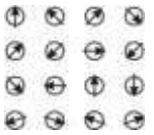
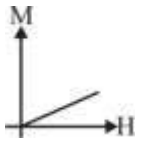
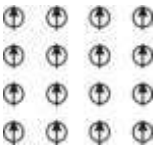
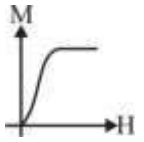
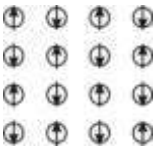
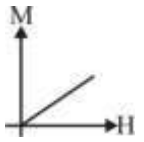
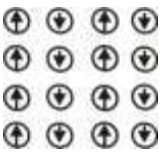
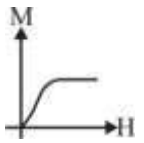


- **Paramagnetic –** Curie's law $\boxed{\chi_m = \frac{C}{T}}$
- **Ferromagnetic –** Curie- weiss law $\boxed{\chi_m = \frac{C}{T-\theta}}$

  θ- Curie's temperature, T > θ (ferro → para)
- **Anti ferromagnetic –** Curie – Weiss law

  $\boxed{\chi_m = \frac{C}{T+\theta_n}}$ T > θ_n (Neel's Temp)

■ Different types of magnetic materials and their properties :

Type	Example	Atomic/Magnetic Behaviour		
Diamagnetic	Inert gases, many metals - Au, Cu, Hg, non-metallic elements - Bi, Si, P, S, many ions - Na^+, Cl^- & their salts, diatomic molecules - H_2, N_2, H_2O, most organic compounds, graphite	Atoms have no magnetic moment. Susceptibility is small & negative.		
Paramagnetic	Some metals - Al, some diatomic gases - O_2, NO, ions of transition metals and rare earth metals, and their salts, rare earth oxides.	Atoms have randomly oriented magnetic moments. Susceptibility is small & positive.		
Ferromagnetic	Transition metals Fe, CrO_2, Co, Ni, alloys of ferromagnetic elements, some alloys of Mn - MnBi, Cu_2MnAl.	Atoms have parallel aligned magnetic moments. Susceptibility is large (below T_C).		
Antiferromagnetic	Transition metals Mn, Cr & many of their compound - MnO, CO, NiO, Cr_2O_3, MnS, MnSe, CuC_2.	Atoms have antiparallel aligned magnetic moments. Susceptibility is small & positive.		
Ferrimagnetic	(Fe_3O_4-magnetite), (Fe_2O_3-maghemite), mixed oxides of iron and other elements such as Sr ferrite.	Atoms have mixed parallel and anti-parallel aligned magnetic moments. Susceptibility is large (below T_c).		

■ Important Terms Related to Magnetism –

Air gap	The distance between north and south poles of magnetic circuit.
Coercive force	The magnetic field required to reduce the residual magnetism to zero value.
Residual magnetism	Remaining magnetisation in the magnet after magnetic field intensity is zero.
Gauss	The unit of magnetic induction or magnetic flux density used to measure the magnetic field density (magnetic flux/cm^2).
MGO	Mega Gauss Oersted
Oersted	The unit of magnetic intensity in the CGS system that describes magnetic force.
Retentivity	The material's ability to retain the magnetization when magnetic field is removed after saturation.

■ Types of magnetic materials:

- **Soft magnetic materials :-** These are used in transformer, electric machines and magnetic memory.
  - ☛ **Ex.** Iron, Iron-silicon alloys, Nickel-iron alloys.
- **Hard magnetic materials :-** These are also called permanent magnetic materials.
  - ☛ **Ex.** Alnico, Chromium steel, Tungsten steel, Carbon steel etc.

❒ Cable

A wire with a insulation cover is called a cable. The thickness of insulation layer on the conductor of the cables depends on the voltage.

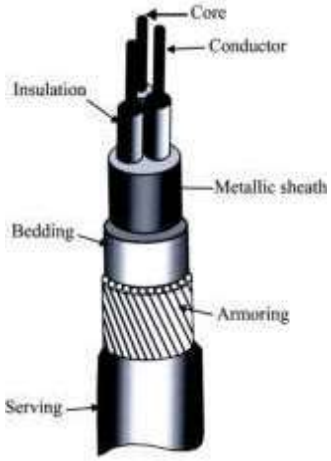
- **The structure of the cable mainly consists of the following parts:**

  Layer over a cable is CIMBAS.

  C→ Core of conductor, I → Insulation

  M → Metallic sheath, B → Bedding,

  A→ Armouring S→ Serving

Main part	Feature	Cable structure
Core	➲ Electric current flows through this part. ➲ In this aluminium or copper wires are used. ➲ Its thickness depends on the current carrying capacity.	
Insulation-covering	➲ Each core has a paper, fabric or varnished paper covering over it. ➲ The thickness of this insulation covering depends on the voltage carried by the cable.	
Metallic Sheath	➲ A layer of lead or lead-alloy is applied on the insulation cover. ➲ This metallic layer does not allow moisture to reach the core.	
Bedding	➲ A layer of fiber and paper material or jute or sackcloth dipped in bedding compound is applied on the metallic sheath. ➲ This layer protects the metallic layer from mechanical injuries, scratches etc.	
Armouring	➲ It is applied on the bedding. ➲ It is an sheath made of galvanized steel wire. ➲ It protects the cable from mechanical injuries, pressure etc.	
Serving	➲ This layer is applied on the armouring. So that the armouring can be protected. For this, fiber containing material or jute/sackcloth dipped in fiber compound is used.	

- The life of the underground cable is 40-50 year.
- In underground cable, losses are less as compare to overhead line.
- Maintenance cost is less in underground cable.
- Initial cost is more in underground cable while initial cost in overhead line is low.
- Surge Impedance of cable to 40 Ω-60Ω where as the surge impedance of overhead line is 400 Ω -600Ω.

☐ **Colour of different types of wire or cables :**

Type	Colour Code
1ϕ−line	Red/Brown
1ϕ Neutral	Black / blue
Ground wire	Green
3-ϕ neutral	Black
Neutral wire Three core flexible cable	Blue

☐ **Cable Insulation**

Based on the use, the following are the types of insulation material used in cable insulation −

1. Rubber	2. Vulcanized Indian rubber
3. Impregnated paper	4. Varnish cambric
5. Polyvinyl chloride	6. Vulcanized bitumen
7. Gutta Purcha	8. Asbestos
9. Silk and Cotton	10. Enamel insulation

☐ **Types of Cables:**

Type of cable	Features	Uses
VIR (Vulcanized India Rubber)	This cable is usually of one core. It is covered with vulcanized Indian rubber (VIR) If required, it can be made of two or three cores.	It is used in casing capping, conduit pipe and temporary type of electrical wiring.
CTS (Cable Tyre Sheathed) Cable	It is made in one, two and three cores. It is also called T.R.S. or tough rubber sheathed cable.	It is used in electrical wiring in moisture places.
PVC cable	This cable is covered with poly-vinyl chloride. It is made in one, two three and four cores.	It is used in electrical wiring. It is used at normal temperature.
Lead Sheathed Cable	It is prepared by covering it with vulcanized Indian rubber and then a protective covering of a metal called lead. It is made in one, two, three and four cores.	It is used in electrical wiring of chemical industries and other machines.
Weather-Proof cable	This cable is similar to VIR cable. It is made weather-proof by dipping in a liquid that can with stand atmospheric changes. It is made in, one, two and three or four cores.	It is used in open spaces in domestic and industrial electrical wiring.

Tropodure Cable	It is prepared by coating a thermo plastic compound on PVC cable. It is made in one, two three or four cores.	It is used in wiring of railway signals and power equipment
Flexible cable	It is made by collecting may thin wires in the form of a group and coating a insulation coating on it.	It is used where they need to withstand motion and flexing.
Ordinary flexible cable	The diameter of these wires is generally 0.193 mm and SWG number is 36.	They are used for general purposes example- temporary electrical wiring, connecting loudspeakers to amplifiers etc.
Cotton or Silk covered flexible cable	These cables are prepared by coating vulcanized Indian rubber on 23 or 40 wires of 36 SWG number of copper. These are usually 3 cores.	These are used as main leed in electrical thermal equipment example- electric Iron, electric toaster etc.
Workshop flexible cable	It is made in the form of 3 or 4 cores with current carrying capacity up to 25A.	It is used as the main leed of mobile machines in the workshop.
Armoured cable	This type of cable is made by coating a insulation layer of polyethylene on a single stranded copper wire.	It is used as an underground cable for power supply.

- **Classification of cables based on voltage grade which are used in electrical equipment/wiring:**

Classification	Rating	Type of cable
Low Voltage Cable	For domestic light, fan and power load up to 250V.	VIR, PVC, CTS, weather proof and flexible type are used.
Medium voltage cable	For domestic and industrial power load up to 650V	VIR, PVC, CTS, weather-proof, lead sheathed, tropodure and flexible type are used.
High voltage cable	Used in power distribution system up to 22,000 V or 22 kV.	Armoured type cables are used in this.
Extra high voltage cable	Voltage above 22,000V or 22 kV	

- **Classification of Underground Cables :**

Based on number of core	Based on voltage	Based on insulation material	Based on area	Based on state of insulation material
1. Single core cable	1. Low tension cable (upto 1 kV)	1. (MI cable) mineral insulated cable	1. Electronic cable	1. Solid cable
2. Two core cable	2. High-tension cable (1 kV to 11 kV)	2. (XLPE) cross linked poly ethylene cable	2. Electric power cable	2. Liquid cable
3. Three core cable	3. Super-tension cable (11 kV to 33 kV)	3. (PVC) Poly vinyl chloride cable		3. Gas cable
4. N - core cable	4. Extra-high tension (33 kV to 66 kV)			
	5. Oil filled and gas pressure cables (66 kV to 132 kV)			

Classification of cable based on structure :

Cable	Voltage
General cable	Below 11 kV
Belted cable	11kV to 22kV
Screened cable	22kV to 66kV
Pressure cable- 1. Oil pressure cable 2. Gas pressure cable	Above 66kV 132kV to 220kV Above 220kV

Types of Underground Cable for 3-phase Supply

Type of underground cable for 3-ϕ	Rating and features
1. Belted cable	➲ In normal conditions it can be used upto 11 kV but in abnormal conditions it can be used up to 22 kV. ➲ It is used for low and medium voltage. In this each core is jointly insulated by paper strips.
2. Shielded cable	➲ This type of cable is used for high voltage generally 22 kV to 66kV
(i) Shielded or H cable	➲ It is used to 66kV. In this after applying a insulated layer on each core, a perforated metallic sheath is applied on it.
(ii) SL Cable (Separate lead cable)	➲ In this type of cable, a insulated layer, metallic cover, bedding and armouring are applied on each.
(iii) HSO cable	➲ The cross-section of this cable is triangular. Due to which its weight and thermal resistance are reduced.
(iv) PILC cable (Paper insulated lead cover cable)	➲ It is suitable for low (250V) and medium (650V) voltage. This is a normal type of paper insulated, belted type cable.
(v) PILCSTA cable (Paper insulated lead covered single tapped armouring cable	➲ It is used up to 11 kV. ➲ This is also a type of belted cable.
(vi) PILCDTA cable (Paper insulated lead covered double tapped armored cable)	➲ It is used up to 33 kV. ➲ It is a belted cable with double armouring.
(vii) PVC cable (Poly Vinyle Chloride cable)	➲ These are used up to 11 kV. ➲ Each core of this cable is separately insulated with PVC.
(viii) $3\frac{1}{2}$ core PILCDTA cable	➲ This is a 4 core belted cable with double armouring. ➲ In this, three cores are of normal thickness and the fourth core is half the other three cores. ➲ The fourth core is used as neutral. It is used in industries upto medium voltage (650V).
3. Pressure cable	➲ This is a PILCDTA type cable in which transformer oil is filled inside the lead covering instead of fiber/jute material. ➲ It is used from 66 kV to 220kV.

Types of joints in optical fiber-

These are the special joints used for fiber optical cables only and can be classified based on their characteristics as follows-

1. Splice

(i) Mechanical splice

(ii) Fusion splice

2. Connector

(i) DNP connector (Dry No Polish)

(ii) SMA connector (Sub Miniature type A)

3. Coupler

(i) T-coupler

(ii) Star

(iii) Three port coupler

Splice -

- It is used to connect the two ends of fiber optic cables permanently.
- This method is commonly used for signal transmission over a long distance.

(i) Mechanical splice - This joint uses a technique designed to hold two fiber ends in a position such that light passes through two fiber cables.

(ii) Fusion Splice-

- It is most reliable joint between two cables.
- This joint uses an electric are to pass a high-voltage signal so that the maximum output is received at the end.

Mechanical splicing	Fusion splicing
(i) Mechanical splicing does not use any other thing to connect two cables.	(i) Fusion splicing uses heat or an electric are to joint two cables.
(ii) Mechanical splicing holds two cables together using its own assembly	(ii) Fusion splicing uses two cables into are single cable.
(iii) It is comparatively less expensive	(iii) It is more expensive than mechanical splicing
(iv) Average signal loss is more because of variability in the type of connector used.	(iv) Average signal loss is less because they offer very high quality signal transmission.

Connector - Fiber optics connectors are joints that are reusable and they to attach and detach at any point in time.

- The connector is of two types-

(i) DNP connector - Dry No Polish connector are pre-assembled connectors that do not require field polishing and assembling.

(ii) SMA connector -It is a sub miniature type A coaxial connector that is used for high - frequency devices like a microwave, mobile signal antenna, wi-fi antenna etc.

DNP Connector	SMA connector
1. DNP is Dry No Polish connector	1. SMA is sub Miniature type A connector
2. It is a pre-assembled design.	2. It is a screw - type coupling design
3. Installation is fast	3. Installation is slower that the DNP connector

Coupler - It is a device that divides one input signal into two output signals.

- Coupler can also be used for dividing two inputs into one output. In such cases, it is called a combiner.

Different types of couples are-

T-coupler - The T-coupler is used split one incoming signal into output signals using a grin lens and beam splitter.

Star coupler- The star coupler in used to split one incoming signal into many output signals.

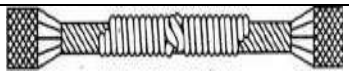
Three ports coupler – The three port coupler splits one input signal into two output signals without using grin lens and beam splitter.

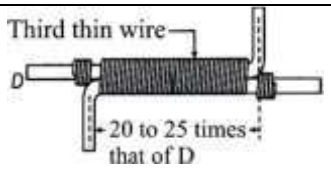
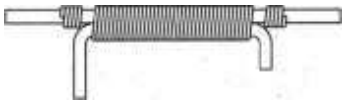
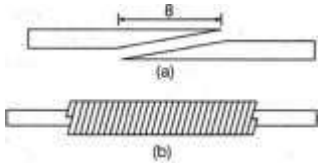
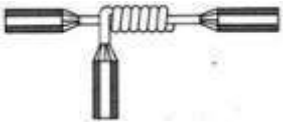
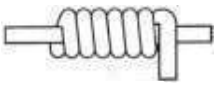
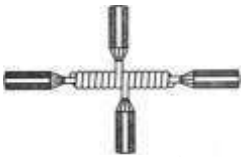
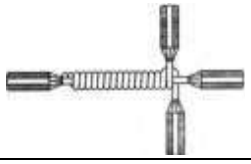
Difference between T-coupler and Star coupler-

T-Coupler	Star Coupler
1. T-coupler has one input and two outputs.	1. A star coupler has one input
2. The output power of the two ports is not evenly distributed.	2. The output power is equally distributed
3. It is used in bus type of networks and small networks	3. It is used in large network.
4. It anyone coupler in the network gets disconnected, all other terminals will also get disconnected.	4. If any one-star coupler terminal gets disconnected, it won't impact other terminals in that network.

❒ Joints in Electrical Conductors

The following types joints are common in overhead wiring and domestic wiring.

Sr.No.	Type of joint	Symbol	Characteristics	Uses
1.	Twisted Joint		➲ In this joint, the end of the wires are twisted together and their terminating ends are bent towards the joint. ➲ It is also called pig-tail joint or rat-tail joint.	It is used on insulators installed on the pole of the overhead line and not in the middle of the line.
2.	Married Joint		In this joint, after twisting the conductor together once or twice, the terminating ends are wrapped in opposite directions.	➲ It can be used in a straight line. ➲ It is also called a straight joint
3.	T-Joint		In this type of joint, only the insulation of the main cable is stripped and the conductor of the other cables are wrapped on both sides of the joint	This joint is used to take branch lines from the main power supply line.

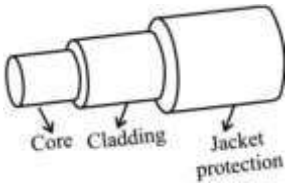
4.	Britannia Joint		In this joint the conductors are kept parallel and adjacent to each other and the terminal end are bend at right angles. Now a third wire wrap is made on both wires to from a joint.	It is used only where the tensile pressure is high.
6.	Britannia T-Joint		Its features are similar to Britannia joint.	This joint is used in overhead lines for the inner exitance of electrical energy perpendicular to the service line.
7.	Western-Union joint		It is a joint that can bear high tensile pressure. In, this the wires are tightly wrapped over each other.	It is used at the ends of overhead lines.
8.	Scarfed joint		It is a lapped joint between two pieces of wood. In this, the ends of two pieces of wood are sharpened and joined by tightening or sticking them together.	It is used in single conductors that bear low tensile pressure. It is used in earth conductors in the wiring inside buildings.
9.	Tap Joint		This joints is made in single conductors up to 2 mm thick without any third wire	
(i)	General tap joint		This joint can be prepared quickly this joint becomes even better after soldering	This joint is used where tensile stress is present.
(ii)	Aerial tap joint		In this type of joints the end of the cable or conductors are wrapped together and one terminal end is left open.	This type joint is mostly used in short current circuits.
(iii)	Knotted tap joint		Its structure is similar to a normal tap joint. But a knot is put at one of the terminal ends.	Knotted tap joint is used where the tensile stress in the conductor is high.
10.	Cross-double-duplex joint		In this joint, A third wire is wrapped over the wires to be joined and a double knot is tied at the terminating ends.	
(i)	Cross-double duplex joint		This joint is a combination of two normal tap joints, in which two other conductors are connected and taken through the middle of the conductor	
(ii)	Duplex cross tap joint			This joint is used where two conductor wires are taken out simultaneously.

❒ Cleaning materials

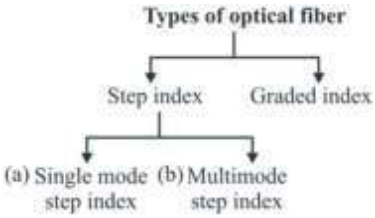
Iso-Propyl rubbing alcohol can be used to clean cable to remove dirt gel, and grease.

❒ Optical fiber

- An optical fiber consists of three basic elements.
  (i) Core **(ii)** Cladding **(iii)** Outer jacket
- Works on the principle of total internal reflection (T.I.R.).

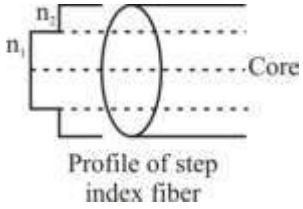


- Refractive index of core (1.5) is always greater than refractive index of cladding (1.48).
- Transmission rate 25 GHz/sec.
- Made from glass or silica (SiO_2).



■ Step index fiber

- Refractive index of core is uniform.
- Refractive index abruptly changes from core to cladding.



(a) Single mode step index

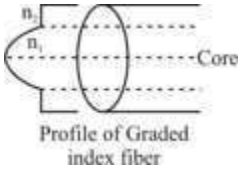
- Center core diameter = 5 μm to 10 μm.
- Well defined boundary between core and cladding.
- Light propagates in straight line.
- High accuracy.

(b) Multi mode step index

- Center core diameter = 50 μm.
- Well defined boundary between core and cladding.
- More than one mode can propagates.
- Low cost.

❒ Graded index fiber

- Variable refractive index inside the core.
- Refractive index is maximum at center of core and decreases as radial distance increases from the core.



■ Deference between step index and graded index fiber-

Step Index	Graded Index
Step index fiber provides a zigzag shaped path for light transmission.	Graded index fiber has a smooth sinusoidal wave shape for light wave to propagate.
Step index fiber offer less bandwidth.	Graded index fiber offers larger bandwidth.
Due to mode dispersion effect , it has limitation on relay functions.	In graded index fiber reduced or removed the dispersion mode.
Step index fiber is used for shorter distance and offers less speeds	The graded index fiber is used for longer distance and offers high speed.

■ Numerical aperture

- Measure of light collecting ability of fiber.
- N.A. = $\sqrt{(n_1)^2 - (n_2)^2}$
- N.A. = $n_1\sqrt{1 - \text{Sin}^2\phi_c}$

■ Acceptance angle

- Maximum value of incident angle to propagate a light signal into fiber.
  $\theta_a = \text{Sin}^{-1}[NA]$

■ Meridional ray

- It passes through core axis.
- Essay to track the path of meridional rays.
- It classified in two type.
  (a) Bound ray (b) Unbound ray

■ Skew Ray

- Not passes through core axis.
- Difficult to track.
- Follow helical path.

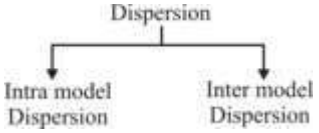
Acceptance angle of skew rays is always greater than acceptance angle of meridional rays.

❒ Isolators

- Unidirectional.
- Allow the transmission of light in only one direction.
- Used to prevent the back reflection of light in fiber.

❒ Dispersion

- Dispersion ↑↑ pulse broadening ↑↑ B.W. ↓↓ Information carrying capacity ↓↓ system will be slow.
- Multimode step index is most affected by dispersion.



■ RIP [Refractive Index Profile]

- It controls the B.W.
- ➢ Measured by transferred near field method.

■ Attenuation

- Attenuation (In dB) = $10\log\left(\frac{P_i}{P_0}\right)$.
- Caused by absorption, scattering and bending losses.

■ Bending losses

- ➢ Bending losses are two types.
- **Macro bending loss -**
- ➢ Due to curvature of the bend is much larger than fiber diameter.
- **Micro bending loss**
- ➢ Due to discontinuity of fiber.
- ➢ It increases by external forces.

■ Linear scattering losses

- It is two type

□ Rayleigh scattering losses -

- $\gamma_R = \frac{8\pi^3}{3\lambda^4} n^8 \rho^2 \beta_C K T_F$
- Occurs when the size of the density fluctuation is less than one-tenth of the operating wavelength of light.
- Rayleigh scattering loss $\propto \frac{1}{\lambda^4}$.

□ Mie scattering losses

- Occurs when the size of the defect is greater than one-tenth of the wave length of light.

❑ Chemical Cell

A chemical cell is a device which converts the chemical energy into electrical energy. Most batteries are chemical cells. A chemical reaction takes place inside the battery and causes electric current to flow.

- The electric cell works on the principle of electrolysis.

☛ There are mainly two types of chemical cell-

1. Primary cell
2. Secondary cell

(i) Primary cell- The chemical reaction in primary cell is not reversible, that is, they cannot be charged again.

□ Some Primary Cells are as Follows

Name of cell	Positive electrode	Negative electrode	Electrolyte	Polarization	Internal resistance	EMF	Application
Voltaic cell	Copper electrode	Zinc electrode	dilute sulphuric acid (H_2SO_4)	Hydrogen gas Bubbles	Very less	1.08V	In electrical devices providing constant voltage and current such as TV, Remote, Car Battery, Inverter
Daniell cell	Copper electrode is immersed in copper sulphate solution	Zinc electrode is immersed in zinc sulphate solution	Copper sulphate solution ($CuSO_4$)	Copper sulphate	2Ω to 6Ω	1.1V	To providing a constant voltage in laboratory
Leclanche cell	Carbon electrode	Zinc electrode	Ammonium chloride (NH_4Cl)	Powder of Carbon and Manganese dioxide	1Ω to 5Ω	1.46V	Where intermittently electric current is required such as Electric Bell, Telephone, Flash Light etc.
Dry cell	Carbon electrode	Zinc electrode	Ammonium chloride, Zinc chloride, Plaster of paris paste	Manganese dioxide, Carbon, Ammonium chloride, Powder of Zinc chloride in ratio (10:10:2:1)	1Ω	1.4V-1.5V	Torch, Telephone, Camera, Wall Clock, Tape Recorder etc.
Mercury cell	Nickel coated steel electrode	Zinc electrode	Potassium Hydroxide (KOH)	Mercury oxide also known as Mercuric oxide (HgO)	0.035Ω	1.35V– 1.4V	Wrist Watch, Pocket Calculator etc.

Silver oxide cell	Silver oxide	Zinc powder	Zinc oxide	Silver oxide	5-15Ω	1.5V	In such devices that flow constant electric current, in small sized, digital devices and instrument.
Alkaline cell	Manganese dioxide	Zinc electrode	Potassium hydroxide		High	1.5V	Digital Camera, MP3 player, Radio etc.
Bunsen cell	Carbon	Zinc	Potassium nitrate and sulfuric acid		0.8Ω	1.9V	Extract metals
Zinc chloride cell	Carbon rod	Zinc	Zinc chloride		2Ω	1.5 V	In heavy duty batteries

(ii) Secondary cell:

Those cell which are recharged and used; are called secondary cell. It's chemical reaction is reversible. Some secondary cells are as follows

Name of cell	Positive electrode	Negative electrode	EMF
Lead Acid Cell	Lead peroxide (PbO_2)	lead (Pb)	In the fully charged condition the emf of lead acid cell is 2.1 volt per cell and the internal resistance is 2 ohms
Nickel-Iron Cell or Edison Cell	Nickel hydroxide $Ni(OH)_4$	Iron (Fe)	In the fully charged condition, the emf is 1.2 volts per cell and the internal resistance is high.
Nickel-Cadmium Cell	Nickel hydroxide $Ni(OH)_4$	Cadmium (Cd)	1.2 to 1.5 Volt
Lithium-Ion Cell	Lithium cobalt oxide or Lithium iron phosphate or Lithium manganese oxide	Ethylene carbonate or Diethyl carbonate	3.6 to 3.95 Volt

Name of cell	Chemical reaction	
	During charging	**During discharging**
Lead-Acid Cell	**At the anode** $PbSO_4+2H_2O+SO_4 \rightarrow PbO_2+2H_2SO_4$ **At the Cathode** $PbSO_4+2H^+ \rightarrow Pb+H_2SO_4$	**At the anode** $PbO_2+2H^++H_2SO_4 \rightarrow PbSO_4+2H_2O$ **At the Cathode** $Pb+O^{2-}+H_2SO_4 \rightarrow PbSO_4+H_2O$
Nickel-Iron Cell	**At the anode** $Ni(OH)_2 + 2OH^- \rightarrow Ni(OH)_4$ **At the Cathode** $Fe(OH)_2 + 2K^+ \rightarrow Fe+2KOH$	**At the anode** $Ni(OH)_4 + 2K^+ \rightarrow Ni(OH)_2+2KOH$ **At the Cathode** $Fe^+ + 2OH^- \rightarrow Fe(OH)_2$
Nickel-Cadmium Cell	**At the anode** $Ni(OH)_2+2(OH)^- \rightarrow Ni(OH)_4$ **At the Cathode** $Cd(OH)_2+ 2K^+ \rightarrow Cd+2KOH$	**At the anode** $Ni(OH)_2 + 2K^+ + OH^- \rightarrow Ni(OH)_2 + 2KOH$ **At the Cathode** $Cd^{2+}+2OH^- \rightarrow Cd(OH)_2$

□ Comparison between primary cell and secondary cell

Primary Cell	Secondary Cell
➲ Its weight is usually less.	➲ Its weight is more.
➲ It's voltage (E.M.F) is less	➲ Its voltage (E.M.F) is more.
➲ It can be used immediately	➲ It has to be charged first through DC supply, so it cannot be used immediately.
➲ It can not be charge again	➲ It can be charged again

➲ It can be used only one time	➲ It can be used repeatedly by charging it.
➲ It's cost is less	➲ Its cost is more.
➲ These are used for lower rates	➲ These are used for higher rates.

Capacity of Secondary Cell:

- ➲ The capacity of an accumulator cell is measured in Ampere-hours (Ah).
- ➲ The capacity of a cell depends on discharge rate of the battery, the specific gravity of electrolyte and temperature.
- ➲ As the discharge rate of cell increases the capacity of cell is decreases.
- ➲ If both the temperature and specific gravity of the cell increases, the capacity of the cell increases.

Signs of fully charge and discharge of battery:

	Fully charge condition	Fully discharge condition
Voltage of battery	2.2 Volt	1.8 V
Colour of plates	+Ve plate-chocolate brown -Ve plate slate	+Ve and -Ve Plate, White
Reading of specific gravity of electrolyte	1.250 to 1.280	1.150 to 1.200

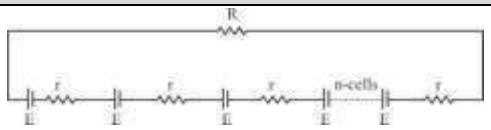
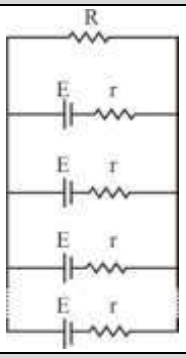
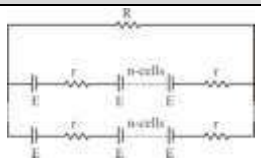
☛ **Note-** While charging the battery the temperature of the electrolyte should not exceed 40ºC.

Battery

A group of cell is called a battery.

Grouping of cells- Connection of more than one cell in series, parallel or mixed (series-parallel) is called grouping.

■ Cell can be connected in the following methods:

Characteristics	Series combination	Parallel combination	Mixed combination
Equivalent circuit			
Total EMF	$E_T = nE$	$E_T = E$	$E_T = nE$
Total internal resistance	$r_T = nr$	$r_T = \frac{r}{n}$	$r_T = \frac{nr}{m}$
Total current of circuit	$I = \frac{nE}{nr + R}$	$I = \frac{nE}{r + nR}$	$I = \frac{nmE}{nr + mR}$
Purpose	Cell are connected in series to get more electromotive force (voltage).	To obtain higher electric current or longer duration of electric current, cells are connected in parallel.	To obtain more e.m.f and electric current for longer period cells are connected to mixed connection i.e series-parallel

☐ Efficiency of battery

Ampere-hour efficiency	Watt-hour efficiency
Ampere-hour efficiency in percentage - $\eta_{Ah}\% = \frac{\text{Discharging Ampere} \times \text{hour}}{\text{Charging Ampere} \times \text{hour}} \times 100$ $\boxed{\eta_{Ah}\% = \frac{I_d \times h_d}{I_c \times h_c} \times 100}$ ➲ The Ampere- hour efficiency of Lead-acid battery is (90 -95)%.	Watt-hour efficiency in percentage $\eta_{Ah}\% = \frac{\text{Discharging Watt} \times \text{hour}}{\text{Charging Watt} \times \text{hour}} \times 100$ $\boxed{\eta_{Wh}\% = \frac{V_d \times I_d \times h_d}{V_c \times I_c \times h_c} \times 100}$ ➲ The watt-hour efficiency of Lead-acid battery is (80-85)%. ➲ Watt-hour efficiency is also called energy efficiency.

The ampere hour capacity of a battery used in car is 30-60Ah.

☐ **Efficiency of lead acid battery depend on:**

- On the rate of charging and discharging.
- On internal resistance and polarity.
- At temperature
- The time between discharging and recharging the battery.

☐ **Fault in lead acid battery and their Remedies:**

	Fault	Remedies
Sulphation	The deposition of a layer of lead sulphate on +Ve or -Ve plate is called sulphation.	To overcome this, the battery is charged at low electric current. It is also known trickle charging.
Buckling	Bending of plates is called buckling	To overcome this problem the plates are replaced.
Sedimentation	The fallings down of the material of the battery plates is called sedimentation. Due to this the life and voltage of the battery gets reduces	To overcome this problem, the battery is opened, cleaned and re-fitted. Distilled water is also added to it.

☐ **Testing Instrument:**

The charging of the battery can be checked by two types of testing equipment.

1. Hydrometer
2. High-rate discharge cell tester or Tong tester

☐ **Hydrometer:** The specific gravity of electrolyte is measured by hydrometers.

☐ **High-rate discharge cell tester or Tong tester:**

Fully charge – Green colour
Half charge – Yellow colour
Fully discharge- Red colour

☐ **Battery safety and care:**

☞
- ➲ The battery should not be discharged below a minimum value of 1.8 V.
- ➲ The battery should be discharged and recharged once in a week.
- ➲ The electrolyte on the battery plates should be fully filled and the bottom of the electrolyte should be about 10 mm to 15 mm above the plates.
- ➲ A discharged battery should never be tested with a high-rate discharge tester.
- ➲ The high-rate discharge tester should only be used on batteries for a periods of less than 10 seconds.
- ➲ The cell temperature should not exceed 44ºC under any circumstances and should not be less than –46ºC under the minimum circumstances.

❒ Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals.

☐ **Essential qualities and requirements of protective relaying -**

- Reliability
- Stability
- Sensitivity
- Adequateness
- Speed and time
- Selectivity and discrimination
- Simplicity and economy

$\boxed{k_s = \frac{I_s}{I_o}}$ Where,

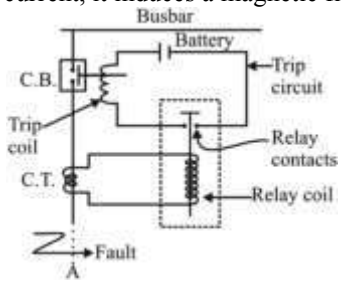
k_s = Sensitivity factor

I_s = Minimum short circuit current in the zone

I_o = Minimum operating current for the protection

☐ Works of relay

- Relay works on the principle of electromagnetic induction.
- When the electromagnet is applied with some current, it induces a magnetic field around it.



☐ Classification of protective relays

Electromagnetic attraction type relays	➲ Solenoid type
	➲ Attracted armature type
	➲ Balanced beam type
Induction type relays	➲ Induction Disc type
	➲ Induction cup type
Directional type relays	➲ Reverse current type
	➲ Reverse power type
Relays based on timing	➲ Instantaneous type
	➲ Definite time lag type
	➲ Inverse time lag type
Distance type relays	➲ Impedance type
	➲ Reactance type
	➲ Admittance type
Differential type relays	➲ Current differential type
	➲ Voltage differential type
Other types of relays	➲ Under voltage, current, power relay
	➲ Over voltage, current, power relay
	➲ Thermal relay ➢ Rectifier relay
	➲ Permanent magnet moving coil relay
	➲ Static relay ➢ Gas operated relay

☐ Comparison of static and electromechanical relay

Point of comparison	Static	Electromechanical
Working principle	Semiconductor technology	Electromagnetic attraction or repulsion
Construction	Robust	Simple
Moving part	No moving part	Moving part available
Number of operations	More compare to electromagnetic relay	Less compared to SSR
Testing	Difficult	Easy

2. Induction type relays

The induction type relays are also called magnitude relays. These relays works on the principle of the induction motor or an energy meter.

- **Types (Based on construction)**

1. Shaded pole type
2. Watt hour meter type
3. induction cup type

- **Torque equation for induction type relays -**

$$F \propto \phi_1 \phi_2 \sin\alpha$$

α = Phase difference between ϕ_1 & ϕ_2

NOTE

ce or torque acting on the disc is every instant. The action of relay uch force is free from vibrations.

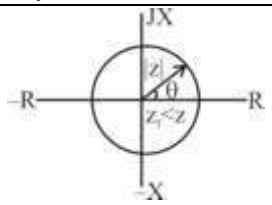
- **Direction of net force** - Decided by which flux is leading the other.

1- Shaded pole type	Watt hour meter type Induction relay	Induction cup type relay–
$T \propto \phi_s \phi_u \sin\alpha$, if $\phi_s \& \phi_u \propto I$ $T \propto I^2 \sin\alpha$, $T = kI^2$ ϕ_s = Flux shaded portion ϕ_u = Flux in unshaded portion $\sin\alpha$ = Constant for the given design.	$T = K\phi_1\phi_2 \sin\alpha$ • Current setting can be adjusted • Most of the induction relays are of this type. • Operation can be controlled by opening or closing of the secondary winding.	• Most accurate relay • Very fast in operation. (10 ms) • Adjustable speeds are possible • Various shapes of time against operating quantity curves can be obtained.

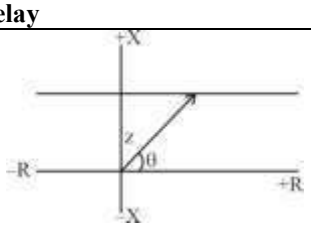
■ Distance relay

- In distance relay the operation is dependent on the ration of voltage and current.
- Three type of distance relay-

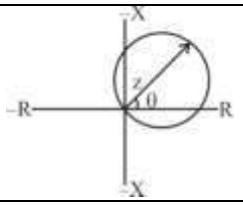
(i) Impedance relay

R-X diagram	 If $z_f < z$ Relay operates $z_f > z$ Relay is not operates Such a relay is non-directional.
Torque equation	$T_{op} = K_1 I^2 - K_2 V^2$ –Ve = Restrain
Other name	Voltage restrain over current relay or Voltage restrain non-directional relay.
Application	Medium transmission line

(ii) Reactance relay

R-X diagram	 The relay will operate for all the impedances whose heads lies below the operating characteristics, whether below or above the R-axis.
Other name	Directional restrain over current relay.
Application	Short transmission line.

(iii) Mho relay

R-X diagram	
	The relay operates when the impedance seen by the relay falls within this circle
Other name	Voltage restrained directional relay.
Use	Long transmission line.

■ **Buchholz relay (Gas actuated relay)**

- Buchholz relay is a gas operated relay used for the protection of oil immersed transformers against all the type of internal faults.
- It is also known as incipient fault relay.
- Oil decomposes- generating the hydrogen gas.
- Buchholz relays are provided for the transformer having rating above 500 kVA.

2. Effect of power swing on distance relays

Reactance relay > Impedance relay > mho relay

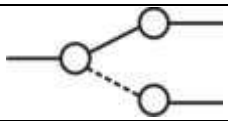
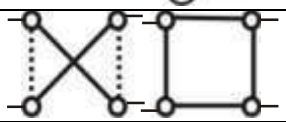
❒ Switch

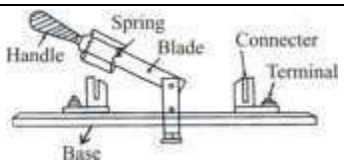
Switch is a controlling device.

■ A device used to control the flow of electric current in an electrical circuit i.e. to turn 'ON' or 'OFF' is called a switch.

■ Switches can be classified into three categories.

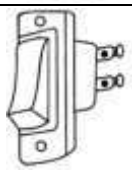
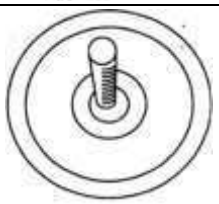
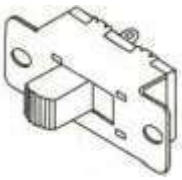
1. According to work

Name of switch	Symbol	Structure	Uses
Single-Pole One-Way Switch		It has one pole and one path.	It is used to switch ON/OFF a lamp or any other electrical devices or appliance from one place.
Single Pole Two-Way Switch		It has one pole and two path.	It is used to control a lamp in a staircase from two place.
Intermediate Switch		It is a four terminal device.	It is used to control a lamp/electrical device from three or more places.
Push-Button Switch		It is switching device with spring, ON pressing which the circuit can be temporarily turn 'ON' and releasing the push button the circuit automatically turn OFF.	It is used in bells, buzzers etc.
Ceiling Switch		➲ It is a special type of push-button switch. pressing or pulling it once it turns the circuit ON and pressing or pulling it a second time it turn OFF. ➲ It is called bed switch or pull switch.	It is used in decorative lamps, night-lamps, table lamps, etc.
Double pole iron clad OR DPIC switch.		➲ It work as the main switch for single phase AC or DC supply line and has a fuse in series with each line. ➲ These switches are made from 15A to 200A and 250V to 660V. ➲ The metallic part of the switch must be earthed.	It is used as the main switch in an electrical circuit.

Tripple Pole Iron Clad TPIC Switch		It work as the main switch for a 3-phase AC line and has a fuse in a series with each line and a neutral link. ➲ These switches are made from 30A to 400A and 400V to 1100V. ➲ The metallic part of the switch must be earthed.	It is used as a main switch in any electrical circuit where three phase are required.
Knife Switch		It is a high current carrying switch without cover, it is designed for current carrying capacity from 30A to 1000A.	It is used only at the substation and distribution station.

Both DPIC and TPIC types of switches are 'ON' in the upward direction and 'OFF' in the downward direction while other switches are 'ON' in the downward.

2. According to Construction

S.N.	Name of switch	Symbol	Structure	Uses
1.	**Tumbler Type Single-Way Switch**		It is a switch that is screwed in to surface of a board. It is one-pole one path and one pole two-path type.	The use of this switch has now become very rare.
2.	**Flush Type Switch**		It is a switch which is screwed inside the surface of the board, it is single Pole single path and single pole, two path type	Nowadays only flush type switches are used in electrical wiring.
3.	**Toggle Switch**		It is also a switch that is screwed inside the surface of the board. It is of one-pole one-path, one-pole two path and intermediate type.	Its often used in electrical and electronic devices.
4.	**Slide Switch**		It is also a switch which is screwed inside the surface of the board. ➲ It is single pole single path, single-pole two-path and multiple pole multiple path.	It is used in electrical and electronic equipment and devices.
5.	**Rotary Switch**		It is also a switch that is screwed inside the board, the rotating knob of the switch remains outside the board. It is a single-pole and multi-pole and single path and multiple path switch.	It is used in electric fans, coolers and other electronic equipment.

3. According to current Rating:

5A, 240V switch	15A, 240V switch	30A, 415V switch	More than 30A
Switches of this rating are single-pole one-way, single pole two-way, intermediate, push button, ceiling type, tumbler, flush, toggle, slide and rotary.	Switches of this rating Single-pole one path, single pole two-path type, tumbler and flush type.	Switches of this rating are of DPIC, TPIC and knife type.	➲ In this categories, rating of the switches is 30A to 1000A in different capacities for making main switches. ➲ These are of three pole iron clad (TPIC) and knife type. ➲ It is used up to 33kV. These include air circuit breaker and oil circuit breaker switches used in substations.

■ Miniature circuit Breaker

A miniature circuit breaker can be defines as an electromagnetically operated safety switching device that is used in electrical circuit to protect the circuit from short circuit.

■ Type of miniature circuit breaker

☐ According to their numbers of poles

Single pole	Its working on a single phase.
Double pole	Its provides protection for two phase-neutral of the circuit.
Triple pole	Switching protection for three phases of circuit.
Triple pole with neutral	It's provides protection for three phase circuit and neutrals is also a part as a separate pole in the MCB.
Four pole	It's construction similar as three-pole MCB and protective release for the neutral pole.

■ According to their tripping characteristics-

Type B	Tripping current is 3 to 5 times full load current.
Type C	Tripping current is 5 to 10 times full load current.
Type D	Tripping current is 10 to 20 times full load current.
Type K	Tripping current is 8 to 12 times full load current.
Type Z	Tripping current is 2 to 3 times full load current.

❒ Working Principle of MCB

It is based on a thermal- Magnetic tripping mechanism that combines a bimetallic strip and an prevent electrical faults.

❒ Connectors

- Electronic connectors are devices that join electronic circuits.
- They are used in assembling installing and supplying power to electrical devices.

■ Board to Board connectors

This type of connector is linkage of PCB to PCB.

■ Audio connectors

- They are two-conductor connectors typically used with shield cable.
- it is also caused "RCA" plug and jack.

☐ Application

Microphones

Audio amplifiers

Speakers

■ Modular connectors

- These are used with unshielded twisted pair cables.
- It is used for telephone.

☛ Example

RJ11- Used with 4-wire telephone cables.

RJ12- Used with 6-wire cables.

RJ45- Used with 8-wire LAN (Local area network)

Exam Pointer

- Best conductor but very much costly is- **Silver**
- Brass is an alloy of- **Copper and Zinc**
- The alloy mainly used for corrosion resistance in stainless steels is- **Chromium**
- The resistance of a copper conductor will theoretically become zero at- **–234.5°C**
- _____Specific resistance of a conductor, when it is _____in temperatures- **Increase, Increase**
- Constantan consists of - **Copper and Nickel**
- All good conductors have high- **Conductivity**
- Nichrome is an alloy of _____. **80% nickel and 20% chromium**
- The thermal conductivity of nichrome- **11.3 $Wm^{-1}C^{-1}$**
- The melting point of nichrome wire is- **1400°C**
- Permealloy is an alloy containing- **Nickel and iron**
- The number of electrons in an aluminium atom is- **13**
- Aluminium becomes super conductor at- **–272.15°C**
- Copper wires coated with a thin layer of enamel varnish are called- **Super enameled wire**
- Mica is an example of a- **Insulator material**
- The material commonly used for insulation in high voltage cables is- **Impregnated paper**
- If the material is said to be an insulator, it will have a property- **Blocking the flow of electric current**
- The main requirement of insulating materials used in cables- **High insulating resistance**
- The maximum safe temperature for the insulating material like mica, glass, fiber and asbestos- **130°C**
- The commonly used covers are made from- **Poly vinyl chloride**
- The permissible normal operating temperature of PVC of electric wire- **70°C**
- Bakelite is a- **Insulator**
- The full from of V.I.R.- **Vulcanized Indian Rubber**
- Micanite is a- **Insulating solid sheet.**
- What is the maximum temperature that class-B insulation can withstand- **130°C**
- At_____contact of temperature polyvinyl chloride becomes as _____. **Low, Brittle**
- Limiting temperature of 'F' class insulting material is- **155°C**
- An insulating material should have- **Low cost, high dielectric strength and high mechanical strength.**
- Ceramic is one -. **Insulator**
- _____are generally flexible and light weight- **Soft material insulator**
- In insulators there is no flow of current because- **They don't have any free electrons**
- The resistance of an insulating material is- **Dependent of the temperature**
- The effect of moisture on an insulating material- **Dielectric less increases.**
- Energy band gap size for insulators is in the range of eV.- **3-6 eV**
- The necessary to check in air break switches maintenance is- **Damage of earth wire, Blades/ contact burning**
- The material used for making arcing contact is _____. **Silver tungsten**
- _____ is one type of switch, the contacts of which are opened or closed by the position of mercury placed in a tube- **Float switch**
- The electric switch to control any electrical equipment will act as a– **ON/OFF controller**
- Material used for making knife switch is– **Brass**
- If a circuit has to switch between two power sources then which type of switch is required– **DPST**
- Oil switches are used for– **High voltage and large current circuits**
- The relay operates when current exceeds a preset value– **Over current relay**
- A relay performs the function of– **Fault detection**
- A distance relay with inherent directional property is known as– **Admittance relay**
- The relay represents the phasor difference of two or more similar electrical quantities exceed a predetermined value– **Differential relay**
- An over current relay with directional restrain is– **Reactance relay**
- If the current increases to a maximum value in a relay- **Heavy current flow in the coil, Closes the trip coil of the breaker and Isolate the faulty section from the rest**
- A solenoid type relay is what type of relay as far as the relay timing is concerned– **Instantaneous relay**
- Buchholz relay is– **Gas actuated device**
- The purpose of backup relay is to- **Guard against failure of primary protection**
- The main application of long time over current relays is– **As backup earth fault protection**
- The type of distance relay– **Mho relay, Reactance relay and Impedance relay**
- In case of IDMT over current relay, IDMT means– **Inverse Definite Minimum Time**
- The protective relay is provided to– **Close the relay contacts when the actuating quantity attains a certain predetermined value**
- A differential relay measures the vector difference between .....- **Two or more similar quantities**
- The output best suited for both AC and DC output devices is .....- **Relay output**
- For a protective relay, _____is expressed in terms of minimum volt-amperes required for the relay operation- **Sensitivity**

- An electromagnetic attraction type relay operates on ____. **Both AC & DC**
- An ability of Relay system to operate under predetermined condition is called _____. **Reliability**
- A relay used for protection of motors against overload is– **Thermal over current relay**
- In case of transformer, Buchholz relay is used to protect from..... **Incipient faults**
- …….. is static relay- **Transistor relay**
- Impedance relay is used for protection in– **Medium transmission lines**
- The operation of distance relay depends upon– **Ratio of voltage to current**
- Relay using Induction disc principle operate– **Only on A.C**
- Impedance relay can be used for– **Phase fault only**
- Mho relay is suitable for _____ transmission lines– **Ultra and extra high voltage**
- The induction cup structure is used in the– **Mho relays**
- A relay is– **An electromechanical switch**
- Differential relays are used to protect the equipment– **Internal faults**
- By burden on the relay, we generally mean– **Volt-ampere rating of relay**
- Programmable Logical controllers are the devices that were invented basically to replace– **Relays**
- Restoring force in an electromagnetic relay is produced by– **Spring**
- A device, which detects the fault and supply information to the breaker for circuit interruption is called– **Relay**
- The minimum value of current at which a relay operates is called the– **Pick-up value**
- A substance which has very few free electrons is called as _____ **Insulator**
- A semiconductor is formed by _____ bonds– **Covalent**
- The barrier potential of Silicon is approximately– **0.7 V**
- The forbidden energy gap for germanium is- **0.72 eV**
- Considering adding impurities to semiconductors the full form of 'PPM' is- **Parts per Million**
- Forbidden energy gap is largest in..... **Insulator**
- The temperature coefficient of resistance is .....for silicon and..... for copper- **Negative, Positive**
- P- type impurities are - **Indium, Boron, Aluminium**
- Donor type impurities have .... valence electrons– **5**
- ..... has the largest number of free electrons– **Conductor**
- The Fermi level for an intrinsic semiconductor lies– **Midway in the forbidden gap**
- The Barrier potential of a germanium semiconductor is approximately– **0.3 V**
- The expression of carrier mobility of a semiconductor material? (Where e is electric field, n is carrier density and σ is conductivity.) $\mu = \frac{\sigma}{ne}$
- The net charge on a neutral atom of an element will be _____– **Zero**
- In silicon, ... energy must be supplied to push the electron from valance band to conduction band– **1.1 eV**
- The material having negative temperature coefficient of resistance is- **Carbon**
- The number of valency electrons in indium material is– **Three**
- In pure silicon– **The holes and electrons exist in equal numbers**
- A semiconductor when placed at 0° K, will act as– **Insulator**
- Doping materials are called impurities because they– **Alter the crystal structures of pure semiconductors**
- Resistivity of a semiconductor depends on– **The atomic nature of the semiconductor**
- The dielectric constant of silicon is– **11.7**
- Conduction bands and valence bands overlap in– **Conductor**
- The elements of nucleus of an atom is – **Both neutron and proton**
- The transition temperature of mercury is– **4.12°K**
- Major part of current in an intrinsic semiconductor is due to– **Thermally generated electrons**
- In a pure semiconductor, electric current is due to– **Holes and Electrons**
- Consider a single crystal of an intrinsic semiconductor. The number of free carriers at the Fermi level at room temperature is– **Half the number of free electrons in the crystal**
- Intrinsic semiconductors at room temperature have– **Equal number of hole and free electrons**
- A hole is the vacancy created when– **An electron breaks its covalent bond**
- In the silicon crystal structure, the recombination rate is proportional to the number of– **Free electrons and holes**
- In semiconductors, a donor may be– **A pentavalent impurity**
- The process by which impurities are added to a pure semiconductor is called– **Doping**
- The minority carriers in n-type semiconductors are– **Holes**
- The majority charge carriers in an N-type semiconductors are– **Electrons**
- An n-type semiconductor is– **Electrically neutral**
- Fermi energy level for n-type extrinsic semiconductors lies– **Close to conduction band**
- Arsenic mixes with ..... to form a N–type semiconductor– **Germanium**
- …….Function is used to find the probability of an electron existing as a function of energy level– **Fermi-Dirac**
- The majority carrier in p type semiconductor is–**Hole**

- Impurity atoms to be added to pure silicon in order to make a p-type semiconductor belongs to– **Boron**
- Free electrons in a p-type material– **Are minority carriers**
- Donor impurity atom in a semiconductor result in new– **Discrete energy level just below conduction level**
- Conduction takes place when an electron jumps from– **Valence band to conduction band**
- In an atom, the number of proton will be equal to the– **Number of electron**
- In an intrinsic semiconductor, the mass action law is given as– $\mathbf{np = n_i^2}$
- The concentration (P_n) of holes in n–type semiconductor is– $\mathbf{P_n = \frac{n_i^2}{N_D}}$
- The minority carrier concentration is largely a function of– **Temperature**
- Conduction electrons have more mobility than holes because they– **Need less energy to move them**
- The electron-hole mobility ratio in Germanium is– **2 : 1**
- With increase in temperature, the resistance of semiconductors– **Decreases**
- The band gap energy (Eg) is the minimum energy required to break a covalent bond and thus, generates– **An electron–hole pair**
- For elements having energy gap more than 5 eV. act as– **Insulators**
- The potential barrier acts as a barrier against the flow of– **Electrons and holes**
- Fermi level is the measure of– **Probability of occupancy of electrons or holes**
- The Fermi level E_F in an intrinsic semiconductor, if effective masses of holes and electrons are same is– $\mathbf{\frac{E_C + E_V}{2}}$
- Fermi energy level for p-type extrinsic semiconductors lies– **Close to valence band**
- In a semiconductor, drift current is due to– **Applied electric field**
- Parallel connection of battery cells increases- **Current capacity**
- In which cells polarization is the major defect– **Voltaic cell**
- How is an electrochemical cell rated if 'n' cells are connected in series- **n Ah**
- The container of cells are made of …. **Zinc**
- Batteries are composed of one or more cells, each containing – **A positive electrode, negative electrode, separator and electrolyte**
- --------- batteries are used in car. **Lead-acid**
- The name of the instrument used to measure the specific gravity of a battery is– **Hydrometer**
- ..... trickle charging of the batteries is done– **Keep it fresh and fully charged**
- The expression of capacity of a battery is– **Ampere-hour rating**
- A battery is a sources of– **DC voltage**
- The fastest method of charge in batteries is– **Constant voltage system**
- The electrode for a battery must be– **A good conductor of electricity**
- Internal resistance of a cell is reduced by– **Using vent plug to permit gas formed during discharge, increasing the plate area, putting plates very close together**
- If a battery is wrongly connected on charge what will happen– **Current drawing will be very high**
- Shelf life of a small dry cell is– **Less than that of large dry cell**
- Proper charging rate of a battery in ampere is about ..... of its ampere-hour capacity– $\mathbf{\frac{1}{8}}$
- A primary cell is chemically..... **Irreversible**
- All dry cells when new have about .....– **1.5 V**
- Polarisation in a cell is due to accumulation of .....gas over anode– $\mathbf{H_2}$
- To prevent local action in battery, only ..... is used in electrolytes– **Distilled water**
- Ampere hour capacity of an industrial battery is based on ..... hours discharge rate– **8**
- Pickling is– **Removal of scale, grease etc, from the surface**
- The ampere-hour (A.h.) capacity of a battery used on cars is– **30 to 60 Ah**
- Internal resistance of a battery cell increases with– **Increase in distance between two electrodes**
- One ampere hour charges is equivalent to– **3600 coulombs**
- ..... battery is used in aeroplanes– **Nickel-cadmium**
- The greater of internal resistance of a cell– **The lesser the terminal voltage**
- The voltage of a simple voltaic cell is– **1.08 V**
- In constant current method of charging, the cell temperature does not exceed ..... ºC– **45**
- A constant voltage source has– **Low internal resistance**
- The physical change will happen to the cathode of the lead acid battery on charging– **The colour will change to grey**
- The normal cell voltage of a lithium ion battery - **3.6 V**
- Depolariser in leclanche cell– $\mathbf{MnO_2}$
- The active material of the positive plates of silver-zinc batteries is– **Silver oxide**
- The electrochemical reactions are not reversible in case of– **Primary cells only**
- Dry cell is modification of– **Leclanche cell**
- The electrolyte in a Leclanche cell is– **Aqueous solution of ammonium chloride**
- A dry storage cell is– **Carbon-zinc cell**
- The output voltage of a silver oxide cell is– **1.5 V**
- Capacity of a dry cell, is– **More when it supplies current intermittently**

- Internal resistance of primary cell varies– **Directly with the distance between electrodes, with the nature of electrodes**
- ..... primary cells has the highest voltage– **Lithium (2.95V)**
- Negative electrode of simple voltaic cell is made of– **Zinc**
- The defects of a primary cell is– **Local action and polarization**
- The function of the depolarizer in a carbon-zinc cell is that..... **It converts the produced hydrogen into water**
- ..... is work for a depolarizer in a dry cell– **Manganese dioxide**
- The most common used primary cell is : **Lithium cell**
- In dry cells, free electrons are released at– **Anode**
- Positive Electrode of a dry cell is made of- **Carbon**
- Generally the Leclanche cell is used for- **Intermittent purposes**
- In Leclanche cell the anode is made from – **Carbon rod or plate**
- In Leclanche cell the Cathode is made from – **Zinc plate**
- The active material of a nickel-iron battery is ..... **Nickel hydroxide**
- A Lead-acid battery should not be discharged beyond..... **1.8 V**
- The active materials of a nickel-iron battery are **Nickel hydroxide, 21% solution of KOH, powdered iron and its oxide**
- The output of a lead acid cell is: **2.2 V**
- Petroleum jelly is applied to the terminals of the lead acid battery in order to prevent. **Corrosion**
- The colour of the positive plate in a Lead acid cell at fully discharged condition is– **Whitish**
- The number of negative plates in Lead-acid cell is– **One more than number of positive plates**
- The active material on the negative plate of a fully charged lead acid cell is– **Pure lead**
- ..... is used as an electrolyte in a lead acid battery– **Sulphuric acid**
- Life of the Edison cell is at least– **Five years**
- The open circuit voltage of any storage cell depends wholly upon– **Its chemical constituents, on the strength of its electrolyte, its temperature**
- When the specific gravity of the electrolyte of a lead-acid cell is reduced to 1.15 to 1.1 the cell is in- **Discharged state**
- In a lead accumulator, the plates are placed close to each other, as– **It decreases the internal resistance of the accumulator**
- When the battery is being discharged, the terminal voltage decreases with– **Increasing discharge rate**
- Life of the batteries is in the ascending order– **Lead-acid cell, Edison cell, Nickel cadmium cell**
- ..... of electrolyte indicates the state of charge of the battery– **Specific gravity**
- The indication of battery on charge has attained full charge– **Colour of electrode, Gassing, Specific gravity**
- In alkaline cell the electrolyte is– **KOH**
- Specific gravity of electrolyte in Edison cell is– **1.21**
- A substance that changes its Electrical resistance when light falls on it, is known as– **Photo conductive substance**
- Charging of sulphated battery produces..... heat– **More**
- In a lead acid battery, fillers are provided to– **Facilitate flow of gasses**
- In lead acid batteries, sedimentation occurs due to– **Overcharging at high rate**
- Sulphated cells are indicated by the– **Low specific gravity, low voltage on discharge, low capacity**
- The capacity of a lead acid battery does not depend upon– **Charge rate**
- The capacity of a lead acid battery is adversely affected by increase in– **Discharge rate**
- During charging and discharging of an Edison cell– **Electrolyte does not take part in chemical reaction**
- In nickel-iron cell the electrolyte is– **Dilute potassium hydroxide**
- In Edison cell the concentration of electrolyte– **Remains unaltered**
- For preparing electrolyte of lead-acid battery, acid is poured into water to– **Avoid generation of excess heat**
- Specific gravity of alkaline cell is– **Remains unchanged**
- The storage battery generally used in electric power station is– **Lead-acid battery**
- Negative plate of an Edison cell is made of– **Iron**
- When water is added to sulphuric acid– **Lot of heat is generated**
- Container of a lead acid battery– **Molded hard rubber, ceramics, celluloid**
- The life of a lead acid battery is expected to be– **2 to 5 years**
- When the lead acid cell is fully charged the electrolyte assumes.....appearance– **Milky**
- Sulphation in a lead acid battery occurs due to– **Incomplete charging**
- The number of positive and negative plates are placed in a 9 plate lead acid cell– **4 Positive plate and 5 Negative plate**
- The number of positive and negative plates are placed in a 9 plate Ni -Cd cell– **5 Positive plate and 4 Negative plate**
- During the charging and discharging of a nickel-iron cell– **Water is neither formed nor absorbed**
- In a lead-acid cell dilute sulphuric acid (electrolyte) approximately comprises– **Three parts H_2O, one part H_2SO_4**
- The capacity of a lead-acid cell depends on– **Rate of discharge, temperature, density of electrolyte**

- The e.m.f. of an Edison cell, when fully charged, is nearly– **1.4 V**
- The average charging voltage for alkali cell is about– **1.7 V**
- In a nickel cadmium cell potassium hydroxide (KOH) is– **The electrolyte**
- The sulfuric acid (H_2SO_4) concentration in a lead-acid battery becomes highest when: **The cell is fully charged**
- The electrolyte in lead-acid battery is a mixture of: **Sulphuric acid and water**
- ..... batteries does not require trickle charging – **Alkaline cell**
- Internal resistance per cell of Lead Acid cell is always..... **Less than Edison cell**
- When two batteries are connected in parallel– **They should have the same emf**
- The voltage rating for batteries is based on the ---- **Number of cells connected in series**
- WH efficiency of the battery for UPS varies from - **70-80%**
- The ampere-hour efficiency of lead-acid batteries is usually between_____. **90 to 95%**
- ..... efficiency of the battery is more– **Ampere hour efficiency**
- The ratio of ampere-hour efficiency to watt-hour efficiency of a lead acid cell is– **Always greater than one**
- The advantage of the nickel-iron battery over the lead acid battery is that..... **It needs less maintenance**
- Nickel–cadmium accumulators in comparison to nickel–iron accumulators have the advantages of– **Low internal resistance and longer life**
- Hydrogen evolved during charging produces explosive mixture when it is more than– **8%**
- Weston standard cell at 20°C has voltage of ..... volts– **1.0187**
- Under normal charging rate, the charging current should be– **10% of capacity**
- Vacuum is considered **Non–magnetic material**
- One Maxwell is equal to– **10^{-8} Webers**
- The materials can be used for permanent magnets– **Iron–Cobalt alloy**
- The magnetic material used in permanent magnets is– **Hardened steel**
- When a Magnet is heated– **It losses magnetism**
- Permanent Magnets are made of– **Ferromagnetic Materials**
- A magnet is able to attract– **Nickel, cobalt and steel**
- Copper, Silver, Diamond are examples of– **Diamagnetic substance**
- A material which is slightly repelled by a magnetic field is known as– **Diamagnatic materia**l
- Paramagnetic substances are– **Weakly attracted by a magnetic field**
- property is a diamagnetic material,– **Negative magnetism**
- The equivalent of ferromagnetic curie temperature for iron in terms of Kelvin is– **1043**
- The curie temperature of Nickel (in kelvin) is – **627 K**
- Curie point is– **The temperature at which a magnetic material losses its magnetic property**
- Example of ferromagnetic material is– **Nickel, Iron, Cobalt**
- In Diamagnetic materials– **Susceptibility is independent of temperature**
- Susceptibility of Ferromagnetic materials is– **Large and positive**
- Oxygen belong to– **Paramagnetic material**
- Ferrites are a sub–group of– **Ferri–magnetic materials**
- ..... type of materials are not very important for engineering applications– **Diamagnetic**
- The susceptibility of paramagnetic materials generally lies between– **10^{-3} and 10^{-5}**
- If the magnetic susceptibility of any material is less than zero then the material is– **diamagnetic**
- material does not have a constant relative permeability– **Ferromagnetic**
- ..... types, the atoms are aligned in parallel magnetic moments– **Ferro–magnetism**
- Magnetic shields are made from materials having– **High permeability**
- A diamagnetic material is– **Graphite**
- ..... types of magnet is magnetised only when the magnetic field is present– **Soft magnets**
- Ampere–Turns is a unit of _____.– **MMF**
- Property of magnetic material which opposes to establish the flux in it is called – **Reluctance**
- Unit of magnetic reluctance is– **Ampere – Turn/weber or 1/Henry**
- Hard ferrites are used for Making– **Light weight permanent magnet**
- The presence of carbon as an impurity in ferromagnetic material decreases – **Permeability**
- The relative permeability of ferromagnetic material is– **Greater than unity**
- Relative permeability of diamagnetic material is– **Slightly less than unity**
- The ability of a material to alter the magnetic field in the area that it occupies is known as – **Permeability**
- Permeability can be considered as – **Readiness of a material to accept magnetism**
- Aluminium is a …….. material – **Paramagnetic**
- Ampere turns per unit length of each part of a magnetic material depends upon the – **Working flux density**
- The unit of pole strength is – **Ampere–meter**
- Absolute permeability of free space equal to – **$\mu_0 = 4\pi \times 10^{-7}$ H/m**
- Magnetic field strength is quantified in terms of – **N/Wb or Ampere turn/meter**
- ..... property of a material supports the passes of magnetic flux through it– **Permeance**
- Magnetic reluctivity is– **The reciprocal of permeability**
- Magnetic flux per unit area is called– **Magnetic flux density**

- The S.I. unit magnetic permeance is– **Henry**
- The relative permeability of paramagnetic material is– **Slightly greater than one**
- The mathematical expression for magnetic permeability is– $\mu = \frac{B}{H}$
- The unit of magnetic flux density is– **Tesla or Weber/m^2**
- In magnetism, the equivalent of unit N/ Wb is– **A/m**
- Permeability of the substance is the measure of– **Conductivity of a substance for magnetic line of forces**
- Relative permeability of vacuum is– **1**
- The relative permeability μ_r is given by– $\mu_r = \frac{B}{\mu_0 H}$
- The relative permeability of iron is of the order of– 10^{+4}
- Magnetic field intensity is a– **Vector quantity**
- The relative permeability of the medium μ_r is related to its own permeability μ and permeability of free space μ_0 as– $\mu_r = \frac{\mu}{\mu_0}$
- Unit of magnetic flux is– **Weber**
- One Tesla is equal to– **1 Wb/m^2**
- Magnetic lines of force– **Can not intersect at all**
- The unit of relative permeability is– **No unit**
- Magnetic flux density is a– **Vector quantity**
- The tubes of force within the magnetic material are known as– **Lines of force**
- The unit of flux is the same as that of– **Pole strength**
- The gauss is a unit of– **Magnetic flux density**
- A unit of overall magnetic field quantity is the– **Maxwell**
- The unit of retentivity is– **Weber/m^2**
- The principle of optic-fiber cable is work on **Reflection**
- The band of frequncy suitable for the optical wave communication is **30THz to 300 THz**
- Twisted pair signal lines are used to reduce the offect of **Magnetic field coupling**
- What is the condition to achieve total internal reflection in an optical fiber- **Angle of incidence > Critical angle**
- The numerical operature (NA) of step -index fiber for meridional rays is $\left(n_1^2 - n_2^2\right)^{1/2}$
- Light is confined within the core of an optical fiber due to **Total internal reflection at the core cladding boundary**
- A fiber optical cable operates at approximately– **20GHz**
- Insertion loss for SC type fiber cannector in dB is of the range **0.2 to 0.45**
- What is the mximum angle of the axis at which light can enter into the fiber in order to be propagated **Acceptance angle**
- In optical fiber the attenuation rate is- **Zero dB**
- The device used for measuring the power in an optical singal **Optical power meter**
- The range (in μm) of core diameter of a multimode step index fiber **100 to 150**
- A typical optical fiber has- **High refractive index core and low refractive index cladding**
- The material is preferred for making the core of a fiber-optic cable **Glass**
- Ideal bandwidth of optical fibre is- **Infinite**
- For transmission of singnal, optical fiber used- **LASER**
- For fiber optical sensors - **Single mode transmission**
- Optical fiber operates in - **Ultraviolet, visible and Infrared band**
- MCB stand for in electrical systems - **Miniature circuit breaker**
- Main purpose of an MCB is- **Over currents protection**
- MCB generally trip in case of an overload condition- **Thermal mechanism**

Important Objective Questions asked in various Exams.

1. Examples of donor type impurities are-
(a) Phosphorus and arsenic
(b) Aluminum
(c) Arsenic and gallium
(d) Gallium and Indium
IOCL (TA)-29.09.2024, 1:30 PM – 3:30 PM

Ans. (a) : Phosphorous and arsenic are examples of donor type impurities. When a small amount of pentavalent impurity (Antimony, phosphorous or Arsenic) is added to a pure semiconductors crystal during the crystal growth, the resulting crystal is called donor type impurities /N-type semiconductor.

2. Using Arduino for home automation applications, fans can be switched ON/OFF automatically based on room temperature using a_____
(a) Direct connection (b) Transformer
(c) Relay (d) Diode
IOCL (TA)-29.09.2024, 1:30 PM – 3:30 PM

Ans. (c) : Using arduino for home automation applications, fans can be switched ON/OFF automatically based on room temperature using a relay.
● Relay are used where it is necessary to control a circuit by an independent low-power signal, or where several circuit must be controlled by one signal.

3. Pentavalent impurity is added to pure semiconductor crystal to get.
(a) N type semiconductor
(b) P type semiconductor
(c) Intrinsic semiconductor
(d) None of the above
ISRO URSC (TA), 18.04.2024

Ans. (a) : To get N-type semiconductor pentavalent impurity is added to pure semiconductor crystal.
● Intrinsic semiconductor doped with pentavalent impurity or donor impurity is called as N-type semiconductor.

4. Trivalent impurity is added to pure semiconductor to get.

(a) N type semiconductor
(b) P type semiconductor
(c) Intrinsic semiconductor
(d) None of the above

ISRO URSC (TA), 18.04.2024

Ans. (b) : Trivalent impurity is added to pure semiconductor to get P type semiconductor.
Ex- Indium, Gallium and Aluminium.

5. Which of the materials below, the conduction band and the valance band overlap?

(a) Insulators (b) Semiconductors
(c) Conductors (d) Both a and b

ISRO URSC (TA), 18.04.2024

Ans. (c) : In conductors, the conduction band and the valance band are overlap.
- Conductors have more free electron.
- In conductor the resistivity is less than insulator and semiconductor.
- Ex-Copper, Brass, Steel, Gold and Aluminium.

6. Buchholz relay is used on :

(a) welding transformers
(b) air cooled transformers
(c) furnace transformers
(d) oil cooled transformers

CGPSC AE 15.01.2021
Mizoram PSC IOF 2019 Paper-II
RRB JE 30.08.2019 Shift-II
ESIC JE 2016
LMRC JE 2015

Ans. (d) : Buchholz relay is used only in oil cooled transformer. It is a type of oil and gas actuated protection relay. It is used for the protection of a transformer from the fault occurring inside the transformer, such as impulse breakdown of the insulating oil, insulation failure of turns etc.

7. The property of material by which it can be rolled into sheets is called–

(a) Plasticity (b) Malleability
(c) Ductility (d) Elasticity

RRB JE- 01.09.2019

Ans. (b) : The property of material by which it can be rolled into sheets is called malleability. A material is made by hitting, pressing and rotating it. Malleable metal are gold and silver, which can be molded into any shape by these processes.

8. Protective relay system should have the following qualities-

(a) selectivity (b) speed
(c) sensitivity (d) All above

PGCIL SR-I, 22.08.2021
Nagaland PSC CTSE (Diploma) 2015, Paper-II

Ans. (d) : Selectivity- Selectivity is defined as the ability of protection system to eliminate a fault in a shortest time possible with the least disconnection of the system components.
Sensitivity-The ability of relay to operate with low value of actuating quantity
Speed- Speed of operation is such that it suited the desired level of fault current. For this we use primary protection and back up protection.
Hence, all the above quality necessary for a protective relay system.

9. Protective relays can be designed to respond to _____.

(a) Light intensity, impedance
(b) Temperature, resistance, reactance
(c) Voltage and current
(d) All of these

UPPSC AE 13.12.2020, Paper-II
BWSSB Code 127, 13.11.2016
Karnataka PSC JE-2016
Mizoram PSC (PHED) April 2016, Paper-I

Ans. (d) : Protective relays can be designed to respond to light intensity, impedance, temperature, resistance, reactance, voltage and current.
- A protective relay is a device that detects the fault and initiates the operation of the circuit breaker to isolate the defective elements from the rest of the system.

10. Which of the following is static relay?

(a) Transistor relay
(b) Mho relay
(c) Induction-cup relay
(d) Thermal relay

UPPCL JE 27.11.2019, Shift-I

Ans. (a) : Transistor, semiconductor diodes, thyristors, logic gates etc. are static relays integrated circuits are now being used in place of transistors.
- Fast response and long life.
- This is high sensitivity.

11. An electromagnetic attraction type relay operates on ____.

(a) Pulsated DC (b) DC only
(c) AC only (d) Both AC & DC

UPPCL JE 27.11.2019, Shift-II

Ans. (d) : Resultant torque of electromagnetic attraction type relay

$$T_R = K_1 I^2 - K$$

As the operating torque produced is proportional to the square of the current.
Hence the electromagnetic attraction type relay can be used for A.C. as well as D.C.

12. A relay performs the function of-

(a) fault isolation (b) fault detection
(c) fault prevention (d) all of these

Mizoram PSC Jr. Grade (PHED) 2014 Paper-II
SSC JE 2008

Ans. (b) : Relay perform the function of fault detection. A relay is an electromechanical switch which used to detect the fault condition and allow the trip signal to circuit breaker.

13. Induction relays are used with quantities.

(a) a.c.
(b) d.c.
(c) both a.c. and d.c.
(d) none of these

Nagaland PSC CTSE (Diploma) 2015, Paper-II

Ans. (a) : Induction relay used for A.C. only. It works on the principle of change in flux between two discs. In D.C. there is no change in flux.

14. Differential relays are used to protect the equipment

(a) Internal faults (b) Reverse current
(c) Over current (d) Over voltage

TSTRANSCO JE 2018
HPSSC JE 2017(Code-580)
Mizoram PSC (PHED) April 2016, Paper-I
BSNL TTA (JE) 14.07.2013

Ans. : (a) Differential relays are used to protect the equipments internal faults. This relay will operate when the phasor difference of two or more similar electrical quantities exceeds a pre determined amount.
Examples – Merz price protection current balance relay, electromotive force balance relay.

15. A relay is

(a) A mechanical switch
(b) An electronic switch
(c) An electromechanical switch
(d) none of these

BSNL TTA 28.09.2016, 10 AM

Ans. (c) : A relay is an electromechanical switch. Relays are used where the circuit is required to be controlled by a low power signal, or where multiple circuits must be controlled by a signal. The first relay was used as amplifier in long distance telegraphy circuits.

16. Which of the following is NOT a type of distance relay?

(a) Mho relay
(b) Buchholz relay
(c) Reactance relay
(d) Impedance relay

UPPCL JE 08.09.2021, Shift-II

Ans. (b) : The type of distance relay are-
• Mho relay
• Reactance relay
• Impedance relay
Buchholz relay is not a type of distance relay.

17. The induction cup structure is used in the -

(a) Differential relays
(b) I.D.M.T. relays
(c) Time delay relays
(d) Mho relays

DMRC JE 2015

Ans. (d) : The induction cup structure is used in the mho relays. Mho relay is high speed relay and is also known as the admittance relay.

18. Impedance relay can be used for

(a) Earth fault
(b) Phase fault only
(c) Both earth & phase fault
(d) None

HPSSC JE 2017(Code-580)

Ans. (b) : An impedance relay can be used for phase fault only, impedance relay is used in medium transmission line.

19. Overload relays are of _____ type.

(a) Solid state (b) Thermal
(c) Electromagnetic (d) All of these

UPPCL JE 11.02.2018, Shift-I

Ans : (d) Overload relay- A device that protects an electric motor against overload and phase-failure is called an overload relay.
Thermal, electromagnetic and solid state relays are the type of overload relay.

20. A Mho relay is a:

(a) voltage controlled directional relay
(b) directional restrained over current relay
(c) voltage controlled over current relay
(d) directional restrained over voltage relay

PSPCL JE 2019, Shift-II
UKPSC JE 2013, Paper-II

Ans. (a) : Mho Relay- A mho relay is also known as admittance relay. It is used for the protection of long transmission line. So that it will not produce trip signal for the power swings. Torque equation of a relay-

$T = k_1 I^2 + k_2 v^2 + k_3 VI\cos(\theta - T) - k_4$

For mho relay assume $k_1 = 0$, k_4 = very small, k_2 = -ve

$T = k_3 VI\cos(\theta\text{-}T) - k_2 V^2$

Where, $k_3 VI\cos(\theta - T)$ = Directional torque

$k_2 V^2$ = over voltage

Thus a mho relay is a voltage controlled direction relay.

21. Merz price protection system is applied to protect the alternators against

(a) External faults
(b) Internal faults
(c) Internal as well as external faults
(d) None of these

HPSSC JE 08.08.2021
HPSSSB JE-2017 (Post code- 579)

Ans. (b) : Merz price protection system is applied to protect the alternators against internal faults.

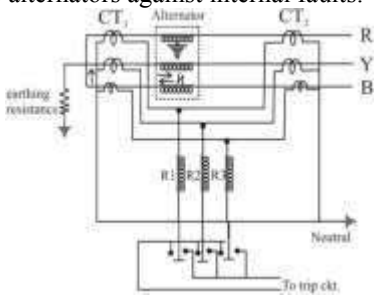


Fig of merz price protection scheme for alternators.

22. A reactance relay is

(a) Voltage restrained over current relay
(b) Voltage restrained directional relay
(c) Directional restrained over current relay
(d) Directional restrained overvoltage relay

JPSC AE 10.04.2021, Paper-I
GPSC AAE, CLASS -3, 25.07.2021

Ans. (c) : Reactance relay is use for short line it is directional restrained over current relay. Reactance relay performance remains unaffected by arc resistance during the occurrence of fault.

23. Which type of "Current Transformer arrangement" (CT) is preferred in protection of star-star power transformer?

(a) star/star connections
(b) star/delta connections
(c) delta/delta connections
(d) delta/star connections

JUVNL JE-2017
ESE-2006

Ans. (c) :

S. N.	Power transformer connection		Current transformer connection	
	Primary	Secondary	Primary	Secondary
1.	Delta	Delta	Star	Star
2.	Star	Star with neutral earth	Delta	Delta
3.	Delta	Star	Star	Delta
4.	Star with neutral earthed	Delta	Delta	Star

24. A Buchholz relay is used for

(a) Protection of induction motor
(b) Protection of synchronous motor
(c) Protection of transformer against external fault
(d) Protection of transformer against internal fault

DMRC JE 2018, Shift III
Vizag Steel 25.10.2018 Shift-I
Vizag Steel JET 27.10.2018
SSC JE 23.01.2018, Shift-I
BWSSB Code 222, 26.05.2017
UJVNL JE 2016, LMRC JE 2016
UPRVUNL JE 09.11.2016
BWSSB Code 85, 10.04.2016
Mizoram PSC Nov.2015, Paper-II
Mizoram PSC Jr. Grade (PHED) 2014 Paper-II
ESE-2005, 2007

Ans. (d) : Buchholz Relay -
It is a gas actuated relay. It is used to detect incipient faults which are initially minor faults. The Buchholz relay detects the failure and gives the alarm to the personnel. The transformer is disconnected from the main supply for maintenance.

25. Which of the following material has a negative temperature coefficient?

(a) Carbon (b) Tin
(c) Brass (d) Copper

UPPCL (TG-2) 10.11.2023, Shift-II
KPSC Electrician- 07.05.2022
UPPCL TG-2, 28.03.2021 Shift I
KPSC Junior Instructor 19.07.2019
RSMSSB Instructor (Wireman)-24.03.2019
KPSC Instructor 16.01.2017
UPRVUNL TG-II Electrician-2016

Ans (a) : Carbon is a semi-conductor material and the temperature coefficient of resistance of the semiconductor material is negative.
Example.– Carbon, silicon, Germanium etc.
While the metal conductor has a positive temperature coefficient.
Example– Copper, Aluminium etc.

26. Assigned limiting insulation temperature for materials like Ceramic and quartz without binders or with silicon resins of higher thermal stability is.

(a) Above 180°C (b) 120°C
(c) 90°C (d) 180°C

UPPCL (TG-2) 07.11.2023, Shift-II
UPPCL (TG-2) 09.11.2023, Shift-I
UPPCL (TG-2) 03.11.2023, Shift-I
UPPCL (TG-2) 10.11.2023, Shift-I
UPPCL (TG-2) 08.11.2023, Shift-II
UPRVUNL (TG-II) 21.12.2022, Shift-I

Ans. (a) : Ceramic and quartz without binder is a class C type insulation. The maximum operating temperature of class C insulation is above 180ºC.

Temperature classification of Insulating material.

Class	Maximum Temperature	Materials
Class Y	90ºC	Cotton, Silk, paper, cellulose, wood.
Class A	105ºC	The material of class Y impregnated with natural resin, cellulose, ester, insulating oil etc.
Class E	120ºC	Synthetic resin enamels, cotton and paper laminated with formaldehyde bonding etc.
Class B	130ºC	Mica, glass, fibre.
Class F	155ºC	The material of class B with bonding material of higher thermal stability.
Class H	180ºC	Glass, fibre, asbestos, mica with silicon resin.
Class C	above 180º	Mica, ceramic, glass quartz without binders or with silicon resin of higher thermal stability.

27. Which of the following insulating materials can be used only with tinned copper conductors?

(a) Impregnated paper
(b) Vulcanised Indian Rubber
(c) Varnished cambric
(d) Polyvinyl chloride

UPPCL (TG-2) 09.11.2023, Shift-II
UPPCL (TG-2) 10.11.2023, Shift-II
UPPCL (TG-2) 08.11.2023, Shift-II
MPESB Electrician 22.12.2022

Ans. (b) : Vulcanised Indian Rubber (VIR) insulating materials can be used only with tinned copper conductors.

28. The main requirements of the insulating materials used in cables is:

(a) low insulation resistance
(b) high insulation reactance
(c) high dielectric strength
(d) low insulation reactance

UPPCL (TG-2) 07.11.2023, Shift-II
UPPCL (TG-2) 03.11.2023, Shift-I
UPPCL (TG-2) 09.11.2023, Shift-II
UPPCL (TG-2) 10.11.2023, Shift-I
UPRVUNL TG-2, 15.07.2021 Shift I

Ans (c) : The insulating materials used in cable insulation should have the following properties–

(i) The dielectric strength of the insulating material should be high.
(ii) The insulating material should be flexible so that its insulation does not break during use.
(iii) The insulating material should not be hygroscopic.
(iv) The insulating material should have mechanical properties like elasticity and tensile etc.
(v) Insulating material must be non-inflammable.
(vi) The thermal expansion coefficient of the material should be low.
(vii) The insulating material must be able to with stand high temperatures without damage.
(viii) Chemical substance like acid or base should not have any effect on the insulating material.

29. Mica is an example of a .....

(a) Conductor material
(b) Semiconductor material
(c) Super conductor material
(d) Insulator material

UPPCL (TG-2), 07.11.2023, Shift-I
UPPCL (TG-2) 03.11.2023, Shift-I
DMRC Maintainer 18.02.2020 (9.00-10.30)

Ans (d) : Mica is an example of a insulator material.
Solid insulators- Glass, porcelain, mica, paper, rubber, asbestos, wood, plastic etc.
Liquid insulators- Bromine, transformer oil, switch gear and circuit breaker oil, distilled water etc.
Gases insulators material – Nitrogen, oxygen, halogen, air, CO_2, helium, neon etc.

30. Which of the following is not an insulating material?

(a) Mica (b) Rubber
(c) P.V.C. (d) Nichrome

UPPCL (TG-2) 09.11.2023, Shift-I
DSSSB Electric Driver or Electric Mistry-11.07.2023
UPPCL-TG-2 Electrical-2014

Ans : (d) Nichrome is not an insulating material.

- The insulator is a material in which the electron does not flow freely.
- The electron of the insulator is tightly bound in atoms.

Example of Insulators - PVC, plastics, rubber, mica, glass and bakelite.

31. The material commonly used for insulation in high voltage cables is-

(a) Teflon (b) Impregnated paper
(c) Rubber (d) PVC

UPPCL (TG-2) 09.11.2023, Shift-I
(ISRO DT. 10.02.2019)

Ans : (b) The material commonly used for insulation in high voltage cables is impregnated paper.

- Impregnated paper is generally used for insulation in high voltage cables. In high voltage cables, insulating oil and impregnated paper is used.
- Paper, varnished cambric and vulcanized bitumen etc. are used in low voltage cables. Petroleum jelly is used with varnish cambric tape to prevent damage from movement.

32. Which of the following is NOT a desirable characteristic of insulation material?

(a) High mechanical strength
(b) High resistance to temperature
(c) High flexibility
(d) Low dielectric strength

UPPCL (TG-2) 10.11.2023, Shift-II
UPRVUNL (TG-2) 21.12.2022, Shift-II

Ans. (d) : Low dielectric strength is not a properties of insulating material.

Property of Insulating material –

- The material must have high mechanical strength so that it carries the tension and weight of the conductors.
- They must have high dielectric strength.
- The material is non-porous and free from impurities.
- Thermal stability is good.

33. High resistance material constantan consists of:

(a) Chromium - nickel alloy
(b) Copper - aluminium alloy
(c) Copper - nickel alloy
(d) Copper - tungsten alloy

MPPGCL JE (Plant)-29.04.2023, 4:30PM – 6:30 PM

Ans. (c) : High resistance material constantan consist of copper-nickel alloy.

Constantan:

- It is also known as Eureka.
- It usually consist of 55% copper and 45% nickel.

Properties of constantan:

- Temperature coefficient of resistance at 20^0C: $0.000031/^0$C
- Good mechanical strength
- Melting point : 1300^0C
- Easily ductile

Application:

- It is used for the measurement of temperature.
- For making rheostats
- It is mainly used for thermocouples and electrical resistance heating.
- Constantan is used for making electrical connections in instruments such as, shunt resistor (used in ammeters) swamp resistors (to reduce thermal emf) etc.

34. Which of the following is NOT a property of an insulating material for cable?

(a) High dielectric strength
(b) High insulation resistance
(c) Non - inflammable
(d) Hygroscopic

MPPGCL JE (Plant)-29.04.2023, 4:30PM – 6:30 PM

Ans. (d) : Properties of insulating material-

- High dielectric strength
- Low permittivity
- High mechanical strength
- Non-inflammable
- Non-hygroscopic
- High insulation resistance
- Unaffected by acids and alkaloids.

35. Pure Metals generally have:

(a) High Conductivity and Low temperature coefficient
(b) High Conductivity and High temperature coefficient
(c) Low Conductivity and zero temperature coefficient
(d) Low Conductivity and High temperature coefficient

UPPCL JE Electrical, 11.11.2016

Ans : (b) Pure metal generally have high conductivity and high temperature co-efficient. Pure metal has low value of specific resistance and high value of conductivity. It has positive temperature co-efficient.

36. Bakelite is a

(a) Insulator
(b) Semiconductor
(c) High resistivity conductor
(d) Low resistive conductor

RRB Guwahati Electronic- 2014, AAI 26.4.2015

Ans : (a) Bakelite is a insulator. Bakelite is an example of a thermosetting polymer and also a type of phenol-formaldehyde polymer. These are obtained by the condensation reaction of phenol with formaldehyde in the presence of either an acid or a base catalyst.

37. In insulators :

(a) Internal Electric Charges flows freely external electric field
(b) Internal Electric Charges does not flows freely external electric field
(c) Internal Electric Charges flows along with external electric field
(d) Internal Electric Charges flows opposite to external electric field

AAI 26.4.2015

Ans : (b) In insulator internal electric charges does not flows freely in an external electric field because-

- They have no loosely bound or free, electrons that may drift through the insulator.
- Insulators are used in electrical equipment to support and separate electrical conductors without allowing current through themselves.

38. The resistances in the higher range an mostly made of :

(a) Carbon (b) Aluminium
(c) Silicon (d) Germanium

KVS JE Electrical & Electronic-2016

Ans : (a) The resistance is the higher range an mostly made of carbon. Resistance is the property of an electric circuit that transform electrical energy into heat energy in opposing electric current, resistance depend on the material of the conductor.

39. Which of the following materials is NOT an insulator?

(a) Wood (b) Aluminum
(c) Plastics (d) Rubber

NPCIL- 2019

Ans. (b) : Insulator is a material in which there are no free electron. The flow of charge is negligible in it. When a strong electric field is applied.
Example - Wood, plastic, rubber etc.
Aluminium is a conducting material.

40. In which earthing system is galvanized steel used?

(a) Pipe Earthing
(b) Rod Earthing
(c) Strip or Wire Earthing
(d) All of the options

NPCIL- 2019

Ans. (d) : Galvanization is the process of a protective zinc coating to steel or iron to prevent rusting. The zinc coating is often applied using a 'hot bip' process whereby steel is immersed into molten zinc for a metallurgic bond.
Galvanised steel used -
1. Pipe earthing
2. Rod earthing
3. Strip or wire earthing

41. Which of the following material has the highest electrical conductivity?

(a) Gold (b) Silver
(c) Copper (d) Aluminium

SSC IMD 25.11.2017 Evening

Ans. (b) : A conductor is a material which gives very little resistance to the flow of an electric current.
Silver has the highest electrical conductivity out of all material. The decreasing order of conductivity is Silver > Copper > Gold > Aluminium.

42. In which of the following material's resistance is independent of change in temperature?

(a) Brass
(b) Platinum
(c) Tungsten
(d) Alloys of Constantan and Manganin

SSC IMD 25.11.2017 Evening

Ans. (d) : Alloy of constantan and manganin resistance is independent of change in temperature. Constantan is also known as Eureka. It is alloy of copper and nickel. Manganin is made of a mixture of copper manganese and nickel. Temperature has no effect on these alloy.

43. In a ferromagnetic material, susceptibility is

(a) Very small and positive
(b) Very large and positive
(c) Very small and negative
(d) Very large and negative

Karnataka Telecom Circle- 2010

Ans. (b) : Ferromagnetic materials- Ferromagnetic materials are these materials which exhibit a spontaneous net magnetization at the atomic level, even in the absence of an external magnetic field.
Example: Iron, Cobalt, Nickel etc.

- In a ferromagnetic material, susceptibility is very large and positive.
- It is strongly attracted to a magnate.

44. Which material does the following figure represent -

↑ ↑ ↑ ↑ ↑

(a) Diamagnetic (b) Ferromagnetic
(c) Paramagnetic (d) Ferrimagnetic

Karnataka Telecom Circle- 2010

Ans. (b) : ↑ ↑ ↑ ↑ ↑
Figure represent the ferromagnetic material. A ferromagnetic material is a substance by which permanent magnetism is created. It is magnetized externally, it remain magnetized even when the magnetic field is removed.

45. _____ is a material that is used to make cable sheaths.

(a) Aluminium (b) Copper
(c) Lead (d) Cast iron

DFCCIL EE 11.11.2018, 12:30 PM–2:30 PM

Ans. (c) : Lead is a material that is used to make cable sheath. The advantage of lead sheathed cable -
1. Protection against the entry of hydrocarbon.
2. Protection against moisture.

46. _____has a low temperature co-efficient of resistance.

(a) Tungsten (b) Manganin
(c) Carbon (d) Aluminium

NPCIL- 2019

Ans. (b) : Manganin has a low temperature co-efficient of resistance. Therefore it does not change much with temperature.

- It is combination of copper, nickel and manganese
- It has a very high resistivity.
- It is used in potentiometer.

47. Out of four materials the best insulator is

(a) SiO_2 (b) PVC
(c) Porcelain (d) Bakelite

Gujarat Telecom Circle- 2012

Ans. (a) : Out of these the best insulator material is SiO_2. Electric charge do not flow freely through insulator. SiO_2 is an amorphous material used in microsystem as a dielectric in capacitor and transistor as an insulator to isolate various electronic element.
Example - Rubber, glass, pure water oil, air, diamond etc.

48. An insulator will conduct when the

(a) Voltage applied is more than the break down voltage
(b) Temperature is raised to very high level
(c) Either of (a) or (b)
(d) None of these

West Bengal Telecom circle-2008

Ans. (c) : An insulator will conduct when the voltage is more than the break down voltage or temperature is raised to very high level.

- Insulator are materials that have just the opposite effect on the flow of electrons.
- Its atoms have tightly bound electrons.
- They do not have free electrons which is responsible for conduction.

49. Which among the following is an insulator

(a) Germanium (b) Silicon
(c) Mica (d) Selenium

Cochin Shipyard-2021

Ans. (c) : Germanium, Silicon and Selenium are a semiconductor but "Mica is an insulator". Mica is a naturally element. It is optically flat, translucent and elastic in nature. It composition is silicate, aluminium, potassium, manganese, water and iron. It contains the highest amount of Silica. So, it is most preferred in industries.

50. The order of resistivity of silver is-

(a) Ohm meter
(b) Milli-ohm meter
(c) Nano-ohm meter
(d) Mega-ohm meter

NPCIL- 2019

Ans. (c) : The order of resistivity of silver is Nano-ohm meter.

Material		Resistivity at 20ºC ρ (Ω–m)	Conductivity at 20ºC (Siemen/meter)
(1)	Silver	1.59×10^{-8}	6.30×10^{7}
(2)	Copper	1.68×10^{-8}	5.96×10^{7}
(3)	Gold	2.44×10^{-8}	4.10×10^{7}

51. The dielectric strength of a substance depends on.

(a) Apply voltage
(b) Thickness
(c) Shape of electrode
(d) All of these

UPPCL TG-2 10.11.2023, Shift-II
JVVNL Electrician Helper III, 23.08.2018 Shift III

Ans. (d) : The dielectric strength of a substance depends on applied voltage, thickness and shape of electrode.

52. What is the maximum safe temperature for the insulating material like mica, glass, fiber and asbestos?

(a) 130ºC (b) 90ºC
(c) 180ºC (d) 155ºC

UPPCL (TG-2) 17.11.2023, Shift-I
MPESB Electrician 22.12.2022

Ans. (a) : The maximum safe temperature for the insulating material like mica, glass, fiber and asbestos is 130ºC.

■ These insulating material are come in class - B of temperature classification of insulating materials.

53. Which of the following materials is good conductor of electricity?

(a) Gold (b) Iron
(c) Aluminium (d) Copper

KPSC Electrician– 07.05.2022

Ans. (d) : The copper material is good conductor of electricity. Electrical resistivities of some materials at 20ºC are given below.

Silver	1.60×10^{-8} Ω-m
Copper	1.72×10^{-8} Ω-m
Tungsten	5.520×10^{-8} Ω-m
Iron	9.8×10^{-8} Ω-m
Mercury	95.0×10^{-8} Ω-m
Nichrome	108×10^{-8} Ω-m

54. Which of the following is a conductor of electricity?

(a) Mica (b) Sand
(c) Glass (d) Tap water

IREL Electrician Tradesman-04.09.2022

Ans. (d) : Tap water includes impurities, such as dissolved sodium, calcium and magnesium salt, thus it is an excellent conductor of electricity.

55. Which material has the highest electrical conductivity?

(a) Steel (b) Silver
(c) Aluminium (d) Lead

JVVNL Electrician Helper III, 24.08.2018 Shift I
ISRO. DT. 24.03.2019

Ans. (b) : Silver has the highest electrical conductivity.

■ It is high conductivity and low specific resistance
■ Its melting point is 961.8°C.
■ Its resistivity is around 1.59×10^{-8} Ω-m. or 1.6×10^{-8}

Material	–	Electric Conductivity at 20°C
Silver	–	6.30×10^{7}
Copper	–	5.96×10^{7}
Gold	–	4.11×10^{7}
Aluminium	–	3.5×10^{7}
Iron	–	1.00×10^{7}

56. Constantan consists of_____.

(a) Silver and tin
(b) Copper and tungsten
(c) Tungsten and silver
(d) Copper and nickel

JVVNL Electrician Helper III, 24.08.2018 Shift III

Ans. (d) : Constantan is a Nickel-Copper alloy also known as Eureka.

■ It usually consists of 55% copper and 45% Nickel.
■ Its main feature is the low thermal variation of its resistivity, which is constant over a wide range of temperature.

57. In which case the forbidden energy gap is maximum?

(a) Metal (b) Insulator
(c) Semiconductor (d) Semi metal

JVVNL Electrician Helper III, 25.08.2018 Shift I

Ans. (b) : A forbidden energy gap is maximum in the case of insulators.

■ The forbidden energy gap for insulator is greater than 5eV.

58. Nichrome is an alloy of_____.

(a) 80% nickel and 20% chromium
(b) 20% nickel and 80% chromium
(c) 50% nickel and 50% chromium
(d) 20% chromium and 80% iron

JVVNL Electrician Helper III, 25.08.2018 Shift II

Ans. (a) : Nichrome is an alloy of 80% nickel and 20% chromium.

■ Operating temperature of nichrome is 1150°C.

59. The maximum working temperature of an insulator made of paper for safe use is .....

(a) 80ºC (b) 90ºC
(c) 105ºC (d) 50ºC

[DMRC Maintainer 10.04.2018, 9.00 -10:30 am]

Ans. (b) : The maximum working temperature of an insulator made of paper for safe use is 90°C.

Class	Safety tem.	Insulator material
Y	90ºC	Silk, normal paper.
A	105ºC	Cotton, Silk, Oil.
E	120ºC	Leathered Paper, Fiber, Empire Cloth.
B	130ºC	Mica, glass, Impregnated Insulating Material.
F	155ºC	Mica, fiber glass, asbestos.
H	180ºC	Elastomer and mica, Fiber, Glass.

60. Which of the following has an enamel varnish coating over a copper wire?

(a) Enamelled wire (b) PVC wire
(c) Cotton wire (d) Flexible wire

[DMRC Maintainer 12.04.2018, 9.00 -10:30 am]

Ans. (a) : Enamelled wire is coated with enamel varnish.

- Magnet wire or enamelled wire, also known as winding wire.
- Winding wire is a copper (Cu) or Aluminium (Al) wire which coated with a thin layer of insulation.
- Magnet or enamel is used construction of transformer, inductors, motors, generators, speakers, hard disk head actuator, electromagnet and other application that require tight coil of insulated wire.

61. Which of the following is not an insulator?

(a) Gold (b) Mica
(c) Glass (d) Wood

ALP, Technician 22.01.2019, [08:30-11:00]

Ans. (a) : Gold is not an insulator because it has a large number of free electron. Gold is a good conductor.

- The material that do not allow current to pass through them easily are called insulator. Here wood, mica, glass and cotton are insulators, which do not allow the current to pass through them.

62. Ceramic ring is used as .....

(a) Bonding agent
(b) Strong coupler
(c) Impedance regulator
(d) Insulator

ALP, Technician 22.01.2019, [04:30-07:00]

Ans. (d) : Ceramic ring is used as insulator.

- Ceramic are hard and brittle and are in the form of amorphous or glassy solid. The bond in these materials is mixed ionic and covalent.
- The electrons are not free to move, hence they are thermal and electrical insulator at low temperatures, ceramic behave elastically.

Ceramic have certain properties like-

- High melting points so they are highly heat resistant.
- Great hardness and strength.
- Very durable
- Very low thermal conductivity.

63. With rise in temperature the resistance of pure metals–

(a) increases
(b) decreases
(c) first increases and then decreases
(d) remains constant

UPPCL Electrician TG-2 Trainee 16.10.2016, Re-Exam

Ans : (a) With rise in temperature the resistance of pure metals increases because the conductor have positive temperature coefficient of resistance

- Semiconductor and insulator have negative temperature coefficient of resistance.

64. Which of the following material is not a good conductor?

(a) Porcelain (b) Aluminium
(c) Silver (d) Copper

Noida Metro Technician Grade-II–2017

Ans : (a) Porcelain is not a good conductor of electricity

- Materials like glass and plastic are poor (negligible) electrical conductors so it is called insulator.
- Good conductors are the materials that allow the electricity to pass through itself.

65. Which is not a good conductor of electricity ?

(a) Copper (b) Silver
(c) Aluminium (d) PVC

HPSSC Lineman Instructor 15.07.2018

Ans. (d) PVC is not a good conductor of electricity.

- P.V.C is use to provide insulation in electrical circuits. The full-form of PVC is Polyvinyl Chloride.
- Its dielectric strength is high.
- Copper, silver, aluminium etc. are good conductors of electricity whose resistivity is extremely low**.**

66. The maximum safe temperature for class F insulating material is.

(a) 155 ºC (b) 130 ºC
(c) 120 ºC (d) 180 ºC

KPSC Junior Instructor Electrician-28.09.2015

Ans. (a) : The maximum safe temperature for class F insulating material is 155°C.

Class of materials	Temperature
Class Y	90ºC
Class A	105 ºC
Class E	120 ºC
Class B	130 ºC
Class F	155 ºC
Class H	180 ºC
Class C	Above 180 ºC

67. Capacity of a storage battery is measured in.....

(a) Ampere (b) Watts
(c) Ampere hour (d) Volts

UPPCL (TG-2) 08.11.2023, Shift-II
KPSC Electrician 07.05.2022
IREL Electrician Tradesman-04.09.2022
UPPCL TG-2, 19.03.2021, Shift-I
NPCIL Cat-II, Electrician maintainer 12.09.2021
DMRC maintainer, 17.02.2020, 9.00-10.30AM
KPSC Instruction Electrician 26.09.2020
KPSC Electrician 30.09.2020
ALP Technician 30.01.2019
UPPCL TG-2 (25.01.2019), Shift-II
KPSC Junior Instruction 19.08.2019
UPPCL TG-2 26.06.2016 / ISRO Technician 27.11.2016
Kerala PSC Wireman Inspector 26.02.2016
UPPCL TG-2 Electrical 2015

Ans. (c) : Capacity of a storage battery is measured in Ampere hour.

- Battery capacity is a measure of the charge stored by the battery and is determined by the mass of active material contained in the battery.
- The battery capacity represent the maximum amount of energy that can be extracted from the battery under certain specified conditions.

68. The bending of the electrode (plates) due to excessive charge or discharge of the battery is called?

(a) Buckling (b) Sedimentation
(c) Corrosion (d) Sulfation

UPPCL (TG-2) 08.11.2023, Shift-I
UPPCL TG-2, 27.03.2021 Shift II
UPPCL TG-2 24.01.2019 Shift II
DMRC Maintainer 17.04.2018(9:00 - 10:30 am)
KPSC Line man Exam 19.01.2021
DSSSB Instructor Electrician 16.10.2019

Ans (a) : The bending of the electrode (plates) due to excessive charge or discharge of the battery is called buckling

- Sulfation in lead acid battery refer to the formation of lead sulfate ($PbSO_4$) on the plates of the battery.

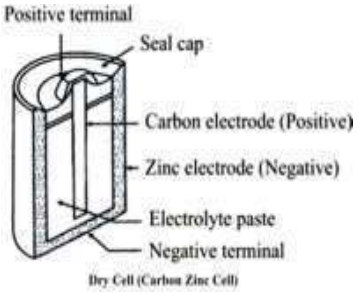
69. Which of the following is a dry cell?

(a) Lithium cell
(b) Silver oxide cell
(c) Zinc carbon cell
(d) Zink chloride cell

UPPCL (TG-2) 07.11.2023, Shift-I
UPPCL (TG-2) 08.11.2023, Shift-I
DSSSB Electric Driver or Electric Mistry- 11.07.2023
UPPCL TG-2, 28.03.2021 Shift I
ALP Technician 23.01.2019 Shift I
IOF paper I 2017
MP Line Attendent 24.08.2018

Ans : (c) Zinc carbon cell is a dry cell.

- **Primary cells:** It is a cell that once it has been discharge cannot be recharged.



Dry Cell (Carbon Zinc Cell)

Primary cell	Secondary cell
Zinc carbon dry cell	Nickel-cadmium cell
Lithium cell	lithium-ion cell
Mercury cell	Nickel-metal hydride cell
Silver oxide cell	Lead Acid Cell

70. Positive plate of lead acid cell is made of.....

(a) Carbon (b) Lead
(c) Copper (d) Lead peroxide

JSSC Electrician -20.10.2023
UPPCL (TG-2) 17.11.2023, Shift-I
NPCIL Cat-II Electrician Maintainer-12.09.2021
NPCIL (STM) 03.12.2019
HPSSC Lineman Instructor 15.07.2018

Ans. (d) : Positive plate of lead acid cell is made of lead peroxide (PbO_2).

- Negative plate of lead acid cell is made of lead(Pb).
- Colour of positive plate $\rightarrow$ Dark chocolate brown.
- Colour of negative plate $\rightarrow$ Gray color.

71. Which of the following cells has the highest life compared to other primary cells?

(a) Silver Oxide Cell (b) alkaline cell
(c) Dry cell (d) Lithium cell

MAHATRANSCO Technician-2023
UPPCL TG-2, 27.03.2021 Shift-I
UPPCL TG-2, 28.03.2021 Shift-II

Ans (d) : Lithium cell has the highest life time as compared to other primary cell. It generate voltage from 2.5 V to 3.7 V.

Advantage of lithium cell over other primary cell are–

- Longer self life - near about 10 year

72. Nickel-iron cell is-

(a) Secondary cell
(b) Dry primary cell
(c) Primary cell
(d) Dry secondary cell

JSSC Electrician -20.10.2023
(R.R.B. Chennai (L.P.)-2010), (IOF 2015)

Ans : (a) Nickel-iron cell is secondary cell. The electromotive force of this cell from 1.2 to 1.4 V. Steel plates are very strong. Hence the life of the cell is longer than that the lead-acid cell.

73. What is the output of a lead acid cell?

(a) 1.35 V (b) 2.2 V
(c) 4 V (d) 6 V

JSSC Electrician -20.10.2023
JVVNL Electrician Helper III, 25.08.2018 Shift III

Ans. (b) : The nominal voltage or output voltage of a fully charged lead-acid cell is 2.2V.

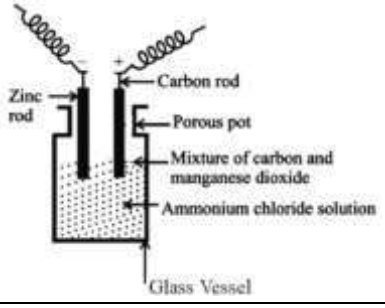
Primary cell	Voltage	Secondary cell	Voltage
Mercury	1.35 V	Silver cadmium	1.1 V
Carbon zinc	1.5 V	Silver zinc	1.86 V
Zinc chloride	1.5 V	Lead-acid cell	2.2 V
Silver oxide	1.5 V	Nickel-iron cell	1.36 V
Lithium	2.95 V	Nickel Cadmium	1.25 V

74. In Lechlanche cell, electrolyte is:

(a) Zinc
(b) Carbon
(c) Sulfuric acid
(d) Ammonium chloride

JSSC Electrician -20.10.2023
UPPCL (TG-2) 07.11.2023, Shift-I
(ISRO Technician Electroplating 27.11.2016)

Ans : (d) Ammonium chloride solution is used in lechlanche cell which is act as an electrolyte. The carbon and zinc rods act as positive and negative electrodes respectively.



75. The indications of a fully-charged cell are :

(a) Temperature (b) Weight
(c) Gassing (d) Volume

UPPCL (TG-2) 03.11.2023, Shift-I
UPRVUNL TG-2, 14.07.2021 Shift I

Ans (c) : The indications of a fully charged cell particularly in lead acid batteries gassing occurs due to the electrolysis of water releasing hydrogen and oxygen gases.

- The colour of the positive plates will be dark chocolate brown colour. This can be seen only if the battery has transparent cover.
- Voltage per cell of lead acid cell will be 2.2 volts.

76. Which of the following is a primary cell?

(a) Lead-acid (b) Mercury-oxide
(c) Lithium-ion (d) Nickel-cadmium

UPPCL (TG-2) 09.11.2023, Shift-I
UPPCL (TG-2) 08.11.2023, Shift-II
JVVNL Technical Helper-27.08.2022,12:00-2:00PM

Ans. (b) : Mercury-oxide cell is a primary cell.

Primary cell	Nominal Voltage
Mercury cell	1.35 V
Voltaic cell	1.08 V
Daniel cell	1.1 V
Lechlanche cell	1.5 V
Dry cell	1.5 V
Lithium cell	2.95 V
Secondary cell	**Voltage**
Lead acid cell	2.2 V
Nickel iron cell	1.2 V
Nickel Cadmium cell	1.25 V
Silver-zinc cell	1.86 V

77. The watt hour efficiency of lead acid cell is-

(a) 60% (b) 90%
(c) 50% (d) 75%

UPPCL (TG-2) 08.11.2023, Shift-II
UPPCL TG-2 (Date : 25-01-2019) Shift-II

Ans : (d) The watt hour efficiency of lead acid cell is about 75%.

- **The efficiency of lead acid cell is represented in two ways-**
  (i) Ampere–hour efficiency (90% to 95%)
  (ii) Watt – hour efficiency (70% to 80%)

78. In Edison cell the positive plate consist of

(a) Nickel Hydroxide (b) Iron
(c) Nickel Oxide (d) Copper

UPPCL TG-2, 08.11.2023 Shift I
UPPCL TG-2, 10.11.2023 Shift I
GSSSB Supervisor Instructor 15.09.2019

Ans. (a) : The positive plate in Edison cell is made of nickel hydroxide $Ni(OH)_4$.

- After the charging process, the positive plate is becomes of nickel hydroxide $[Ni(OH)_4]$ and the negative plate is becomes of iron [Fe].
- After the discharging process, the positive plate is becomes of nickel hydrate $[Ni(OH)_2]$ and the negative plate is becomes of iron hydrate $[Fe(OH)_2]$.
- 20% KOH + 1% LiOH is used as electrolyte in Edison cell.
- The emf of the Edison battery at full charge is 1.36 and at discharged is 1.1V.
- Ampere hour efficiency is approximately 80% and watt hour efficiency is approx 60%.

79. What is the electrolyte of nickel iron cell?

(a) Dilute sulfuric acid
(b) Alkaline
(c) Sulfur dioxide
(d) 21% solution of KOH

UPPCL TG-2, 09.11.2023 Shift II
UPPCL TG-2, 10.11.2023 Shift I
UPPCL TG-2, 28.03.2021 Shift I

Ans : (d) The electrolyte of nickel iron cell is 21% solution of KOH.

Nickel iron cell:

- The weight of this battery is lower than other type of battery because they need fewer amounts of electrolytes and plates are also lighter.

The service life of the battery is much higher because of various provisions made.

80. A battery is used to

(a) measure electric current.
(b) measure electric potential
(c) safeguard against short circuit
(d) maintain a potential difference.

IREL Electrician Tradesman-04.09.2022

Ans. (d) : A battery is used to maintain a potential difference.

Potential difference: It can be defined as the difference in the amount of energy that the charge carrier has between the two points in the circuit is called a potential difference.

- It is always measured in the volt also known as voltage.
- It may also be defined as the amount of work done in moving a specific charge from one point to another point.

81. What is the voltage rating of single dry cell (Zinc-Carbon)?

(a) 1.5 V (b) 2.2 V
(c) 2.4 V (d) 3.6 V

NPCIL Cat-II Electrician Maintainer-12.09.2021
NPCIL (STM)13.12.2019

Ans. (a) : The voltage rating of single dry cell (zinc-carbon) is 1.5 volt.

Dry cell: A dry cell consists of a metal container in which a low moisture electrolyte paste covers the graphite rod. Generally the container will be zinc whose base acts as a negative electrode and a carbon rod acts as a positive. It is surround by MnO_2 and low moisture electrolyte (NH_4Cl paste) which will produce a maximum of 1.5 V of voltage, and it is not reversible.

Cell	Voltage
Zinc-carbon	1.5 V
Daniel cell	1.1 V
Lechlanche cell	1.5 V
Lithium cell	2.95 V

82. The nominal voltage for lead acid cells is:

(a) 1.4 V (b) 2 V
(c) 24 V (d) 12 V

UPRVUNL TG-2, 14.07.2021 Shift II
KPSC Fireman Exam 19.01.2021
UPPCL-TG-2 Electrical 2015

Ans. (b) : For lead acid cell nominal voltage is 2 volt.

- Lead-acid batteries can be classified as secondary batteries. The chemical reaction occur in secondary cells are reversible.

83. During charging of lead acid battery.

(a) Anode colour become dark red.
(b) Anode colour become white.
(c) Anode colour become dark yellow.
(d) Anode colour become chocolate brown.

UPRVUNL TG-2, 15.07.2021 Shift I

Ans (d) : During charging of lead acid battery anode color become chocolate brown.

- The active elements of lead acid batteries are lead peroxide (PbO_2), sponge lead, and dilute sulfuric acid (H_2SO_4).

84. During discharging of lead acid battery……..

(a) Only the anode is converted to $PbSO_4$.
(b) Both anode and cathode are converted into Pb_2SO_4.
(c) Only cathode are converted into $PbSO_4$
(d) Both anode and cathode are converted into $PbSO_4$.

UPRVUNL TG-2, 15.07.2021 Shift I

Ans (d) : During discharging of lead acid battery both anode and cathode are converted into $PbSO_4$.

$$\underset{\text{Neg. plate}}{Pb} + \underset{\text{Pos.plate}}{PbO_2} + 2H_2SO_4 \underset{\text{Charging}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\text{Pos.plate}}{2PbSO_4} + 2H_2O + \underset{\text{Neg. plate}}{PbSO_4}$$

85. Complete the following discharge reaction that occurs at the positive plate of nickel-cadmium battery.

$Ni(OH)_4 + 2K \rightarrow$

(a) $NiOH_2 + 2KOH$
(b) $2NIOH_2 + 2KOH$
(c) $Ni(OH)_2 + 2\ KOH$
(d) $2KOH_2 + 2NiOH$

UPRVUNL TG-2, 15.07.2021 Shift II

Ans (c) : Positive plate- $Ni(OH)_4 + 2K \rightarrow Ni(OH)_2 + 2$ KOH

Negative plate- $Cd + 2OH \rightarrow Cd(OH)_2$

■ Ni-Cd battery:-

The active material in the nickel cadmium battery is Nickel hydroxide $Ni(OH)_2$ acts as a positive plate where cadmium acts as a negative plate.

Reaction during charging state:-

Positive plate $Ni(OH)_2 + 2OH \rightarrow Ni(OH)_4$
Negative plate $Cd(OH)_2 + 2K \rightarrow Cd + 2KOH$

86. Which parameter of magnetism is measured in unit of Tesla?

(a) Magnetic field
(b) Magnetic flux path reluctance
(c) Magnetic flux
(d) Magnetic flux density

UPPCL (TG-2) 17.11.2023, Shift-II
UPPCL (TG-2) 07.11.2023, Shift-II
UPPCL TG-2, 28.03.2021 Shift I

Ans : (d) The magnetic flux density of a magnetism is measured in unit of Tesla. It is denoted by symbol 'B'.

$$B = \frac{\phi}{A} \quad \frac{Wb}{m^2} \text{ or Tesla}$$

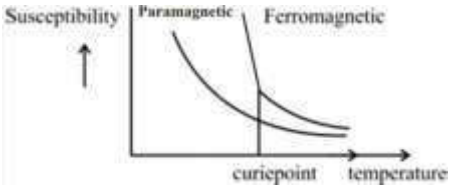
Magnetic flux density is a vector quantity.

87. The saturation magnetization of ferromagnets at the curie temperature is-

(a) Maximum
(b) In between maximum and minimum
(c) Zero
(d) Minimum

UPRVUNL (TG-II) 21.12.2022, Shift-I

Ans. (c) : The saturation magnetization of Ferromagnets at the curie temperature becomes zero and above that it becomes paramagnetic.



88. ..... is the strongest diamagnetic material.

(a) Water (b) Paper
(c) Graphite (d) Bismuth

UPRVUNL (TG-2) 21.12.2022, Shift-II

Ans. (d) : Bismuth is the strongest diamagnetic material.

Diamagnetic substance – Diamagnetic substance are those substances which are repelled by a magnet. Some example of diamagnetic material.

Antimony, bismuth, graphite, copper, lead, gold, silver etc.

- Two of the strongest diamagnetic material are graphite and bismuth, and bismuth is more strongest.

Properties of diamagnetic substances –

- When it is placed in a magnetic field, it develops weak magnetization in a direction opposite to the direction of magnetic field.
- The permeability of a diamagnetic material is slightly less than one.
- The susceptibility of diamagnetic materials is negative.

89. Which of the following is not a paramagnetic material?

(a) Siderite (b) Nontronite
(c) Nickel (d) Pyrite

UPRVUNL TG-2 22.12.2022, Shift-II

Ans. (c) : Nickel is not a paramagnetic material.

Paramagnetic material- Paramagnetic materials have a small positive susceptibility to magnetic fields. These materials are slightly attracted by magnetic field do not retain the magnetic properties when the external field is remove ex- Aluminium, phosphorous, oxygen.

90. Susceptibility is positive for

(a) Ferromagnetic materials
(b) Diamagnetic materials
(c) Paramagnetic materials
(d) None of these

KPSC Electrician– 07.05.2022

Ans. (a) : The susceptibility of ferromagnetic materials is high and positive.

- The susceptibility of paramagnetic materials low and positive.
- The susceptibility of diamagnetic materials is low and negative.

91. The diamagnetic material has a relative permeability is.

(a) Less than 1
(b) More than 1
(c) More than 100
(d) Equal to ferromagnetic material

KPSC Electrician– 07.05.2022

Ans. (a) : The relative permeability of diamagnetic material is less than one.

$$\boxed{\mu_r < 1}$$

- The relative permeability of paramagnetic material is slightly greater than one.

$$\boxed{\mu_r > 1}$$

- The relative permeability of ferromagnetic material is more greater than one.

$$\boxed{\mu_r >>> 1}$$

92. Water is.....magnetic in nature.

(a) Dia (b) Ferro
(c) Para (d) Ferri

TRANSCO JLM-11.02.2018

Ans. (a) : Water is a diamagnetic in nature. It should not be affected by a magnetic field.

- The relative permeability of a diamagnetic material is less than one.

$$\boxed{\mu_r < 1}$$

- The susceptibility of diamagnetic material is negative and it does not depends on temperature.

93. The substances which are weakly attracted by magnets are called.....

(a) Ferromagnetic (b) Diamagnetic
(c) Paramagnetic (d) None of these

IREL Electrician Tradesman-04.09.2022

Ans. (c) : The substances which are weakly attracted by magnets are called paramagnetic substance.

- The permeability of paramagnetic substance is slightly greater than one.

$$\mu_r > 1$$

- The susceptibility of paramagnetic substance is slightly greater than one and positive.

94. The magnetic susceptibility of ferromagnetic material gives-

(a) Large positive value
(b) Zero value
(c) Small positive value
(d) Negative value

JVVNL Technical Helper-27.08.2022, 12:00-2:00PM

Ans. (a) : The magnetic susceptibility of ferromagnetic material gives large positive value.

95. Which of the following is an example of soft magnet?

(a) Alnico (b) Tungsten steel
(c) Cobalt-steel (d) Silicon iron

UPRVUNL TG-2, 17.07.2021 Shift I

Ans (d) : The example of soft magnet is silicon iron. The soft magnetic materials are easy to magnetize and demagnetize. These material used for making temporary magnets. The domain wall movement is easy soft magnetic materials should not possess any void and its structure should be homogeneous so that the material are not affected by impurities. They have low hysteresis loss due to small hysteresis area.

These material are used for electrical machine as transformer and electrical magnet etc.

96. Which of the following are diamagnetic materials?

(a) Aluminium, silver, gold
(b) Bismuth, sulpher, glass
(c) Steel, Nickel, cobalt
(d) Platinum, aluminium, copper

UPPCL TG-2, 27.03.2021 Shift II
KPSC Instructor Electrician 16.09.2020

Ans (b) The diamagnetic material is Bismuth, sulpher, glass. The diamagnetic material is weakly magnet. However, the magnetization is in direction opposite to that of the magnetic field. The magnetism that is shown by these material is known as diamagnetism.

Property of Diamagnetic material–

- There are no atomic dipoles in diamagnetic material because the resultant magnetic moment of each atom is zero to paired electrons.
- Magnetic susceptibility is small and negative.
- The relative permeability is slightly less than one.
- Diamagnetic material are independent of temperature.

97. Which of the following is ferromagnetic material?

(a) Tungsten (b) Aluminium
(c) Copper (d) Nickel

JVVNL Electrician Helper III, 23.08.2018 Shift II

Ans. (d) The ferromagnetic material is Nickel, cobalt and iron.

- The permeability of ferromagnetic material is greater than one.
- The susceptibility of ferromagnetic material is large and positive.

98. Which of the following materials is used for making a permanent magnets?

(a) Alnico (b) Ferrite
(c) Silicon steel (d) Wrought iron

JVVNL Electrician Helper III, 23.08.2018 Shift III
Kerala PSC Wireman Instructor 26.02.2016

Ans. (a) The materials used for making a permanent magnets is alnico.

- Ferromagnetic materials is generally used for making permanent magnets. These materials include iron, nickel and cobalt etc.

99. Hard magnetic materials are used-

(a) In electric traction
(b) For relays
(c) In circuit breakers
(d) For making permanent magnets

RSMSSB Instructor (Wireman) 24.03.2019
GSSSB Instructor Electrical 15.11.2016

Ans. (d) : Hard magnetic materials are used for making permanent magnets.

100. The material used for making permanent magnets is-

(a) Cobalt
(b) Soft iron
(c) Nickel
(d) Carbon steel

UPPCL TG-2 (Date : 24-01-2019) Shift-I
Haryana Shifting Assistant 2016

Ans : (d) The material used for making permanent magnets is Carbon steel.

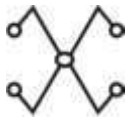
101. Which of the following controlling accessory is a four terminal device capable of making or breaking two connections from two position?

(a) Single pole, two-way switch
(b) Double pole switch
(c) Intermediate switch
(d) Pull switch

UPPCL TG-2, 10.11.2023, Shift-I

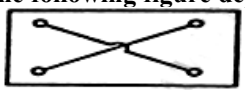
Ans. (c) : Intermediate switch is a four terminal device capable of making or breaking two connections from two position.

■ Symbol of intermediate switch.



■ It is used to control a lamp from more than two locations.

102. The following figure depicts:-



(a) Tumbler type single way switch
(b) File Type Two Way Switch
(c) Intermediate switch
(d) Bed switch

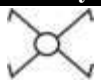
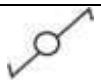
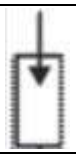
MAHATRANSCO Technician-2023

Ans. (c) : The given symbol represents the intermediate switch.

■ **Bed switch-** This is type of two way switch. It is also called pendant switch.

■ **Surface type switch-** This is a type of single way switch and two way switch. It is also called Tumbler switch.

List of electrical symbols-

Name	Electrical symbol
Intermediate switch	
5A Socket outlet	
15A Socket outlet	
Luminous push button	
Push button	
Two way switch	
Indicating lamp	
Flood light	
Energy meter	
Exhaust fan	
Ceiling fan	
Lightning arrester	
Rewireable fuse	
Cartridge fuse	

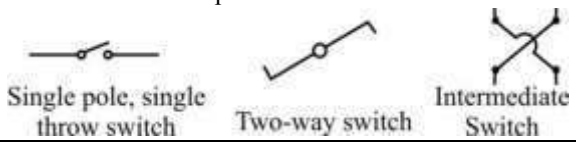
103. A switch in the electrical circuit is always connected to the.....

(a) earth wire (b) live wire
(c) neutral wire (d) Any of these

IREL Electrician Tradesman-04.09.2022
NPCIL CAT-II Electrician Maintainer-12.09.2021
NPCIL (STM)- 03.12.2019
HPSSC Lineman Instructor-15.07.2018

Ans. (b) : A switch in the electrical circuit is always connected to the live wire.

■ Switch acts as to open or close the circuit.



104. Which type of switch is used in stair case wiring?

(a) SPST (b) SPDT
(c) DPDT (d) DPST

GAIL Technician (Telecom & Telemetry)-21.11.2022, 09:00-10:30AM

Ans. (b) : Single pole double throw switch is used in stair-case wiring.

■ Full form of SPDT is single pole double throw.

■ In stair case wiring, two, two-way switch is used to control one lamp from two different places.

105. What is the use of a switch in an electric circuit?

(a) It opens and closes the circuit
(b) It stores the energy
(c) It opposes the current
(d) It provides the current

IREL Electrician Tradesman-04.09.2022

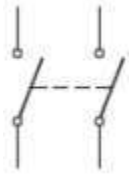
Ans. (a) : The use of a switch in an electric circuit is to open or close the circuit.

■ Switches act as interrupt to the flow of electrons in the circuit.

■ When a switch is in the ON positions, it completes the circuit and allows current to flow.

■ When a switch is in OFF position it breaks the circuit and prevents current from passing through the circuit.

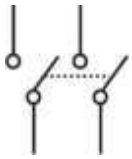
106. Following symbol in a circuit diagram is used for .....



(a) One-way, two-pole switch
(b) Intermediate switch
(c) One-way, single-pole switch
(d) Two-way switch

UPRVUNL (TG-2) 21.12.2022, Shift-II

Ans. (a) : One - way, two pole switch

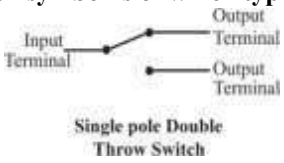


■  (intermediate switch)

■  (One way single pole switch

■  (two way switch)

107. The given symbol is of which type of switch?

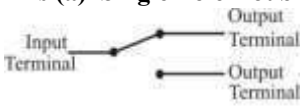


Single pole Double Throw Switch

(a) Single Pole Double Throw
(b) Double Pole Single Throw
(c) Double Pole Double Throw
(d) Single Pole Single Throw

UPPCL TG-2, 20.03.2021 Shift I

Ans (a) Single Pole Double Throw.



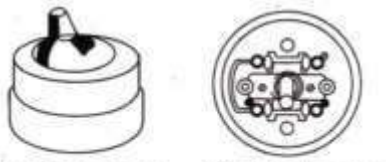
Single pole Double Throw Switch

108. A switch that can be used for sequential switching or ON of decorative lamps and array lighting system is called.....

(a) Two way switch
(b) Tumbler switch
(c) Bell switch
(d) Intermediate switch

UPPCL TG-2, 28.03.2021 Shift II

Ans (b) : Tumbler switch is used for sequential switching or ON of a decorative lamps and array lighting system.



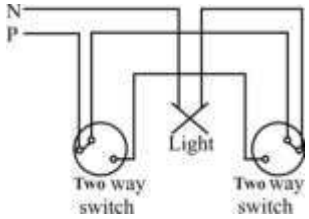
109. What is the number of such switches which are used for lighting circuit of staircase wiring?

(a) 3 two way switch (b) 2 two way switch
(c) 2 one way switch (d) 3 one way switch

RSMSSB Instructor Electrician 24.03.2019
UPPCL TG-2 (Date : 24-01-2019) Shift-I
PGCIL Technician 14.11.2018
MPPKVVCL Line Attendant 26.08.2017
UPPCL TG-2 Electrical 2014

Ans : (b) 2, two-way switches are used for lighting circuit in staircase wiring.

■ In stair case wiring, one light point is controlled from two different places.

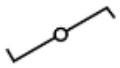


110. 2 way switching means having two or more switches in different locations to control-----

(a) 2 lamps (b) 1 lamp
(c) 3 lamps (d) 4 lamps

(UPPCL Electrician TG-2 Trainee 16.10.2016, Re-Exam)

Ans : (b) 2 way switching means having two or more switches in different locations to control 1 lamp.



Two-way switch

■ Two way switch is used in ladder circuit.

111. A switch is a device used to –

(a) Oppose the current
(b) open and close the electric circuit
(c) provide current
(d) store the energy

(UPPCL Electrician TG-2 Trainee 16.10.2016, Re-Exam)

Ans : (b) Switch is a low voltage switching device. which is used to open and close the electric circuit.
Low voltage switch – (250) volt
High voltage switch – (250–650) volt

112. Which of the following is correct for an N-type semiconductor?

(a) Large number of electrons and large number of holes
(b) Small number of electrons and large number of holes
(c) Large number of electrons and small number of holes
(d) Small number of electrons and small number of holes

UPPCL TG-2, 10.11.2023, Shift-I

Ans. (c) : A N-type semiconductor have large number of electrons and small number of holes. So, In N-type semiconductor, the electrons are called majority charge carriers and the holes are called minority charge carriers.

$$n_e > n_h$$

■ When a pentavalent substance like phosphorous, Arsenic, Antimony etc. are added in pure form of semiconductor (Si, Ge) to make an N-type material.

113. Which of the following bonds is found between semiconductor materials silicon and germanium?

(a) Non-directional bond
(b) Metallic bond
(c) Covalent bond
(d) Ionic bond

UPPCL TG-2, 09.11.2023, Shift-II

Ans. (c) : Covalent bond is found between semiconductor materials silicon and germanium. Two adjacent atoms share electron and form a covalent bond.

■ The covalent bond consists of the two atoms sharing a single electron. Each atom forms four covalent bonds with the four surrounding atoms. Hence between each atom and its four surrounding atom, 8 electrons are being shared.

114. Which of the following, when added with silicon, will form a p-type semiconductor?

(a) Phosphorous (b) Antimony
(c) Aluminium (d) Arsenic

UPPCL TG-2, 07.11.2023, Shift-I

Ans. (c) : The p-type semiconductor is formed by doping aluminium atom with silicon.

■ To make p-type extrinsic semiconductor, trivalent impurity like aluminium is added to the pure semiconductor.
■ Trivalent impurities are called accepter impurity.
■ Trivalent impurities are Indium, Gallium, Aluminium, Boron etc.
■ Trivalent element has three valence electrons in its outer orbit.

115. We will be going to make a _____ if we mix Phosphorus with silicon.

(a) n-type semiconductor
(b) insulator
(c) p type semiconductor
(d) diode

MAHATRANSCO Technician-2023

Ans. (a) : We will be going to make a n-type semiconductor if we mix phosphorus with silicon.

■ The example of pentavalent impurity like As, Sb, Bi etc.
■ These are also called donor type impure semiconductor.
■ In n-type semiconductors fermi level lies near the bottom of conduction bond.

116. If a Germanium atom is doped with an arsenic atom, which of the following impurities is added to the pure semiconductor?

(a) Trivalent impurity
(b) Hexavalent impurity
(c) Pentavalent impurity
(d) Tetravalent impurity

GAIL Technician (Telecom & Telemetry)- 21.11.2022, 09:00-10:30AM
HSSC (ALM)- 14.03.2020 Shift - III
RRB Bhubaneshwar (L.P)- 2010

Ans. (c) : A germanium atom is doped with an arsenic atom then pentavalent impurity is added to the pure semiconductor.

■ When a pentavalent or donor impurity is added to semiconductor, the impurity atom form covalent bond with the semiconductor atom.
■ The pentavalent impurity is called the donor type impurity as it donates one electron to the conduction band of a pure semiconductor.

117. In P- type of semiconductor has .....

(a) More hole and more electrons
(b) Less hole and more electrons
(c) More hole and less electrons
(d) Less hole and less electrons

UPRVUNL TG-2 22.12.2022, Shift-II
CRPF Constable Electrician, 06.01.2013

Ans. (c) : In P-type of semiconductor has more holes and less electrons.

■ In P-type semiconductor materials, the majority carriers are holes while the minority carriers are electrons.

118. Which type of semiconductor material known as pure semiconductor?

(a) P-type (b) Intrinsic type
(c) Extrinsic types (d) N-type

UPPCL TG-2, 28.03.2021 Shift I

Ans : (b) Intrinsic type of semiconductor material known as pure semiconductor.

■ Instrinsic type semiconductor material are electrically neutral.
■ At absolute zero temperature, instrinsic type semiconductor behave as a insulator.
■ Examples of intrinsic semiconductors are Si, Ge etc.

119. Acceptor impurities creates _____.

(a) D-type (b) P-type
(c) N-type (d) C-type

UPPCL TG-2, 19.03.2021 Shift II

Ans : (b) Acceptor impurities creates P-type semiconductor.

- P-type semiconductor or Acceptor.
- When trivalent impurity added to pure semiconductor then acceptor energy level created just above the valence band.
- If an impurity having three (3) valencies (Such as indium, boron, gallium or aluminium) is added to germanium, silicon material, then a P-type semiconductor is obtained due to the creation of holes in a P-type semiconductor. It has the ability to accept an electron.
- P-type semiconductor as insulator at $T = 0K$.

120. Which element is used as impurity to produce N-type semi-conductor?

(a) Boron (b) Gallium
(c) Aluminum (d) Arsenic

UPRVUNL TG-2, 17.07.2021 Shift I
UPPCL TG-2, 20.03.2021 Shift-II

Ans (d) : Arsenic element is used as impurity to produce N-type semiconductor.

- The process of adding small amount of impurities to the semiconductor material is known as doping.
- The impurity elements that replace a regular lattice atom is known as dopants.
- When a small amount of a pentavalent (Antimony, Phosphorus or Arsenic) atom is added to Ge(or Si) Four of these valence electrons from regular electron pair bonds with their neighboring atoms. The Fifth electron, however loosely bound to silicon.
- At room temperature this extra electron becomes disassociated from its atom and move through the crystal as a conduction electrons when a voltage is applied to the crystal. This type of extra electrons is called donors and the crystal becomes N-type semiconductor.

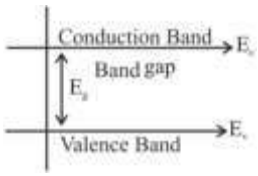
121. Which of the following substances has a forbidden energy gap of 0.7eV.

(a) Germanium (b) Carbon
(c) Copper (d) Silicon

UPPCL TG-2, 20.03.2021 Shift II

Ans. (a) : The energy gap of germanium material is 0.7eV.

- Energy gap is the gap between the conduction band (CB) and the valence band (VB) through which the electron, after acquiring external , enter the conduction band (CB) from the Valence band (VB).



122. The forbidden energy gap for silicon semiconductor is.

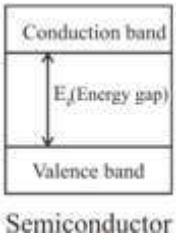
(a) 1.21 eV (b) 0.72eV
(c) 0.3eV (d) 5 eV

KPSC Lineman-19.12.2021

Ans. (a) : The forbidden energy gap for silicon semiconductor is 1.21 eV at 0°K. This value at 300° K is 1.1 eV.

- Energy gap between conduction band and valence band is called forbidden energy gap.

Material	Chemical symbol	Forbidden energy gap at 300 K (eV)	Forbidden energy gap at 0 K (eV)
Germanium	Ge	0.72	0.78
Silicon	Si	1.1	1.21
Gallium Arsenide	GaAs	1.43	1.56



Semiconductor

123. The valence band of germanium and silicon contains _____ electrons.

(a) Three electron (b) Five electron
(c) Four electron (d) None of these

(R.R.B. Bengaluru (L.P.)-2008)

Ans : (c) The valence band of germanium and silicon contain four electron.

- A valence electron is an outer shell electron that is associated with an atom. These electron can participate in the formation of a chemical bond.
- Two types of impurity are added to Germanium or silicon, one is pentavalent impurity like Arsenic or Antimony and the other is trivalent impurity like Aluminium or Indium is added.

124. Which of the following statement is FALSE for refractive index of a Graded index fiber?

(a) Decreasing from core axis to core end
(b) Constant in the cladding
(c) Maximum at cladding
(d) Maximum at core axis

MPPGCL JE (Plant)-29.04.2023, 4:30PM – 6:30 PM

Ans. (c) : Refractive index in graded index fiber is maximum at cladding this is false statement.

Refractive Index in Graded Index fiber :-

- Decreasing from core axis to core end.
- Constant in cladding.
- Refractive index of core is parabolic in nature.
- Maximum at core axis.
- The mathematical term of refractive index of graded index fiber is –

$$n(r)=\begin{cases} n_1\left[1-2\Delta\left(\frac{r}{a}\right)^{\alpha}\right]^{\frac{1}{2}} & \text{for } r<a \\ n_1(1-2\Delta)^{1/2}\approx n_1(1-\Delta)=n_2 & \text{for } r\geq a \end{cases}$$

Where,

$a \rightarrow$ radius of the core

$r \rightarrow$ radial distance from the core axis

$\alpha \rightarrow$ characteristics of the refractive index profile.

$n_1 \rightarrow$ refractive index of core

$n_2 \rightarrow$ refractive index of cladding .

125. Which of the following can be used as a transmitter for an optical fibre?

(a) Photo-diode (b) Bulb

(c) Laser (d) Sun

UPPCL JE CTSE - 25.03.2022, Shit-II
SSC IMD 23.11.2017, Evening
RRB JE - 04.09.2015, Shift-II
Culcutta Telephone - 2010

Ans. (c) : Lasers are used as transmitters for optical fibers. Optical fiber is such a thin wire using which data transfer in light form is done very fast. Light is transmitted in optical fiber, not electricity.

126. The refractive index of the core and cladding of an optical fiber are 1.40 and 1.14 respectively numeric. How much is aperture.

(a) 0.646 (b) 0.312

(c) 0.552 (d) 0.812

SSC IMD (SA)-15.12.2022, 5:00PM

Ans. (d) : Given, $n_1 = 1.40$, $n_2 = 1.14$

We know that-

$$\text{Numerical aperture} = \sqrt{n_1^2 - n_2^2}$$
$$= \sqrt{(1.40)^2 - (1.14)^2}$$
$$= \sqrt{0.67}$$
$$= 0.812$$

127. The principle of optic-fiber cable is .....

(a) Distortion (b) Deflection

(c) Reflection (d) Absorption

SSC IMD (SA) 16.12.2022, Morning

Ans. (c) : The principle of optic-fiber cable is total internal reflection.

- In optical fiber, light energy is converted into the electrical form using photosensitive devices such as photo diodes.
- Optical fibers include a core surrounded by a transparent cladding material with a lower refractive index.
- Optical fiber is used for long distance and high-performance data networking.

128. What is the condition to achieve total internal reflection in an optical fiber?

(a) angle of incidence = 45°

(b) angle of incidence > critical angle

(c) angle of incidence < critical angle

(d) angle of incidence = 90°

UPRVUNL JE 14.05.2022

Ans. (b) : The condition to achieve total internal reflection in an optical fiber is -

Angle of incident > Critical angle

129. Multi mode step index fiber has _____.

(a) Small core diameter and small numerical aperture

(b) Large core diameter and large numerical aperture

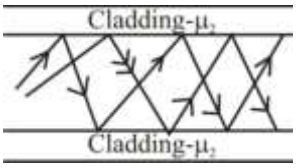
(c) Large core diameter and small numerical aperture

(d) Small core diameter and large numerical aperture

SSC IMD (SA) 15.12.2022, Shift-III
SSC IMD (SA) 25.11.2017, Shift-I

Ans. (b) : Multimode step index fiber has large core diameter and large numerical aperture.

Multimode step index fiber works on the principle of total internal reflection. Its structure is similar to that of single mode step index fiber. But its central core (about 50μm in diameter) is large. It propagates in zig-zag path.



130. Light is confined within the core of an optical fibre due to

(a) Refraction

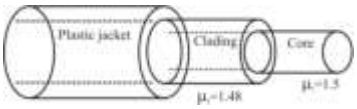
(b) Scattering

(c) Diffraction

(d) Total internal reflection at the core cladding boundary

Cochin Shipyard - 2021
ISRO URSC TA (EC) 24.03.2019
ISRO ISTRAC TA (EC) 01.12.2019
DSSSB -2019
ISRO SDSC TA (EC) 08.04.2018
BSNL TTA -26.09.2016, 3:00 PM
DMRC Electronic - 2014

Ans : **(d)** Light is confined within the core of an optical fiber due to total internal reflection at the core cladding boundary.



- It works on the principle of total internal reflection. It has three layers of core, cladding and plastic jacket.
- In this, signal is propagated in the form of light.
- Laser and LED are used to generate the light signal.

131. Insertion loss for SC type fiber connector in dB is of the range:

(a) 0.3-1.0 (b) 0.2-0.45
(c) 1.5-2.0 (d) 1.0-1.5

UPPCL JE (E&T) 25.03.2021, Shift-I

Ans. (b) : Optical fiber is a reliable and unique means of transmitting light signals. It does not even require amplification.

Insertion loss - Insertion loss is the loss of light signals between fiber cable points. In it damage splicing, passive network connection, misalignment occurs due to contamination. Insertion loss can range from 0.2 to 0.45 dB in SC (Square Connector) type fiber connector.

132. Fibre is preferred over electrical cabling when _____ bandwidth, _____ distance or ____ to electromagnetic interference is required.

(a) high, short, stability
(b) high, long, immunity
(c) low, long, immunity
(d) low, short, stability

UPPCL JE (T&E) 25.03.2021, Shift-II

Ans. (b) : Fibre is preferred over electrical cabling when high bandwidth, long distance or immunity to electromagnetic interference is required.

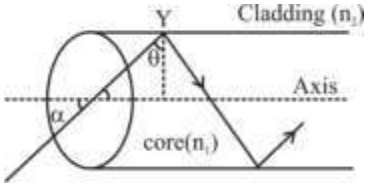
133. What is the maximum angle of the axis at which light can enter into the fiber in order to be propagated?

(a) Numerical Aperture
(b) Critical angle
(c) Refractive index
(d) Acceptance angle

UPPCL JE (E&T) 25.03.2021, Shift-I

Ans. (d) : Acceptance angle is the maximum angle formed at the fiber core and facilitating the transmission of incident light.

Acceptance angle is based on ray optics.



134. Which of the following is NOT the feature of optical cable?

(a) Small size (b) Light weight
(c) Low cost Installation (d) High Bandwidth

UPRVUNL JE (E &M) 01.11.2021

Ans. (c) : Low cost installation is not the feature of optical cable -

Advantage of optical fiber -

- High bandwidth
- Used for long distance communication purpose
- It has not interference
- It has very low loss (0.1 dB/km)

Disadvantage of optical fiber -

- Manufacturing is very complex
- Splicing is very difficult
- It is a costly

135. In Optical fibre, the attenuation rate is_____

(a) Zero dB (b) Medium dB
(c) High dB (d) None of these

ISRO ISTRAC TA (EC) 01.12.2019

Ans. (a) : In optical fiber, the attenuation rate is zero dB.

- The attenuation of an optical fiber measures the amount of light that is lost between the input and output.
- The attenuation of an optical fiber is expressed in decibels per kilometer.
- For fibers, this attenuation depends on the wavelength.

136. Graded index fiber is used to-

(a) Reduce absorption and resulting power loss
(b) Reduce dispersion and there by increase data rate
(c) Establish secure communication
(d) Increases numerical aperture

ISRO: VSSC TA (EC) 25.02.2018

Ans : **(b)** Graded index fiber is used to reduce dispersion and there by increase data rate.

- In graded index fiber n_1 of central axis edge slowly changes due to which distortion is reduced.
- In graded index fiber refractive index is maximum at the center of core and decreases as radial distance increases from the core.

137. Which one of the following is capable of giving the highest data speed ?

(a) Coaxial cable link
(b) Microwave LOS link
(c) Microwave satellite system
(d) Optical fiber system

DMRC Electronics, 2015

Ans : (d) Optical fiber system is capable of providing highest data speed. Optical fiber is used at very high frequency (GHz).