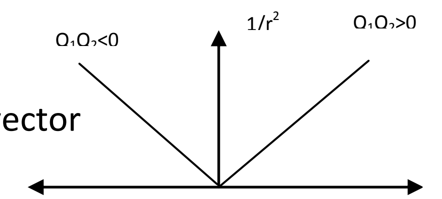
1. ELECTROSTATICS

GIST

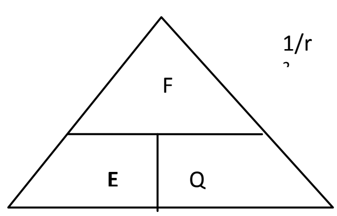
- Electrostatics is the study of charges at rest.
- Charging a body can be done by friction, induction and conduction.
- Properties of charges:
  - Like charges repel and unlike charges attract.
  - Charges are additive in nature i.e., Q=$\sum_{i=1}^{n} q_i$
  - Charges are quantized. i.e., Q= ± ne [n=1,2,3,… & e=1.602 X10^{-19} C]
  - Charge in a body is independent of its velocity.
  - Charge is conserved.
- To measure charge electroscopes are used. The sensitive device which is used to identify whether the body is charged or not is called **electroscope.**
- Coulomb's law: $\vec{F} = \frac{k q_1 q_2}{r^2}\hat{r}$; k=$\frac{1}{4\pi\varepsilon_0}$ = 9 x 10^9 Nm^2C^{-2}

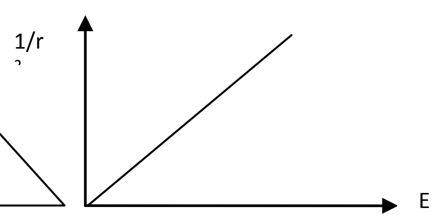
Where, ε_0= absolute permittivity of free space



- Principle of superposition: $F_{total} = \sum_{i=1}^{n} \vec{F_i}$ [vector sum of individual forces]

$$= \frac{1}{4\pi\varepsilon_o}\frac{q_1q_2}{r_{12}^2}\hat{r}_{12} + \frac{1}{4\pi\varepsilon_o}\frac{q_1q_3}{r_{13}^2}\hat{r}_{13} + ...$$

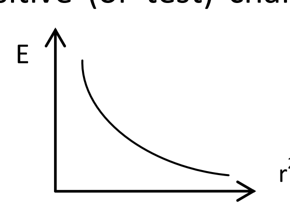




Note**:** *In the above triangle the quantity shown at the vertex, could be arrived by multiplying the quantities shown at the base, ie F=E X Q.*

Any one of the quantity shown at the base is given by the ratio of the quantities shown at vertex & the other quantity shown at the base, ie E=F/Q or Q= F/E.

- Electric field: Force experienced by a unit positive (or test) charge. It is a vector. SI unit is NC^{-1}.



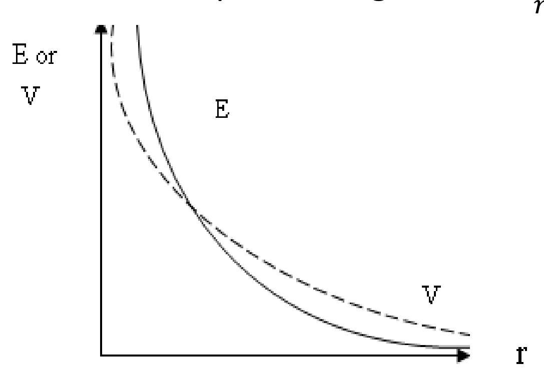
Applications of Gauss' theorem for uniform charge distribution:

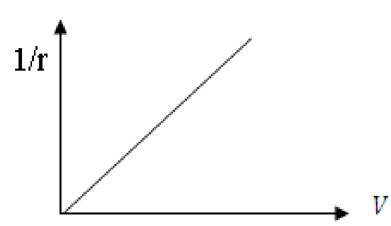
Expression for	**Infinite Linear**	**Infinite plane sheet**	**Thin spherical shell**
Flux Ø	$\frac{\lambda l}{\varepsilon_0}$	$\frac{\sigma S}{\varepsilon_0}$	$\frac{\sigma 4\pi r^2}{\varepsilon_0}$
Magnitude of Field E	$\frac{\lambda}{2\pi r\varepsilon_0}$	$\frac{\sigma}{\varepsilon_0}$	$\frac{Q}{4\pi r^2\varepsilon_0}$ [for points on/outside the shell] ZERO [for points inside the shell]
Charge density	$\lambda = \frac{\Delta q}{\Delta l}$	$\sigma = \frac{\Delta q}{\Delta S}$	$\frac{\sigma}{4\pi r^2}$

- Properties of electric field lines:
  - ✓ Arbitrarily starts from +ve charge and end at –ve charge
  - ✓ Continuous, but never form closed loops
  - ✓ Never intersect
  - ✓ Relative closeness of the field lines represents the magnitude of the field strength.
  - ✓ For a set of two like charges – lateral pressure in between
  - ✓ For a set of two unlike charges – longitudinal contraction in between.
- Electrostatic Potential: Work done per unit positive Test charge to move it from infinity to that point in an electric field. It is a scalar. SI unit: J/C or V

$$V = W / q_o$$

Electric potential for a point charge: $V = \frac{kq}{r}$

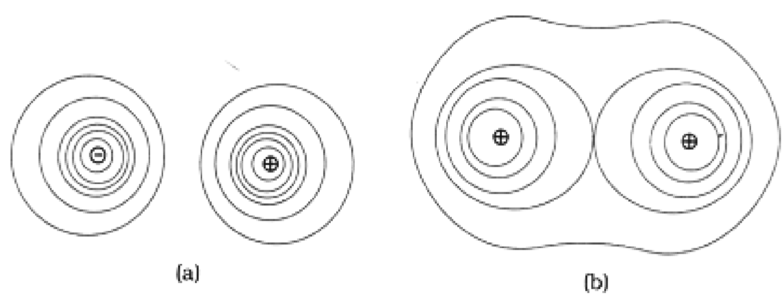




- Electric field is conservative. This means that the work done is independent of the path followed and the total work done in a closed path is zero.
- Potential due to a system of charges: $V_{total} = \sum_{i=1}^{n} \frac{kq_i}{r_i}$
- Potential due to a dipole at a point
  - **<u>on its axial line</u>**: $V_{axial} = \frac{k|\vec{p}|}{r^2}$ [or]$\frac{k|\vec{p}|}{r^2} cos\theta$
  - **<u>on its equatorial line</u>**:V_{eq}= 0
- Potential difference $V_A - V_B = kq\left[\frac{1}{r_A} - \frac{1}{r_B}\right]$
- Potential energy of two charges: U = $\frac{kq_1q_2}{r}$
- Potential energy of a dipole : U = $\vec{p}.\vec{E}$ = p E [$cos\theta_0$ -$cos\theta_1$]
- Electrostatics of conductors

(i) Inside a conductor Electrostatic field is zero
(ii) On the surface E is always Normal
(iii) No charge inside the conductor but gets distributed on the surface
(iv) Charge distribution on the surface is uniform if the surface is smooth
(v) Charge distribution is inversely proportional to '*r*' if the surface is uneven
(vi) Potential is constant inside and on the surface

- Equipotential surfaces: The surfaces on which the potential is same everywhere.
  - ✓ Work done in moving a charge over an equipotential surface is zero.
  - ✓ No two equipotential surfaces intersect.
  - ✓ Electric field lines are always perpendicular to the equipotential surfaces.



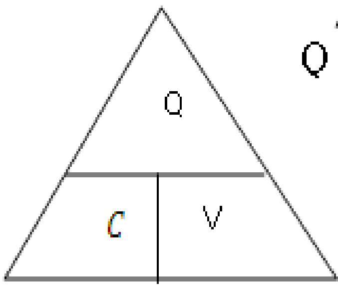
(a) (b)

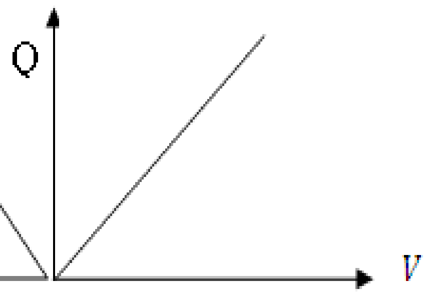
Some equipotential surfaces for (a) a dipole, (b) two identical positive charges.

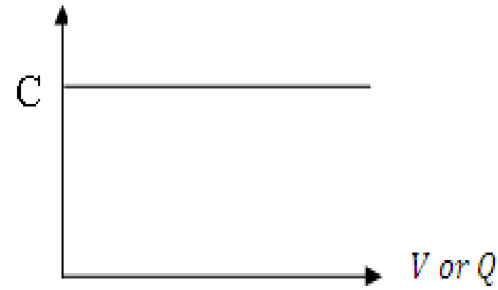
As E= - $\frac{dV}{dr}$ If Vis constant, E∝ $\frac{1}{r}$**and if E is constant, V**∝ r

- Capacitor: A device to store charges and electrostatic potential energy.

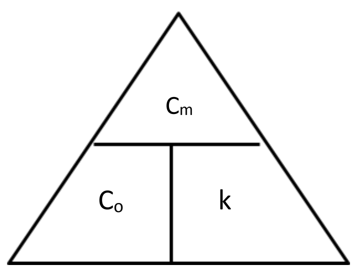
- Capacitance: $C = \frac{Q}{V}$, Ratio of charge and potential difference. Scalar,
- SI unit: farad [F]







- Capacitance of a parallel plate capacitor: $C = \frac{\varepsilon_0 \times A}{d}$
- Capacitance of a parallel plate capacitor with a dielectric medium in between:
  - $C_m = \frac{\epsilon_o A}{\left(d - t + \frac{t}{k}\right)}$
  - If t=0 =>$C_0 = \frac{\epsilon_o A}{(d)}$
  - If t=d =>C_0 =k $\frac{\epsilon_o A}{(d)}$ =>C_m = k C_0

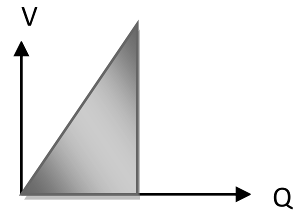


- Combination of capacitors:

Capacitors in series: $\frac{1}{c} = \sum_{i=1}^{n} \frac{1}{c_i}$

Capacitors in parallel : $c = \sum_{i=1}^{n} c_i$

- Energy stored in capacitors: $U = \frac{1}{2} CV^2 = \frac{1}{2} QV = \frac{1}{2} \frac{Q^2}{C}$
- Area shaded in the graph = U $= \frac{1}{2} QV$
- Energy density : $U_d = \frac{1}{2} \varepsilon_0 E^2 = \frac{\sigma^2}{2\varepsilon_0}$



- Introducing dielectric slab between the plates of the charged capacitor with:

Property	Battery connected	Battery disconnected
Charge	K Q_0	Q_0
Potential difference	V_0	V_0/K
Electric field	E_0	E_0/K
Capacitance	KC_0	KC_0
Energy	K times$\frac{1}{2}\varepsilon_0 E^2$[Energy is supplied By battery]	1/K times$\frac{1}{2}\varepsilon_0 E^2$[Energy used for Polarization]

- On connecting two charged capacitors:

  - Common Potential: $V = \frac{C_1V_1+C_2V_2}{V_1+V_2}$
  - Loss of energy: $\Delta U = \frac{1}{2}\frac{C_1\times C_2}{C_1+C_2}(V_1 - V_2)^2$

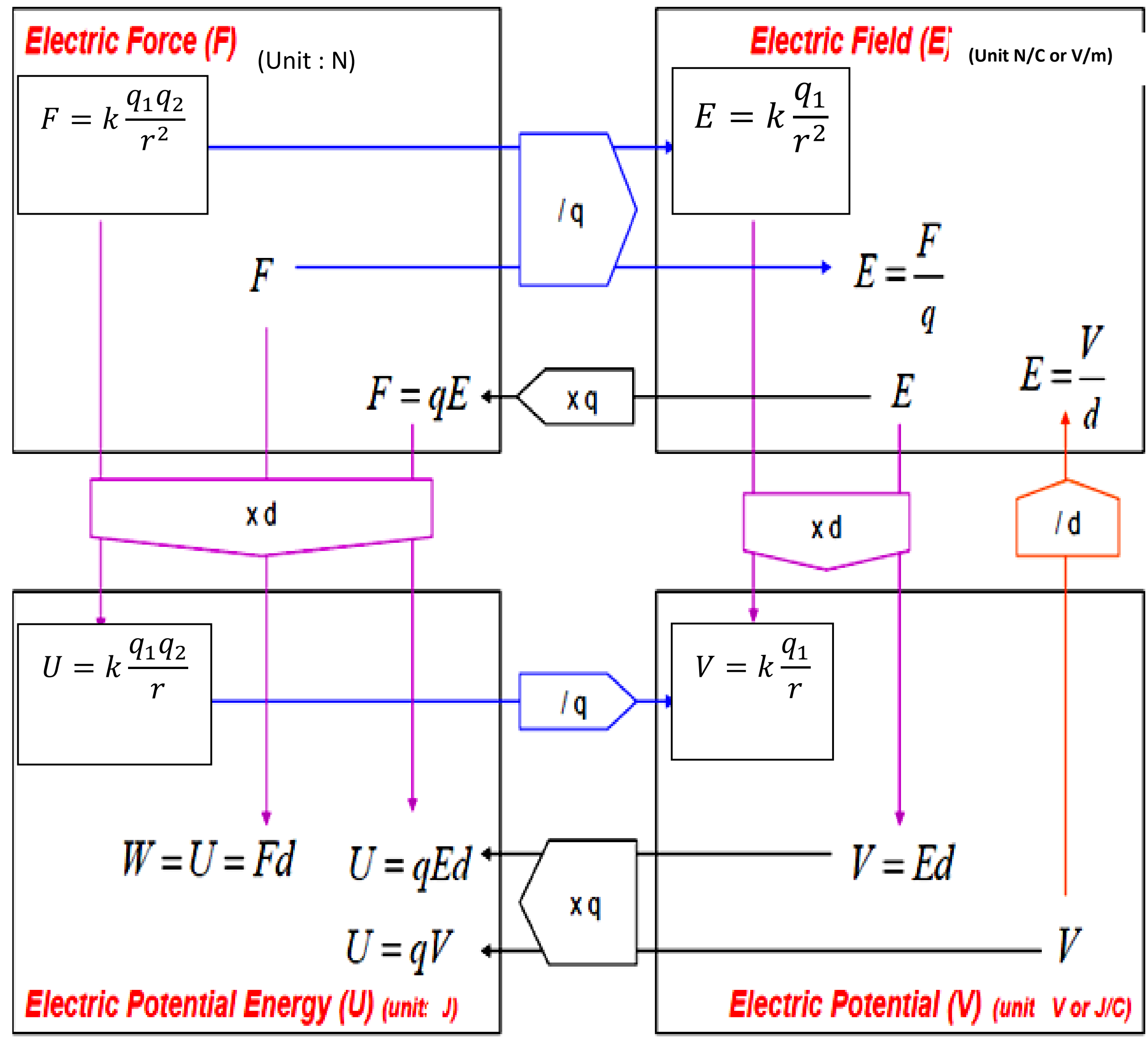
- Van de Graff generator:-

  - ✓ isan electrostatic machine to build very high voltages.
  - ✓ works on the Principle$V(r) - V(R) = kq\left(\frac{1}{r} - \frac{1}{R}\right)$
  - ✓ Corona discharge is the electrical discharge through the defected part of the spherical conductor, where the surface is not smooth. Hence, the hollow spherical conductor in the Van de Graff generator should have a smooth outer surface.

CONCEPT MAP

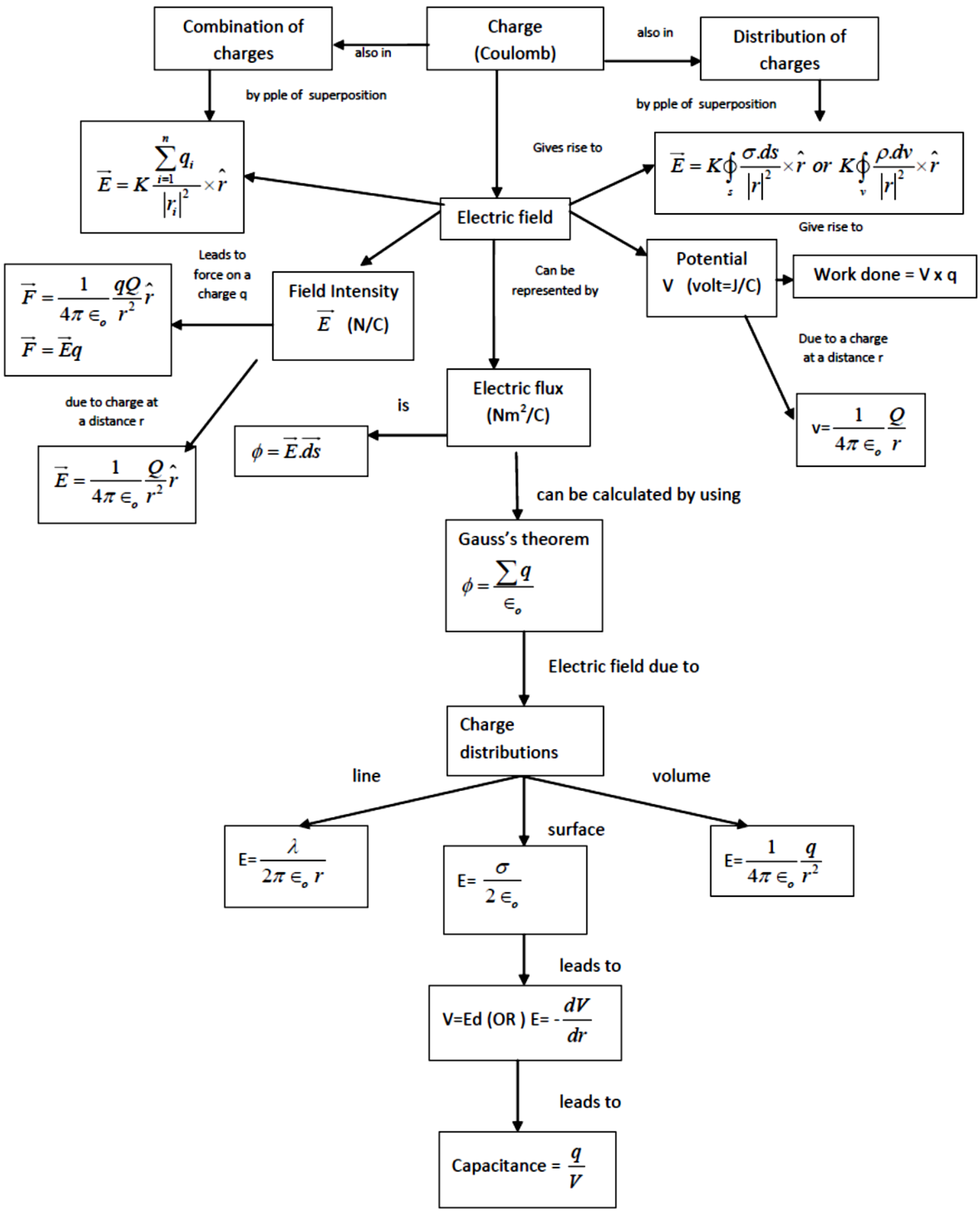
Electric Force/Field/Potential/P.E.

/ q to get "per charge"
x q to get "for an amount of charge"
/ d to get "per distance"
x d (where d = r) to get "over distance"



CONCEPT MAP

Charge and it's impact



CHARGES AND COULOMB'S LAW

QUESTIONS

1. What is the work done in moving a test charge 'q' through a distance of 1 cm along the equatorial axis of an electric dipole? [Hint : on equatorial line V=0] 1

2. Why in Millikan's Oil Drop experiment, the charge measured was always found to be of some discrete value and not any arbitrary value? 1
   Ans: Because charge is always quantized ie., $Q = n \times e$

3. What is meant by electrostatic shielding? Ans: Electric filed inside a cavity is zero. 1

4. Why an electric dipole placed in a uniform electric field does not undergoes acceleration? 1
   Ans: Because the net force on the dipole is zero. $F_{net} = 0$ as $F=\pm qE$

5. Why electric field lines 1
   (i) Can never intersect one another?
   (ii) Cannot for closed loops sometimes?
   (iii) Cannot have break in between?

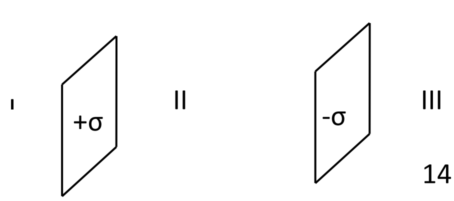
   Ans : Because
   (i) Electric field has an unique direction at any given point
   (ii) Monopoles or single isolated charges exist unlike magnetism
   (iii) Start from +ve charges and terminate at –ve charges
   (iv)

6. Show that at a point where the electric field intensity is zero, electric potential need not be zero. 2
   Ans: If E = 0$\Rightarrow V = constant$ E=-dV/dr

7. What is the electric flux through the surface S in Vaccum? 2

8. Write the expression for the electric field, charge density for a uniformly charged thin spherical shell. 2
   Ans: $E = \frac{kQ}{r^2}$; $\sigma = \frac{Q}{4\pi r^2}$

9. 2



Write the expression for the electric field in the regions I, II, III shown in the above figure.
Ans: $E_I = E_{III} = 0$ $\quad E_{II} = \sigma/\varepsilon_0$

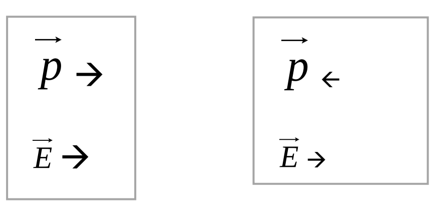
10. Two free protons are separated by a distance of 1 A°. if they are released, what is the kinetic energy of each proton when at infinite separation.[Hint : at inifinte distance $K.E = \frac{e^2}{4\pi\epsilon_o r}$] 2

11. How does the electric flux, electric field enclosing a given charge vary when the area enclosed by the charge is doubled? Ans: (a) $\emptyset$= constant (b) E is halved 2

12. The electric field in a certain region of space is $\vec{E} = 10^4\hat{\imath}NC^{-1}$. How much is the flux passing through an area 'A' if it is a part of XY plane, XZ plane, YZ plane, making an angle 30^0 with the axis? 2
Ans: Φ_{XY} =10A Vm E ΔS COSϕ [ϕ=0] $\quad \phi_{XZ} = \phi_{YZ}$ = 0 Vm (ϕ =90^O)
=10^4 A cos30^O Vm

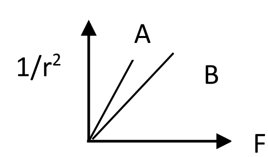
13. An electric dipole ±4µC is kept at co-ordinate points (1, 0, 4) are kept at (2,-1, 5), the electric field is given by $\vec{E}$ = 20 $\hat{\imath}$ NC^{-1}. Calculate the torque on the dipole. 2
Ans: Calculate first dipole moment using $\vec{p}$ =q.2$\vec{a}$
Then calculate torque using $\vec{\tau} = \vec{p} \times \vec{E}$ and hence find $|\vec{\tau}|$ =13.4 N

14. Show diagrammatically the configuration of stable and unstable equilibrium of an electric dipole ($\vec{p}$) placed in a uniform electric field ($\vec{E}$). 2
Ans:



Stable Unstable

15. Plot a graph showing the variation of coulomb force F versus $\frac{1}{r^2}$ where r is the distance between the two charges of each pair of charges: (1µC, 2µC) and (2µC, -3µC) Interpret the graphs obtained. 2
[Hint : graph can be drawn choosing –ve axis for force only]



Ans: $|\overrightarrow{F_B}| > |\overrightarrow{F_A}|$

16. A thin straight infinitely long conducting wire having charge density λ is enclosed by a cylindrical surface of radius r and length l, its axis 2
coinciding with the length of the wire. Find the expression for electric flux through the surface of the cylinder.

Ans: Using Gauss's Law obtain: $\Phi = \frac{\lambda l}{\varepsilon_0}$

17. Calculate the force between two alpha particles kept at a distance of 2
0.02mm in air.

Ans: $F = 9 \times 10^9 \frac{4\times(1.6\times10^{-19})^2}{(2\times10^{-5})^2}$

18. Explain the role of earthing in house hold wiring. 2

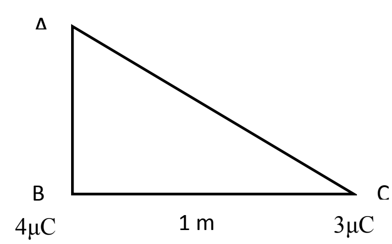
Ans: During short circuit, it provides an easy path or emergency way out for the charges flowing to the ground, preventing the accidents.

19. What is the difference between charging by induction and charging by 2
friction?

* In frictional method, transfer of charges takes place from one object to the other.

* During induction, redistribution of charges takes place within the conductor.

20. Two electric charges 3μC, -4μC are placed at the two corners of an isosceles right angled triangle of side 1 m as shown in the figure. What is the direction and magnitude of electric field at A due to the two charges? 2



Ans: E=45×〚10〛^3 NC^(-1)
θ=36.9° from line AB

21. A sensitive instrument is to be shifted from a strong electric field in its environment. Suggest a possible way. 2

[Hint : Electrostatic shielding]

22. A charge +Q fixed on the Y axis at a distance of 1m from the origin and another charge +2Q is fixed on the X axis at a distance of √2 m from the origin. A third charge – Q is placed at the origin. What is the angle at 3
which it moves?

Ans: Force due to both the changes are equal = KQ^2&$\perp^r$ to each other so the resultant force will make 45^o with X-axis.

23. Two charges 5μC, -3μC are separated by a distance of 40 cm in air. Find 3
the location of a point on the line joining the two charges where the

electric field is zero.

Ans: Solve for x from the equation: $k\frac{5X10^{-6}}{x^2} = k\ \frac{3X10^{-6}}{(40-x)^2}$

24. Deduce Coulomb's law from Gauss' law.
Ans: $\emptyset = \vec{E}.\vec{S} = Q/\varepsilon_0$ $E \times 4\pi r^2 = Q/\varepsilon_0$ 3
$F = Eq_0 \therefore F = Qq_o/(4\pi\varepsilon_0 r^2)$

25. State Gauss's law and use this law to derive the electric filed at a point from an infinitely long straight uniformly charged wire. 3

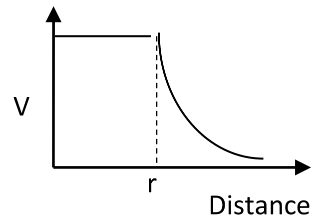
Ans: Statement $\int \overline{E}.\overline{ds} = \frac{q}{\varepsilon_o}$ Derivation for $E = \frac{\lambda}{2\Pi\varepsilon_o r}$

26. Three charges –q, Q and –q are placed at equal distances on a straight line. If the potential energy of system of these charges is zero, then what is the ratio of Q:q [Ans : 1:4] 3

ELECTRIC POTENTIAL

1. Is it possible that the potential at a point is zero, while there is finite electric field intensity at that point? Give an example. 1
Ans: Yes , Centre of a dipole
2. Is it possible that the electric field $\vec{E}$ at a point is zero, while there is a finite electric potential at that point. Give an example. 1
Ans: Yes, Inside charged shell
3. Can two equipotential surfaces intersect? Justify your answer. 1
Ans: No. Otherwise it would mean two directions for force at a point.
4. Is potential gradient a vector or a scalar quantity? 1
Ans: Scalar quantity
5. Write the dimensional formula of 'ϵ_0'the permittivity of free space. 1
Ans: $[M^{-1}L^{-3}T^4A^2]$
6. An electric dipole is placed in an electric field due to a point charge. Will there be a force and torque on the dipole? 1
Ans: Yes, Both force and torque will act as the Electric Field is non uniform.
7. Draw the graph showing the variation of electric potential with distance from the centre of a uniformly charged shell. 1

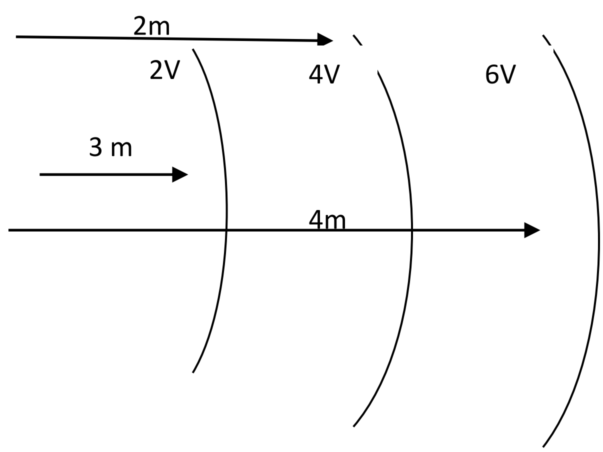
Ans



8. Find the ratio of the electric field lines starting from a proton kept first in vacuum and then in a medium of dielectric constant 6. 1

Ans: 6 : 1

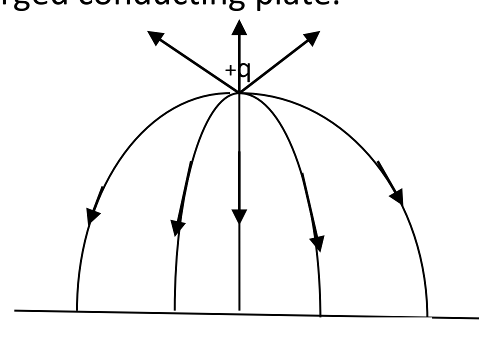
9. Calculate the electric field from the equipotential surface shown below. 1



Ans: 2 V $[E = \frac{-dv}{dr}, dv = 2V, dr = 1m]$

10. Sketch the electric field lines, when a positive charge is kept in the vicinity of an uncharged conducting plate. 1

Ans



11. Two charges are kept as shown. Find dipole moment. 1

Ans: (0,0,2)-q .... +q(0,0,-2)

-15 μc +15 μc

12. Compare the electric flux in a cubical surface of side 10 cm and a spherical surface of radius 10 cm, when a change of 5μC is enclosed by them. 1

Ans: Electric flux will be same in both the cases.

13. Explain why the electric field inside a conductor placed in an external electric field is always zero. 1

Ans: Charge lies on the surface of a conductor only

14. Two identical metal plates are given positive charges Q_1 and Q_2,where $Q_1 > Q_2$. Find the potential difference between them, if they are now brought together to form a parallel plate capacitor with capacitance 2

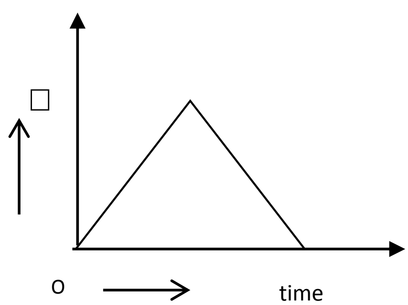
Ans: $(Q_1 – Q_2)/2C$

15. 27 small drops of mercury having the same radius collage to form one big drop. Find the ratio of the capacitance of the big drop to small drop. 2

Ans: [3:1]

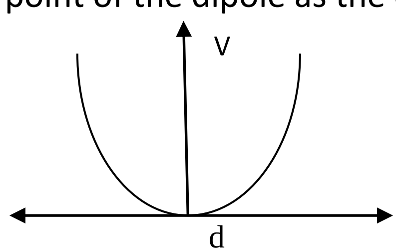
16. A uniformly charged rod with linear charge density λ of length L is inserted into a hollow cubical structure of side 'L' with constant velocity and moves out from the opposite face. Draw the graph between flux and time. 2

Ans



17. Draw a graph showing the variation of potential with distance from the positive charge to negative charge of a dipole, by choosing the mid-point of the dipole as the origin. 2

Ans 2



18. If $\vec{E}$ = $3\hat{\imath}$ +$4\hat{\jmath}$-$5\hat{k}$, calculate the electric flux through a surface of area 50 units in z-x plane 2

Ans: 200 unit

19. Name the physical quantities whose SI units are Vm, Vm^{-1}. Which of these are vectors? 2

Ans: Vm → electric flux, scalar ; Vm^{-1}→electric field, vector

20. The spherical shell of a Van de Graff generator is **to** be charged to a 2

potential of 2 million volt. Calculate the minimum radius the shell can have, if the dielectric strength of air is 0.8 kV/mm.

Ans: [2.5m]

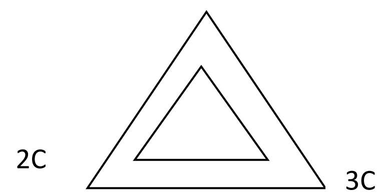
21. How will you connect seven capacitors of 2μf each to obtain an effective capacitance of 10/11 μf. 2

Ans: 5 in parallel and 2 in series

22. A proton moves with a speed of 7.45 x 10^5m/s directly towards a free proton initially at rest. Find the distance of the closest approach for the two protons. 2

Ans: 5.56 x 10^{-23}m

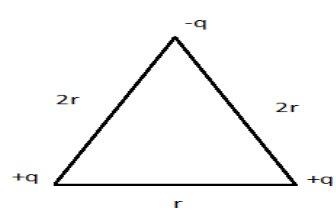
23. Three point charges of 1C, 2C & 3C are placed at the corners of an equilateral triangle of side 1m. Calculate the work done to move these charges to the corners of a smaller equilateral triangle of sides 0.5m. 2



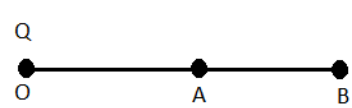
Ans: 9.9 x 10^{10} J

2

24. Suggest an arrangement of three point charges, +q,+q, -q separated by finite distance that has zero electric potential energy



25 A point charge Q is placed at point O as shown. Is the potential difference (V_A-V_B) positive, negative or zero if Q is (i) positive (ii) negative 2



26. Show that the potential of a charged spherical conductor, kept at the centre of a charged hollow spherical conductor is always greater than that of the hollow spherical conductor, irrespective of the charge accumulated on it. 3

Ans: $V_a-V_b=(q/4\pi\epsilon)(1/r-1/R)$

1C

(Principle of Van de Graff generator)

CAPACITORS

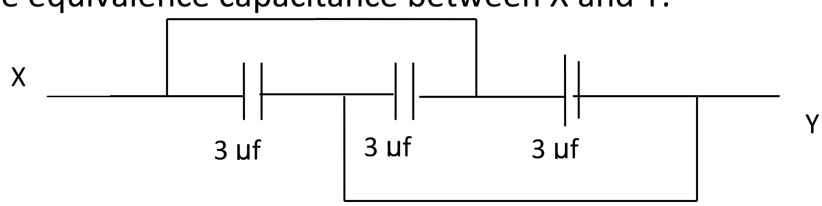
1 What happens to the capacitance of a capacitor when a copper plate of thickness one third of the separation between the plates is introduced in the capacitor? 2

Ans: 1.5 times C_o

2 A parallel plate capacitor is charged and the charging battery is then disconnected. What happens to the potential difference and the energy of the capacitor, if the plates are moved further apart using an insulating handle? 2

Ans: Both Increases

3 Find the equivalence capacitance between X and Y. 2

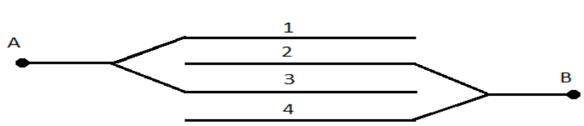


Ans: 9 µf

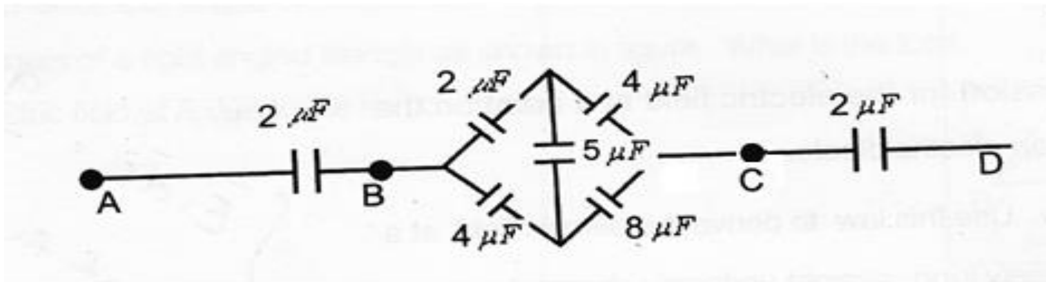
4 A pith ball of mass 0.2 g is hung by insulated thread between the plates of a capacitor of separation 8cm. Find the potential difference between the plates to cause the thread to incline at an angle 15^0 with the vertical, if the charge in the pith ball is equal to 10^{-7}C. 2

Ans: 429 V

5. Find the capacitance of arrangement of 4 plates of Area A at distance d in air as shown. 2



6. What is an equivalent capacitance of the arrangement the shown below 3



If 6V cell is connected across AD. Calculate the potential difference between B&C.

7. A parallel plate capacitor is charged to a potential difference V by d.c. source and then disconnected. The distance between the plates is then halved. Explain with reason for the change in electric field, capacitance and energy of the capacitor. 3

Ans: Use the formulae - Electric field remains same, Capacitance doubled, Energy halved

8. Derive an expression for capacitance of parallel plate capacitor, when a dielectric slab of dielectric constant k is partially introduced between the plates of the capacitor. 3

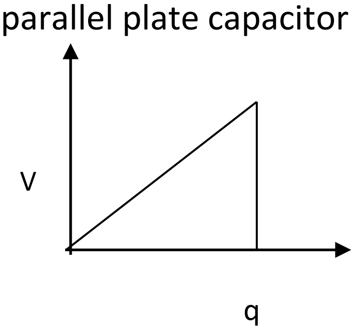
9. A potential difference of 1200 V is established between two parallel plates of a capacitor. The plates of the capacitor are at a distance of 2 cm apart. An electron is released from the negative plate, at the same instant, a proton is released from the +ve plate. 3

(a)How do their (i) velocity (ii) Energy compare, when they strike the opposite plates.

(b) How far from the positive plate will they pass each other?

Ans a. (i)42.84 (ii)equal b. 2.7cm

10. Draw a graph to show the variation of potential applied and charge stored in a capacitor. Derive the expression for energy stored in a parallel plate capacitor from the capacitor. 3

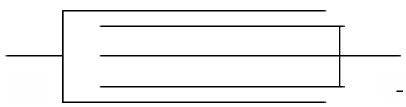


11. Find the capacitance of a system of three parallel plates each of area A m^2 separated by d_1 and d_2 m respectively. The space between them is filled with dielectrics of relative dielectric constant ϵ_1 and ϵ_2. 2

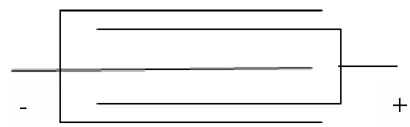
12. Two parallel plate capacitors A and B having capacitance 1µF and 5 µF are charged separately to the same potential 100V. They are then connected such that +ve plate of A is connected to –ve plate of B. Find the charge on each capacitor and total loss of energy in the capacitors. 3

Ans: 400µC, 500µC and 5/3 x 10J

13. Calculate the capacitance of a system having five equally spaced plates, if the area of each plate is 0.02 m^2 and the separation between the neighboring are 3 mm. in case (a) and (b) 3



(a)



(b)

Ans: (Hint: Capacitance of a parallel plate capacitor $\varepsilon_o A/d$)

1.18 x 10^{-4} µ F and 2.36 x 10 µ F

14. Net capacitance of three identical capacitors in series is 1µf. What will be their net capacitance if connected in parallel? 2

Find the ratio of energy stored in the two configurations, if they are both connected to the same source.

Ans: 9µf 1 : 9

15. Two parallel plate capacitors X and Y have the same area of plates and the same separation between them. X has air between the plates and Y contains a dielectric medium of εr=4. Calculate Capacitance of X and Y if equivalent capacitance of combination is 4 µF.

(i) Potential Difference between the plates of X and Y

(ii) What is the ration of electrostatic energy stored in X and Y

[Ans : 5 µF, 20 µF, 9.6 V, 2.4 V, 4:1]

VALUE BASED QUESTIONS

1. Saanvi has dry hair. A comb ran through her dry hair attract small bits of paper. She observes that Chinju with oily hair combs her hair; the comb could not attract small bits of paper. She consults her teacher for this and gets the answer. She then goes to the junior classes and shows this phenomenon as Physics Experiment to them. All the juniors feel very happy and tell her that they will also look for such interesting things in nature and try to find the answers .she succeeds in forming a Science Club in her school.
    - How can you explain the above experiment?
    - What according to you are the values displayed Saanvi?

2. Sneha's mother who was illiterate was folding her synthetic saree. She saw a spark coming out of it .She got frightened and called Sneha. Sneha being a science student gave the reason behind it. After knowing the reason her mother calmed down.

- What is the reason for the spark?
- What value was displayed by Sneha?

2. CURRENT ELECTRICITY

GIST

- Current carriers – The charge particles which flow in a definite direction constitutes the electric current are called current carriers. e.g.: Electrons in conductors, Ions in electrolytes, Electrons and holes in semi-conductors.
- Electric current is defined as the amount of charge flowing through any cross section of the conductor in unit time. *I = Q/t.*
- Current density $|\vec{J}| = I/A$.
- Ohm's law: Current through a conductor is proportional to the potential difference across the ends of the conductor provided the physical conditions such as temperature, pressure etc. Remain constant. $V \alpha I$ i.e. $V = IR$, Where R is the resistance of the conductor. Resistance R is the ratio of V & I
- Resistance is the opposition offered by the conductor to the flow of current.
- Resistance $R = \rho l/A$ where ρ is the resistivity of the material of the conductor- length and A area of cross section of the conductor. If l is increased n times, new resistance becomes n^2R. If A is increased n times, new resistance becomes $\frac{1}{n^2}R$
- Resistivity $\rho = m/ne^2\tau$, Where *m, n, e* are mass, number density and charge of electron respectively, τ-relaxation time of electrons. ρ is independent of geometric dimensions.
- Relaxation time is the average time interval between two successive collisions
- Conductance of the material G =1/R and conductivity σ=1/ρ
- Drift velocity is the average velocity of all electrons in the conductor under the influence of applied electric field. Drift velocity $V_d = (eE/m)\tau$ also $I = neAv_d$
- Mobility (μ) of a current carrier is the ratio of its drift velocity to the applied field $\mu = \frac{V_d}{E}$
- Effect of temperature on resistance: Resistance of a conductor increase with the increase of temperature of conductor $R_T = R_o(1+\alpha T)$, where α is the temperature coefficient of resistance of the conductor. α is slightly positive for metal and conductor, negative for semiconductors and insulators and highly positive for alloys.
- Combination of resistors: $R_{series} = R_1 + R_2 + ...R_n$, $\frac{1}{R_{Parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + ...\frac{1}{R_n}$

- Cells: E.M.F of a cell is defined as the potential difference between its terminals in an open circuit. Terminal potential difference of a cell is defined as the potential difference between its ends in a closed circuit.
- Internal resistance *r* of a cell is defined as the opposition offered by the cell to the flow of current. r = $\left(\frac{E}{V}-1\right)R$ where R is external resistances.
- Grouping of cells :

  i) In series grouping circuit, current is given by $I_s = \frac{nE}{R+nr}$,

  ii) In parallel grouping circuit, current is given by $I_p = \frac{mE}{r+mR}$ where n, m are number of cells in series and parallel connection respectively.
- Kirchhoff's Rule:

  i) Junction Rule:-The algebraic sum of currents meeting at a point is zero. $\sum I = 0$

  ii) Loop rule:-The algebraic sum of potential difference around a closed loop is zero $\sum V = o$
- Wheatstone bridge is an arrangement of four resistors arranged in four arms of the bridge and is used to determine the unknown resistance in terms of other three resistances. For balanced Wheatstone Bridge, $\frac{P}{Q} = \frac{R}{S}$
- Wheatstone bridge is most sensitive when the resistance in the four arms are of the same order
- In the balanced condition of the bridge on interchanging the positions of galvanometer and battery if there is no effect on the balancing length of the bridge.
- Slide Wire Bridge or Metre Bridge is based on Wheatstone bridge and is used to measure unknown resistance. If unknown resistance S is in the right gap, $s = \left(\frac{100-l}{l}\right)R$
- Potentiometer is considered as an ideal voltmeter of infinite resistance.
- Principle of potentiometer: The potential drop across any portion of the uniform wire is proportional to the length of that portion of the wire provided steady current is maintained in it i.e. *v α l*
- Smaller the potential gradient greater will be the sensitivity of potentiometer.
- Potentiometer is used to (i) compare the e.m.f.s of two cells (ii) determine the internal resistance of a cell and (iii) measure small potential differences.

- Expression for comparison of e.m.f of two cells by using potentiometer, $\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$ where l_1, l_2 are the balancing lengths of potentiometer wire for e.m.fs ε_1 and ε_2 of two cells.
- Expression for the determination of internal resistance of a cell I is given by $\left(\frac{l_1 - l_2}{l_2}\right)R$

Where l_1 is the balancing length of potentiometer wire corresponding to e.m.f of the cell, l_2 that of terminal potential difference of the cell when a resistance R is connected in series with the cell whose internal resistance is to be determined

- Expression for determination of potential difference $V = \varepsilon\left(\frac{\varepsilon}{R + r}\right)\frac{rl}{L}$. Where L is the length of the potentiometer wire, l is balancing length, r is the resistance of potentiometer wire, R is the resistance included in the primary circuit.
- Joule's law of heating states that the amount of heat produced in a conductor is proportional to (i) square of the current flowing through the conductor,(ii) resistance of the conductor and (iii) time for which the current is passed. Heat produced is given by the relation $H=I^2Rt$
- Electric power: It is defined as the rate at which work is done in maintaining the current in electric circuit. $P = VI = I^2R = V^2/R$. Power P is the product of V & I
- Electrical energy: The electrical energy consumed in a circuit is defined as the total work done in maintaining the current in an electrical circuit for a given time. Electrical energy = VIt = I^2Rt =$(V^2/R)t$ = Pt
- Commercial unit of energy 1KWh= 3.6×10^6J
- Colour coding :

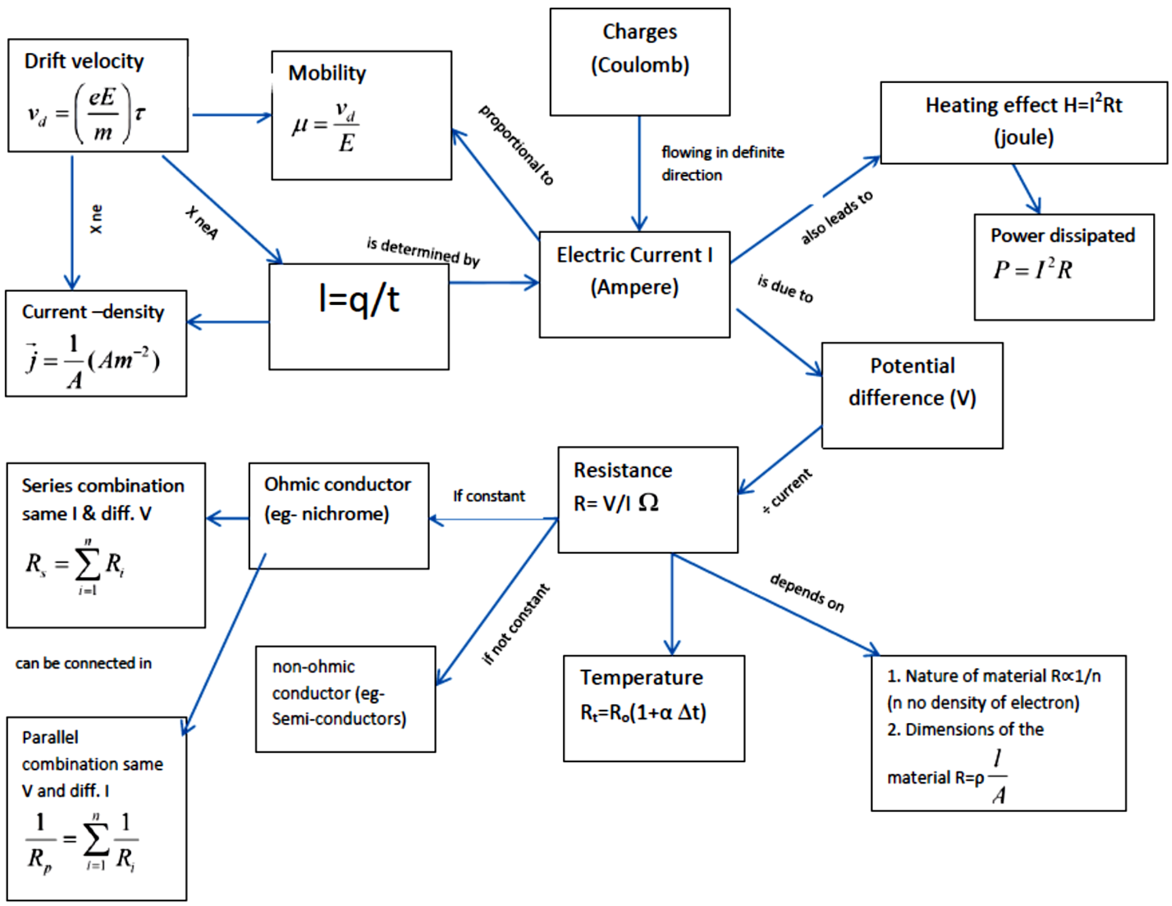
Black	**B**rown	**R**ed	**O**range	**Y**ellow	**G**reen	**B**lue	**V**iolet	**G**ray	**W**hite
0	1	2	3	4	5	6	7	8	9

<u>Tolerance</u> (i) Gold 5% (ii) Silver 10% (iii) No Color 20%

Example: if colour code on carbon resister is Red Yellow and Orange with tolerance colour as silver, the resistance of the giveresister is $(24\times10^3 \pm 10\%)\Omega$.

CONCEPT MAP

Flow of Charges



QUESTIONS

DRIFT VELOCITY, CURRENT, POTENTIAL DIFFERENCE, OHM'S LAW AND RESISTANCE

1. How does the drift velocity of electrons in a metallic conductor vary with increase in temperature? (1)

Ans. remains the same

2. Two different wires X and Y of same diameter but of different materials are joined in series and connected across a battery. If the number density of electrons in X is twice that of Y, find the ratio of drift velocity of electrons in the two wires. (1)

Ans: $V_{dx}/V_{dy} = n_y/n_x = ½$

3. A 4Ω non insulated wire is bent in the middle by 180^0 and both the halves are twisted with each other. Find its new resistance? (1)

Ans: 1Ω

4. Can the terminal potential difference of a cell exceed its emf? Give reason for your answer. (1)

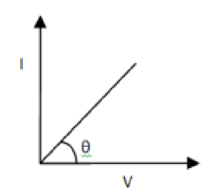
Ans: Yes, during the charging of cell.

5. Two wires of equal length one of copper and the other of manganin have the same resistance. Which wire is thicker? (1)

Ans: Manganin.

6. The V-I graph for a conductor makes angle Θ with V- axis, what is the resistance of the conductor? (1)

Ans: R = Cot Θ



(1)

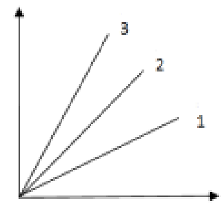
7. It is found that 10^{20} electrons pass from point X towards another point Y in 0.1s. How much is the current & what is its direction? (1) Ans: 160A; from Y to X

8. Two square metal plates A and B are of the same thickness and material. The side of B is twice that of side o fA. If the resistance of A and B are denoted by R_A and R_B, find R_A/R_B. Ans: 1

(1)

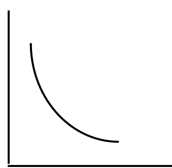
9*. The V-I graph of two resistors in their series combination is shown. Which one of these graphs shows the series combinations of the other two? Give reason for your answer.

Ans: 1



(2)

10. Plot a graph showing the variation of conductivity σ with the temperature T in a metallic conductor. (Ans: see fig1)



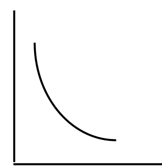


Fig 1 **fig2**

11. Draw a graph to show the variation of resistance R of the metallic wire as a function of its diameter D keeping the other factor constant. (2)

(Ans: see fig2)

12. Two conducting wires X and Y of same diameter but different materials are joined in series across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires. (Ans: $I \alpha \, nv_d$ i.e. $V_{dx}/V_{dy} = n_y/n_x = ½$)

13 A pd of 30V is applied across a colour coded carbon resistor with rings of blue, black and yellow colours. What is the current to the resistor? (2)

Ans: $R = 60 \times 10^4 \Omega$, $I = 5\times 10^{-5}$A (2)

14. A non-conducting ring of radius r has charge q distribute over it. What will be the equivalent current if it rotates with an angular velocity ω? Ans: I= q/t = qω/2π.

15.* Two cells each of emf E and internal resistances r_1 and r_2 are connected in series to an external resistance R. Can a value of R be selected such that the potential difference of the first cell is 0. (2)

Ans: $I = 2Ɛ/(R + r_1 + r_2)$ Potential diff. for first cell $V_1 = Ɛ – I r_1 = 0$

$Ɛ = (2 Ɛ r_1)/R + r_1 + r_2$ Solving these we get, $R = r_1 - r_2$

16. Why does Resistance increase in series combination and decrease in parallel combination (2)

Ans: Effective length increases in series combination (R α l).

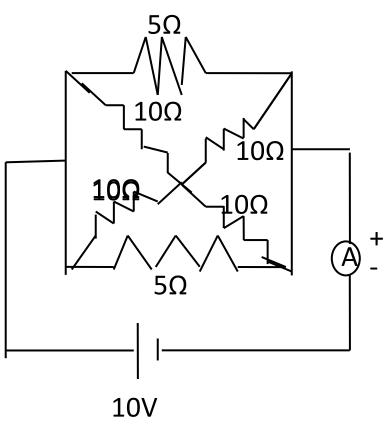
In parallel combination area of cross section increases (R α 1/A)

17. A piece of silver wire has a resistance of 1Ω. What will be the resistance of the constantan wire of one third of its length and one half of its diameter if the specific resistance of the constantan wire is 30 times than that of the silver? (2)

(2)

Ans: 40Ω

18. Calculate the current shown by the ammeter in the circuit in fig 1



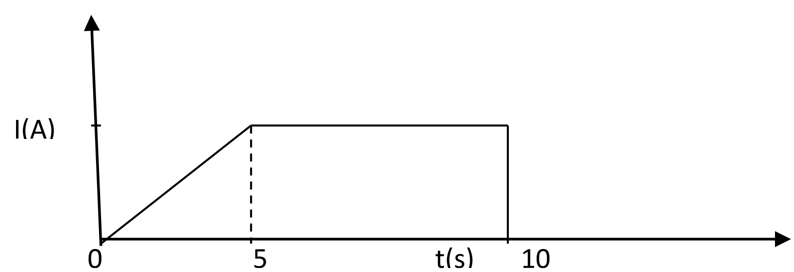


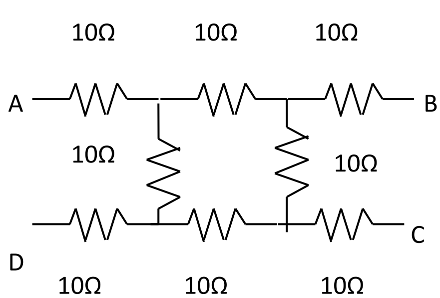
Fig 1. Fig 2.

Ans: R = 2Ω and I = 5A

19. The plot in fig 2 given above shows the variation of current I through the cross section of a wire over a time interval of 10s. Find the amount of charge that flows through the wire over this time period. (2)

Ans: Area under the I-t graph, q = 37.5C

20. Find the resistance between the points (i) A and B and (ii) A and C in the following network (2)



Ans: (i) R_{AB} = 27.5Ω (ii) R_{AC} = 30Ω

21. Two wires of the same material having lengths in the ratio 1:2 and diameter 2:3 are connected in series with an accumulator. Compute the ratio of p.d across the two wires (2)

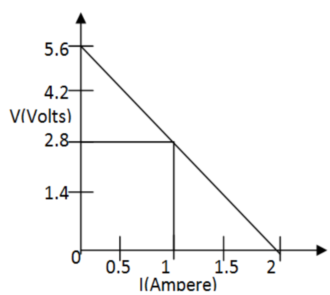
Ans: $R = \rho l/A = 4\rho l/\pi d^2$ $R_A/R_B = 9/8$ $V_A/V_B = I_A R_A/I_B R_B = 9/8$

22. 4 cells of identical emf E_1, internal resistance r are connected in series to a variable resistor. The following graph shows the variation of terminal voltage of the combination with the current output. (3)

(i)What is the emf of each cell used?

(ii)For what current from the cells, does maximum power dissipation occur in the circuit?

(iii)Calculate the internal resistance of each cell



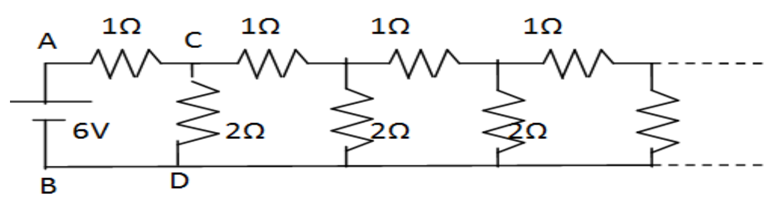
Ans: 4E = 5.6 E = 1.4 V

When I = 1A, V = 2.8/4 = 0.7V

Internal resistance, r= (E – V)/I = 0.7Ω

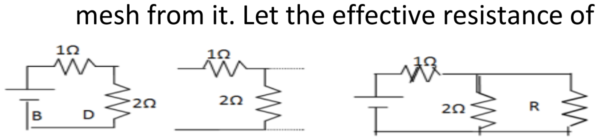
The output power is maximum when internal resistance = external resistance = $4r.I_{max} = 4E/(4r + 4r) = 1A$

23.* An infinite ladder network of resistances is constructed with 1Ω and 2Ω resistances shown. A 6V battery between A and B has negligible resistance. (3)



(i) Find the effective resistance between A and B.

Ans: Since the circuit is infinitely long, its total resistance remains unaffected by removing one mesh from it. Let the effective resistance of the infinite network be R, the circuit will be



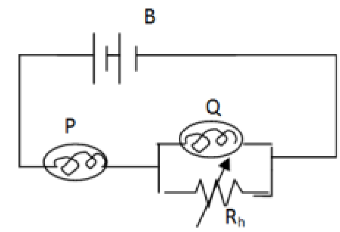
$R = \frac{2R}{R+2} + 1$ $R = 2\Omega$

24. The resistance of a tungsten filament at 150°C is 133Ω. What will be its resistance at 500^0C? The temperature coefficient of tungsten is 0.0045^0C^{-1} at 0^0C. (3)

Ans: Use $R_t = R_0(1 + \alpha t)$ $R_{500} = 258\Omega$

25. The circuit shown in the diagram contains two identical lamps P and Q. (3) What will happen to the brightness of the lamps, if the resistance R_h is increased? Give reason.

Ans: Brightness of P and Q decrease and increase respectively.

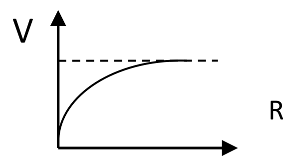


26. A battery has an emf E and internal resistance r. A variable resistance R is connected across the terminals of the battery. Find the value of R such that (a) the current in the circuit is maximum (b) the potential (3) difference across the terminal is maximum. (c)Plot the graph between V and R

Ans: (a) $I = \varepsilon / (r + R)$ $I = I_{max}$ when R =0 $I_{max} = \varepsilon / r$

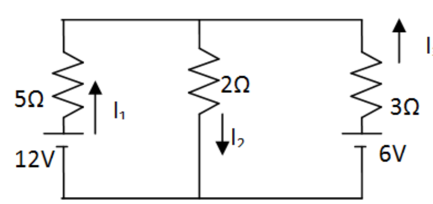
(b) $V = \varepsilon R/(r + R) = \varepsilon /(r/R + 1)$ $V = V_{max}$ when r/R + 1= minimum, r/R = o, V= Ɛ

(c)



II. KIRCHHOFF'S RULE AND APPLICATIONS

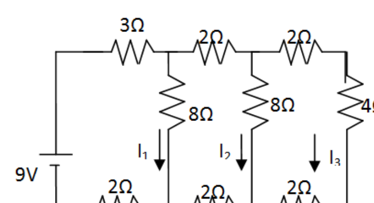
1. Using Kirchhoff's laws, calculate I_1, I_2 and I_3 (3)



Ans: $I_1 = 48/31A$ $I_2 = 18/31A$ $I_3 = 66/31A$

2. In the circuit, find the current through the 4Ω resistor. (3)

(3)



Ans: I = 1A

III. WHEATSTONE BRIDGE AND POTENTIOMETER

1. The emf of a cell used in the main circuit of the potentiometer should be more than the potential difference to be measured. Why? (1)

2. The resistance in the left gap of a metre bridge is 10Ω and the balance point is 45cm from the left end. Calculate the value of the unknown resistance. (1)

Ans S = 12.5Ω

3. How can we improve the sensitivity of a potentiometer? (1)
4. Why is potentiometer preferred over a voltmeter (1)
5. Write the principle of (2)

(i) a meter bridge.
(ii) a potentiometer.

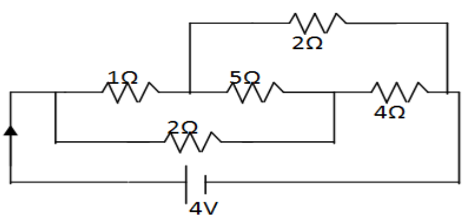
6. How does the balancing point of a Wheatstone bridge get affected (2)
   i) Position of cell and Galvanometer are interchanged?
   ii) Position of the known and unknown resistances is interchanged?

7. Explain with a neat circuit diagram, how will you compare emf of two cells using a potentiometer?

8. With the help of a circuit diagram, describe the method of finding the internal resistance of the Primary Cell using a potentiometer. (3)

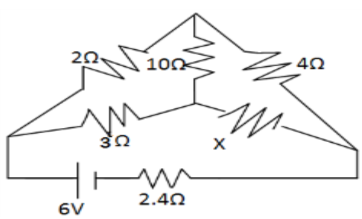
9. With the help of a neat circuit diagram describe the method to determine the potential difference across the conductor using a potentiometer. (3)

10. Calculate the current drawn from the battery in the given network.



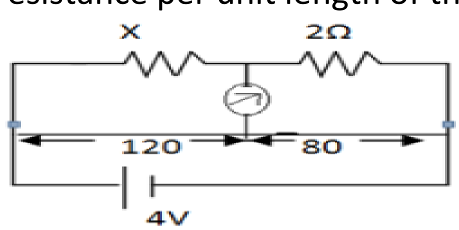
Ans: I = 2A

11. Find the value of X and current drawn from the battery of emf 6V of negligible internal resistance (3)



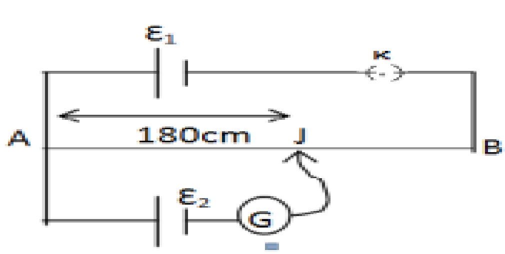
Ans: X = 6Ω and I = 1A

12. Find the value of the unknown resistance X and the current drawn by the circuit from the battery if no current flows through the galvanometer. Assume the resistance per unit length of the wire is $0.01\Omega cm^{-1}$. (3)



Ans: X = 3Ω

13. In the circuit shown, AB is a resistance wire of uniform cross – section in which a potential gradient of $0.01V\ cm^{-1}$ exists. (3)

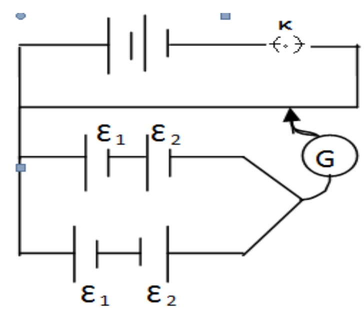


(a)If the galvanometer G shows zero deflection, what is the emf ε_1 of the cell used?

(b)If the internal resistance of the driver cell increases on some account, how will it affect the balance point in the experiment?

Ans: (a) PD V_{AB} = 1.8 V (b) Balance pt. will shift towards B since V/l decreases.

14.* In a potentiometer circuit, a battery of negligible internal resistance is set up as shown to develop a constant potential gradient along the wire AB. Two cells of emfs ε_1 and ε_2 are connected in series as shown in the combination (1) and (2). (3) The balance points are obtained respectively at 400cm and 240cm from the point A. Find (i) $\varepsilon_1/\varepsilon_2$ and (ii) balancing length for the cell ε_1 only.

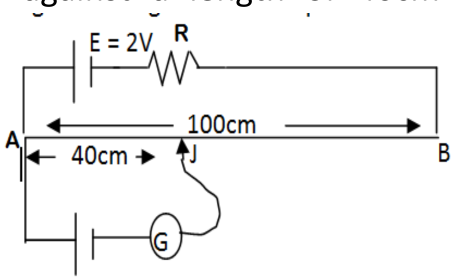


Ans : $\varepsilon_1 + \varepsilon_2 \propto 400$, $\varepsilon_1 - \varepsilon_2 \propto 240$,Solving

$\varepsilon_1/\varepsilon_2 = 4$, $\varepsilon_1 \propto l_1$,

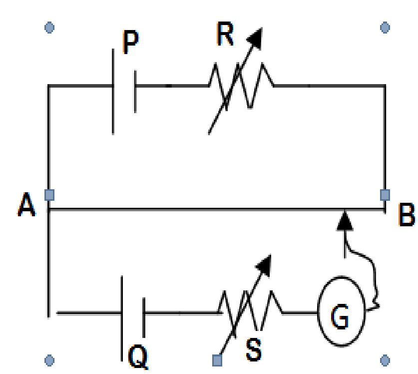
$(\varepsilon_1 + \varepsilon_2)/\varepsilon_1 = 400/l_1$, l_1 = 320cm

15.* A potentiometer wire of length 100cm having a resistance of 10Ω is connected in series with a resistance and cell of emf 2V of negligible internal resistance. A source emf of 10mV is balanced against a length of 40cm of potentiometer wire. What is the value of the external resistance? (3)



Ans: I = E/(R + 10) = (2/R + 10) Resistance of 40cmwire is 4Ω. At J, (2/R +10) x 4 = 10 x 10^{-3} R = 790Ω

16.* In the potentiometer circuit shown, the balance point is at X. State with reason where the balance point will be shifted when (3)



(i)Resistance R is increased, keeping all parameters unchanged.

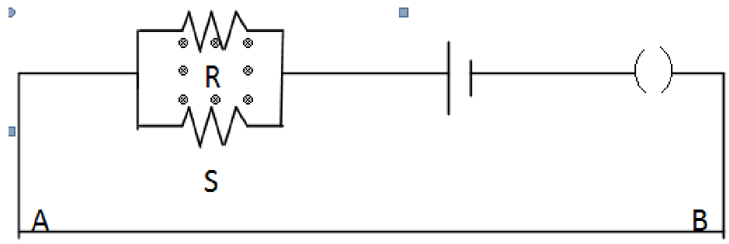
(ii)Resistance S is increased keeping R constant.

(iii)Cell P is replaced by another cell whose emf is lower than that of that cell Q.

Ans: (i) As R is increased V/l will decrease hence X will shift towards B.

(ii)No effect (iii) Balance point is not found.

17.* A potentiometer wire has a length L and resistance R_0. It is connected to a battery and a resistance combination as shown. Obtain an expression for the potential difference per unit length of the potentiometer wire. What is the maximum emf of a 'test cell' for which one can get a balance point on this potentiometer wire? What precautions should one take while connecting this test cell to the circuit? (3)



Ans: Total resistance of potentiometer wire $R = R_0 + RS/(R+S)$

Current in the circuit $I = E/\ (R_0 + (RS/R+S))$

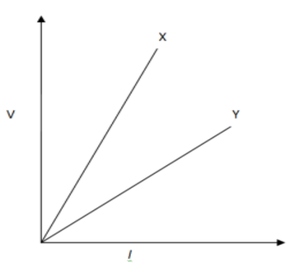
Total potential difference across AB $V = I\,R_0 = E\,R_0/\ (R_0 + (RS/R+S))$

Therefore, PD per unit length is $V/L = E\,R_0/L\ (R_0 + (RS/R+S))$

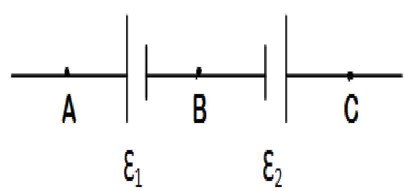
Max emf of a test cell should be less than V.

Precaution: Positive terminal of the test cell must be connected to positive terminal of the battery.

18. The variation of potential difference V with length l in case of two potentiometers X and Y as shown. Which one of these will you prefer for comparing emfs of two cells and why? (3)



Ans : The potentiometer Y is preferred, as it has low potential gradient (V/l)



19. Two cells of emfs ε_1 and ε_2 ($\varepsilon_1 > \varepsilon_2$) are connected as shown in figure When a potentiometer is connected between A and B, the balancing length of the potentiometer wire is 300cm. On connecting the same potentiometer between A and C, the balancing length is 100cm. Calculate the ratio of ε_1 and ε_2.

Ans: $\varepsilon_1\ \alpha\ 300$, $\varepsilon_1 - \varepsilon_2\ \alpha\ 100$, $\varepsilon_1/\varepsilon_2 = 3/2$

IV. ELECTRIC ENERGY AND POWER

1. What is the largest voltage you can safely put across a resistor marked 98Ω - 0.5W? (1)

2. Which lamp has greater resistance (i) 60W and (ii) 100W when connected to the same supply? (1)

Ans: $R = V^2/P$, $R \propto 1/P$, 60 lamp has more resistance

3. Nichrome and Cu wires of the same length and same diameter are connected in series in an electric circuit. In which wire will the heat be produced at a higher rate? Give reason. (2)

Ans: $P = I^2R$ $P \propto R$ Heat produced is higher in Nichrome wire.

4.* An electric bulb rated for 500W at 100V is used in circuit having a 200V supply. Calculate the resistance R that must be put in series with the bulb, so that the bulb delivers 500W. (2)

Ans: Resistance of bulb=V^2/P = 20Ω, I = 5A, for the same power dissipation, current should be 5A when the bulb is connected to a 200V supply. The safe resistance R' = V'/I = 40Ω. Therefore, 20Ω resistor should be connected in series.

5. Two bulbs are marked 220V-100W and 220V-50W. They are connected in series to 220V mains. Find the ratio of heat generated in them. (2)

Ans: $H_1/H_2 = I^2R_1/I^2R_2 = R_1/R_2 = ½$

6.* Can a 30W, 6V bulb be connected supply of 120V? If not what will have to be done for it? (3)

Ans: Resistance of bulb R= V^2/P = 36/30 = 1.2Ω Current capacity of the bulb I = P/V = 5A

A resistance R' to be added in series with the bulb to have current of 5 A, I = V'/R + R' =5, R' = 22.8Ω

<u>VALUE BASED QUESTIONS:</u>

1. Father and a son returned home completely drenched due to heavy rain. Father advised his son not touch any electrical units with wet hands for he may get a shock; In spite of this, on immediately entering the house, the son switches

on the light (supply voltage is 220 V) and gets a severe shock; He was fortunate not to get electrocuted. Father, who is a Biologist, told that when the skin is dry, resistance of a human body is $10^5\ \Omega$; and when the skin is wet the body resistance is 1500 Ω.

What is the lesson learnt by you?

Calculate the current that flow through

(I) a wet body and

(II) a dry body.

When will we have serious consequences dry skin or wet skin? Why?

(**Ans**: to obey elders; b) Using, I = V/R (i) 147 mA; (ii) 2.2 mA.; c) wet skin – with 147mA, when the current flows, the result is fatal)

2. Based on the previous knowledge learnt in the class,two students of class XII(A and B) were asked to conduct an experiment in the laboratory using a meter bridge-one is made of Nichrome and the other one is made of Copper, of same length and same diameter of constant potential difference. The student A could not give explanation for not achieving the result whereas student B, could get the result and was also able to explain.

What made student B to perform successfully?

Give the formula to calculate the rate of heat production.

(**ANS:** a) student B had concentrated in the class room teaching and also had studied again to remember what was taught; b) Refer NCERT Text book)

3. An old woman who had suffered from a heart stroke was taken to the hospital by her grandson who is in class XII. The grandson has studied in Physics that, to save a person who is suffering from a heart stroke, regular beating of the heart is to be restored by delivering a jolt to the heart using a defibrillator, whose capacity is 70 microfarad and charged to a potential of 5000V and energy stored in 875J; 200J of energy is passed through a person's body in a pulse lasting 2 milliseconds. The old woman gets panicked and refuses to be treated by defibrillator. Her grandson then explains to her the process that would be adopted by medical staff and how the result of that would bring her back to normalcy. The woman was then treated and was back to normal

What according to you, are the values displayed by the grandson?

How much power is delivered to the body to save a person's life from heart attack?

(**ANS:** (a)Presence of mind, Knowledge of subject, Concern for his grandmother, Empathy, Helping and caring; (b) Power = energy / time; = 200/2 x 10^{-3} = 100KW)

4. On our return from an excursion trip in our school, I noticed a bird sitting on a high voltage electric wire. I curiously noticed the bird and found to my surprise that the bird flew off after sometime without any electrical shock. This incident made me think of another incident that took place near my house last week where, a boy, who climbed to take a kite, got severe jolt of electric current. I immediately approached my school Physics teacher for an explanation. My teacher explained the effect of electrical current which I told my mother that evening.

What are the values associated with the above incident?

What would be the explanation given by the Physics teacher?

(**ANS:** a) observation, eagerness to learn; b) both the legs of the bird are at same voltage and hence no current passes; to receive a shock there must be a potential difference between one part of the body and another; if a person hangs from a high voltage wire without touching anything else, he can be quite safe and would not feel shock)

5. Mrs Vasundhara left her car headlights on while parking. The car would not start when she returned. Seeing her struggle, Mohit went to her help. Not knowing much about cars, he ran and brought a mechanic Raju from a garage nearby. Raju realized that the battery had got discharged as the headlight had been left on for a long time. He brought another battery and connected its terminals to the terminals of the car battery to get the engine started. Once the engine was running, he disconnected this second battery. This is known as "JUMP STARTING". Mrs. Vasundharathanked both Mohit and Raju for helping her.

(a)What values did Mohit have?

(b) A storage battery of emf 8.0 volts and internal resistance 0.5 ohm is being charged by a 120 volt DC supply using a series resistor of 15.5 ohms. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

ANS: a) Helpful, aware of his weakness, decision making ability

b). $I = E/(R+r) = (120 - 8.00) / (15.5 + 0.5) = 7$ Amp.

Terminal voltage $V = E + Ir = 8.00 + 7 \times 0.5 = 11.5$ volt.

The series resistor limits the current drawn from the external source . In its absence the current will be dangerously high.

6. Rahul and Rohit bought an electric iron. They had a 2 pin plug. Rahul was keen to start using the new iron with the 2 pin plug. However, Rohit insisted that they buy a 3 pin plug before using it. Rahul got angry. Rohit patiently explained the importance of using a 3 pin plug and the earthing wire. He said that if the metallic body of the iron came in contact with the live wire at 220 volts, they would get an electric shock. If earthed, the current would go to the earth and the potential of the metallic body would not rise. The iron would then be safe to use. Hearing Rohit, Rahul calmed down and agreed.

(a) What values did Rahul and Rohit have?

(b) Which has greater resistance – 1 K watt electric heater or 100 watt electric bulb, both marked 220 volts?

ANS: (a) Rahul is enthusiastic and flexible, Rohit is patient, knowledgeable, assertive

(b) $R = V^2 / P$

$R \propto 1 / P$ Hence 100W bulb has greater resistance.

3.MAGNETIC EFFECTS OF CURRENT AND MAGNETISM

GIST

1. Magnetic field:It is a region around a magnet or current carrying conductor in which its magnetic influence can be felt by a magnetic needle.

Biot-Savart Law: $dB = \mu_0 \, IdlSin\theta / 4\pi r^2$

$$\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$$

[Direction of dB can be found by using Maxwell's Right hand thumb rule.]

2. Applications :

   1. Magnetic field at a centre of a current carrying circular coil $B = \mu_0 I/2a$
   2. Magnetic field at a point on the axis of current carrying coil.

   $B = \mu_0 N i a^2 / 2(a^2+x^2)^{3/2}$ (N=no. of turns in the coil)

   Ampere's circuital law: It states that the line integral of magnetic field around any closed path in vacuum/air is μ_0 times the total current threading the closed path. $\int B.\, dl = \mu_0 \mathbf{I}$

3. Applications

   Magnetic field due to straight infinitely long current carrying straight conductor. $B = \mu_0 \mathbf{I}/2\pi r$

4. Magnetic field due to a straight solenoid carrying current $B = \mu_0 n \mathbf{I}$

   n= no. of turns per unit length

5. Magnetic field due to toroidal solenoid carrying current. $B = \mu_0 N \mathbf{I} / 2\pi r$

   N= Total no. of turns.

6. Force on a moving charge [Lorentz Force]

   In magnetic field $F = q(V \times B)$

   In magnetic and electric field $F = q[E + (v \times B)]$ Lorentz force

7. Cyclotron

   Principle :When a charged particle moves at right angle to a uniform magnetic field it describes circular path.

   An ion can acquire sufficiently large energy with a low ac voltage making it to cross the same electric field repeatedly under a strong magnetic field.

   Cyclotron frequency or magnetic resonance frequency

   $v = qB/2\pi m$, $T = 2\pi m/Bq$; $\omega = Bq/m$

   Maximum velocity and maximum kinetic energy of charged particle.

   $V_m = Bqr_m/m$

   $E_m = B^2 q^2 r_m^2 / 2m$

8. Force on a current carrying conductor in uniform

   $F = (I\, l \times B)$ l=length of conductor

   Direction of force can be found out using Fleming's left hand rule.

   Force per unit length between parallel infinitely long current carrying straight conductors.

$F/l = \mu_0 I_1 I_2 / 2\pi d$

If currents are in same direction the wires will attract each other.

If currents are in opposite directions they will repel each other.

9. 1 Ampere – One ampere is that current, which when flowing through each of the two parallel straight conductors of infinite length and placed in free space at a distance of 1m from each other, produces between them a force of 2×10^{-7} N/m of their length.

10. Torque experienced by a current loop in a uniform B.

$\tau = NIBA \sin\theta$

$\tau = M \times B$ Where $M = NIA$

11. Motion of a charge in

Perpendicular magnetic field $F=q(v\times B)$, $F=qvB\sin 90=qvB$ (circular path)

Parallel or antiparallel field $F=qvB\sin 0$ (or) $qvB\sin 180=0$ (Straight-line path)

If $0<\theta<90$, the path is helix

$v\cos\theta$ is responsible for linear motion v, $v\sin\theta$ is responsible for circular motion

Hence trajectory is a helical path

12. **Moving coil galvanometer**

It is a sensitive instrument used for detecting small electric Currents.

Principle: When a current carrying coil is placed in a magnetic field, it experiences a torque.

$I \alpha \theta$ and $I = K\theta$ where $K = NAB / C$

Current sensitivity, $I_s = \theta / I = NBA/K$

voltage sensitivity, $V_s = \theta / V = NBA/KR$

Changing N -> Current sensitivity changes but Voltage Sensitivity does not change

13. Conversion of galvanometer into ammeter

A small resistance S is connected in parallel to the galvanometer coil

$S = I_g G / (I - I_g)$; $R_A = GS/(G+S)$

14. Conversion of galvanometer into a voltmeter.

A high resistance R is connected in series with the galvanometer coil.

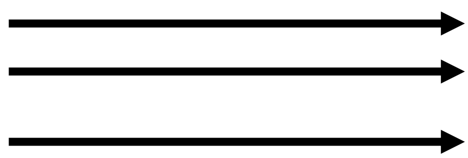
$R = (V/I_g) - G$; $R_v = G + R$

15. Current loop as a magnetic dipole

16. Magnetic dipole moment $M = \frac{evr}{2}$

$M = n(eh / 4\pi m_e)$

Representation of uniform magnetic field.

17.  **B**

18. Magnetic dipole moment of a magnetic dipole.

19. a) $M = m(2l)$

b) SI unit of M - ampere metre m= pole strength.

c) The magnetic permeability of a material may be defined as the ration of magnetic induction B to the magnetic intensity H

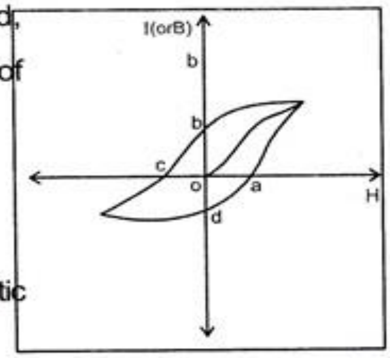
$$\mu = B/H$$

d) Susceptibility

$$\chi = \frac{I}{H}$$

20. Hysteresis

Intensity of magnetisation lags behind the magnetising field, when a magnetic substance is taken through a complete cycle of magnetisation.



a) Retentivity or remanance

ob (or) od

It is the value of magnetic field intensity retained by the magnetic substance when the magnetising field is reduced to zero.

b) Coercivity:- (oc (or) oa):- It is the value of magnetizing field required to reduce the residual intensity of magnetisation of sample to zero.

c) Hysteresis loss:- It is the loss of energy which takes place when a magnetic substance is taken over a complete cycle of magnetisation.

21. a) Electromagnet:- It is a magnet whose magnetism is due to current flowing through a coil wound over a soft iron. It maintains strength till the current is on in the coil. (eg) Soft iron

b) Permanent magnet:- It is a magnet which owes its strength due to the alignment of its molecules.

eg. steel

Properties to make

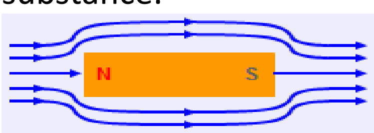
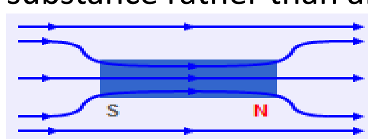
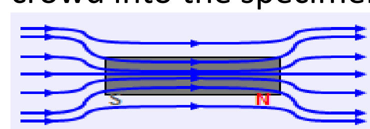
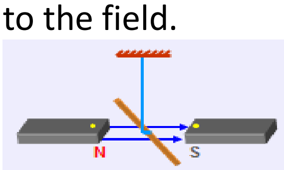
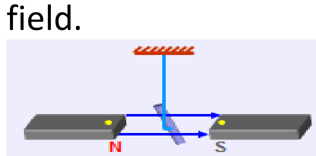
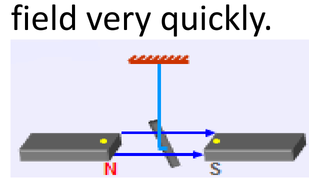
1) Electro magnet

High retentivity and low coercivity

2) Permanent magnet

High retentivity and high coercivity

22. Properties of magnetic substances

<table>
<tr><th>DIA</th><th>PARA</th><th>FERRO</th></tr>
<tr>
<td>1. Diamagnetic substances are those substances which are feebly repelled by a magnet.
Eg. Antimony, Bismuth, Copper, Gold, Silver, Quartz, Mercury, Alcohol, water, Hydrogen, Air, Argon, etc.</td>
<td>Paramagnetic substances are those substances which are feebly attracted by a magnet.
Eg. Aluminium, Chromium, Alkali and Alkaline earth metals, Platinum, Oxygen, etc.</td>
<td>Ferromagnetic substances are those substances which are strongly attracted by a magnet.
Eg. Iron, Cobalt, Nickel, Gadolinium, Dysprosium, etc.</td>
</tr>
<tr>
<td>2. When placed in magnetic field, the lines of force tend to avoid the substance.

</td>
<td>The lines of force prefer to pass through the substance rather than air.

</td>
<td>The lines of force tend to crowd into the specimen.

</td>
</tr>
<tr>
<td>3. When placed in non-uniform magnetic field, it moves from stronger to weaker field (feeble repulsion).</td>
<td>When placed in non-uniform magnetic field, it moves from weaker to stronger field (feeble attraction).</td>
<td>When placed in non-uniform magnetic field, it moves from weaker to stronger field (strong attraction).</td>
</tr>
<tr>
<td>4. When a diamagnetic rod is freely suspended in a uniform magnetic field, it aligns itself in a direction perpendicular to the field.

</td>
<td>When a paramagnetic rod is freely suspended in a uniform magnetic field, it aligns itself in a direction parallel to the field.

</td>
<td>When a paramagnetic rod is freely suspended in a uniform magnetic field, it aligns itself in a direction parallel to the field very quickly.

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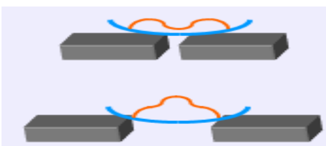
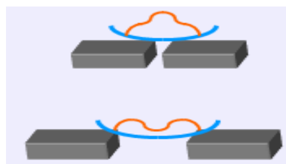
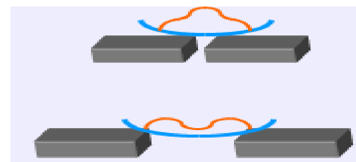
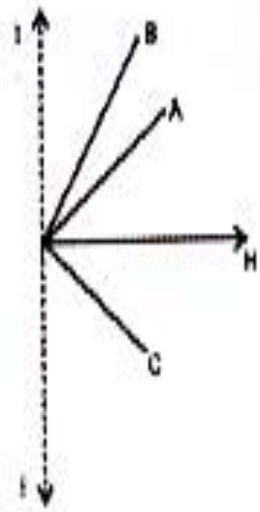
</table>

5. If diamagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects away from the centre when the magnetic poles are closer and collects at the centre when the magnetic poles are farther. 	If paramagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects at the centre when the magnetic poles are closer and collects away from the centre when the magnetic poles are farther. 	If ferromagnetic liquid taken in a watch glass is placed in uniform magnetic field, it collects at the centre when the magnetic poles are closer and collects away from the centre when the magnetic poles are farther. 
6. Induced Dipole Moment (M) is a small – ve value.	Induced Dipole Moment (M) is a small + ve value.	Induced Dipole Moment (M) is a large + ve value.
7. Intensity of Magnetisation (I) has a small – ve value.	Intensity of Magnetisation (I) has a small + ve value.	Intensity of Magnetisation (I) has a large + ve value.
8. Intensity of Magnetisation (I) has a small – ve value.	Intensity of Magnetisation (I) has a small + ve value.	Intensity of Magnetisation (I) has a large + ve value.
9. Magnetic permeability μ is always less than unity.	Magnetic permeability μ is more than unity.	Magnetic permeability μ is large i.e. much more than unity.
10. Magnetic susceptibility c_m has a small – ve value.	Magnetic susceptibility c_m has a small + ve value.	Magnetic susceptibility c_m has a large + ve value.
11. They do not obey Curie's Law. i.e. their properties do not change with temperature.	They obey Curie's Law. They lose their magnetic properties with rise in temperature.	They obey Curie's Law. At a certain temperature called Curie Point, they lose ferromagnetic properties and behave like paramagnetic substances.

Graph between H and I

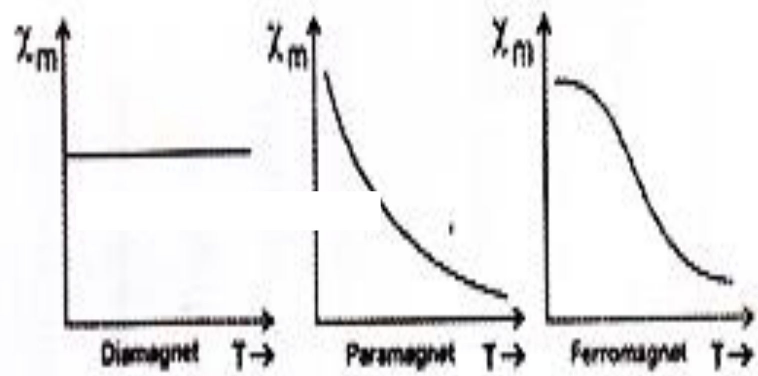


A = Paramagnet

= Ferro magnet

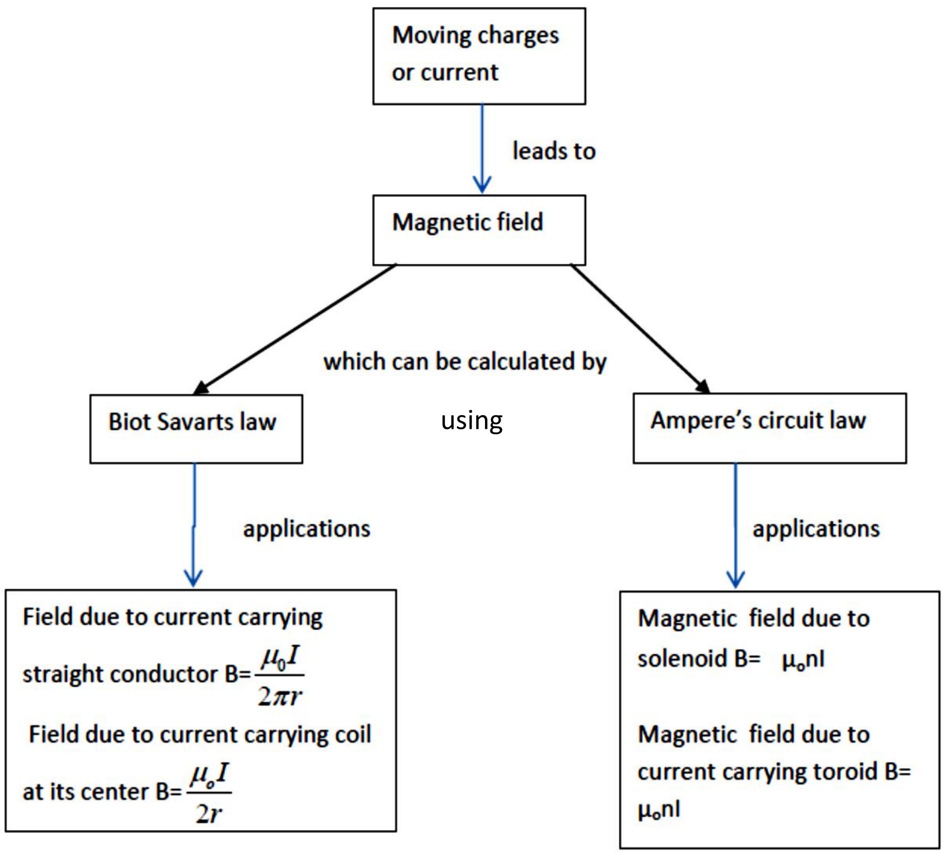
= Diamagnet

. Graph between χm and Temperature



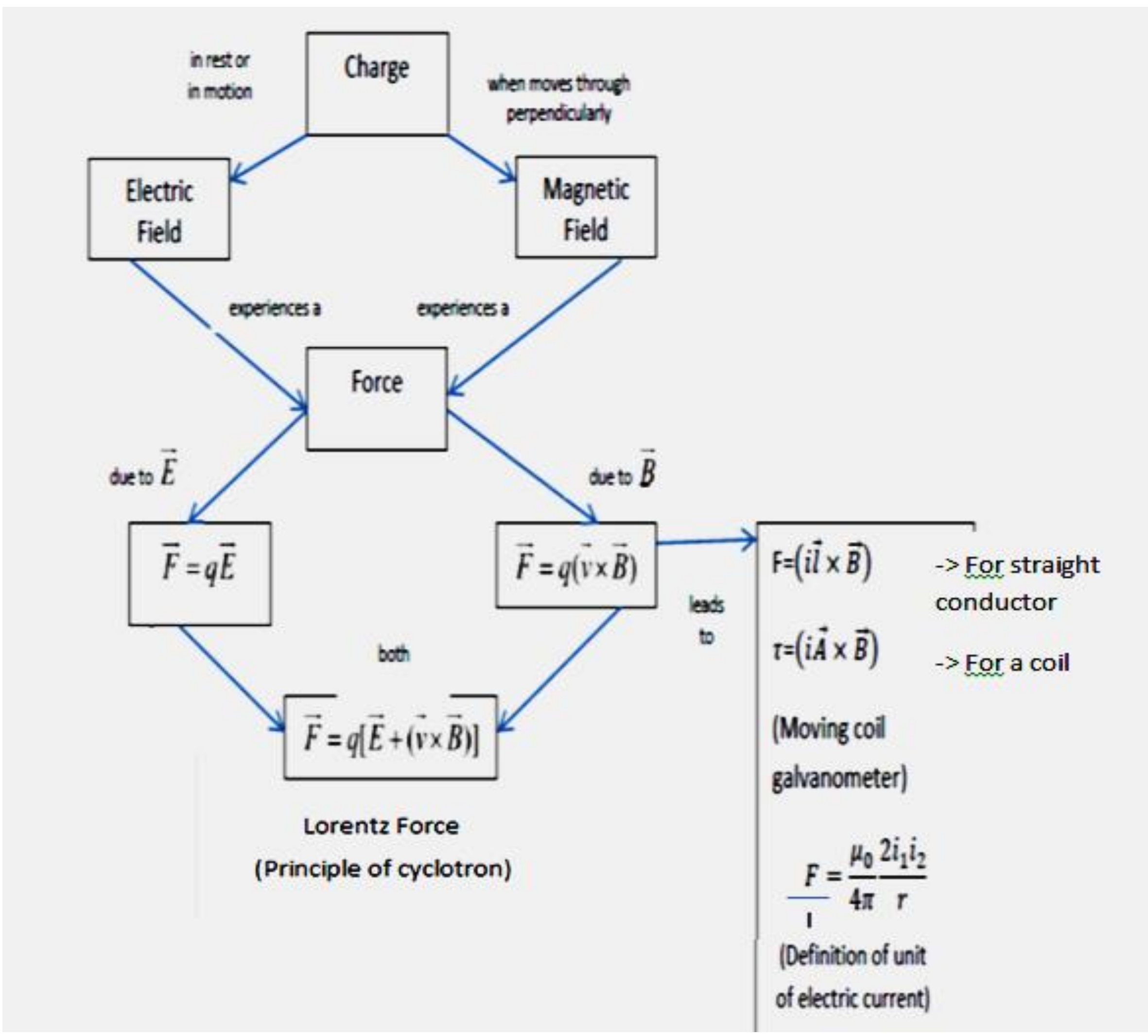
CONCEPT_MAP

Moving Charges



CONCEPT MAP

Moving Charge and Force



QUESTIONS

MAGNETIC FORCE

1* In a certain arrangement, a proton does not get deflected while passing through a magnetic field region. State the condition under which it is possible. 1

Ans: **v** is parallel or antiparallel to **B**

2 An electron beam is moving vertically upwards. If it passes through a magnetic field directed from South to North in a horizontal plane, in what direction will the beam be deflected? 1

Ans:-Towards geographical East in the horizontal plane

3 What is the work done by the magnetic force on a charged particle moving perpendicular to the magnetic field? 1

Ans: Zero

4 A wire of length 0.04m carrying a current of 12 A is placed inside a solenoid, making an angle of 30^0 with its axis. The field due to the solenoid is 0.25 T. Find the force on the wire. Ans; 0.06N 2

5 A circular loop of radius 0.1 m carries a current of 1A and is placed in a uniform magnetic field of 0.5T. The magnetic field is perpendicular to the plane of the loop. What is the force experienced by the loop? 2

Ans: The magnetic dipole does not experience any force in a uniform magnetic field.Hence, the current carrying loop (dipole) does not experience any net force.

6* A proton, alpha particle and deuteron are moving in circular paths with same kinetic energies in the same magnetic fields. Find the ratio of their radii and time periods.

Ans: $R_p : R_\alpha : R_d = 1:1:\sqrt{2}$ 2

$T_p : T_\alpha : T_d = 1:2:2$

7 An electron moving with Kinetic Energy 25 keV moves perpendicular to a uniform magnetic field of 0.2 mT. Calculate the time period of rotation of electron in the magnetic field. 2

Ans: $T = 1.79 \times 10^{-7}$ S

8 A charged particle of mass 'm' charge 'q' moving at a uniform velocity 'v' enters a uniform magnetic field 'B' normal to the field direction. Deduce an expression for Kinetic Energy of the particle. Why does the Kinetic Energy of the charged particle not change when moving through the magnetic field? 3

9 An electron is revolving around the nucleus of an atom in an orbit of radius 0.53 Å. Calculate the equivalent magnetic moment, if the frequency of revolution of the electron is 6.8×10^{9} MHz.

Ans: $p_m = 9.6 \times 10^{-24}$ A m^2 3

BIOT-SAVART LAW AND ITS APPLICATIONS

1 A current is set up in a long copper pipe. What is the magnetic field inside the pipe?

Ans: Zero1

2 A wire placed along north south direction carries a current of 5 A from South to North. Find the magnetic field due to a 1 cm piece of wire at a point 200 cm North East from the piece. 2

Ans: 8.8×10^{-10} T, acting vertically downwards.

3 How will the magnetic filed intensity at the centre of a circular coil carrying current change if the current through the coil is doubled and the radius of the coil is halved. 2

Ans: $B = \mu_0 n \times 2I / 2 \times (R/2) = 4B$

4 A circular coil of 500 turns has a radius of 2 m, and carries a current of 2 A. What is the magnetic field at a point on the axis of the coil at a distance equal to radius of the coil from the center? 2

Ans: $B = 1.11 \times 10^{-4}$ T

5* The strength of magnetic induction at the center of a current carrying circular coil is B_1 and at a point on its axis at a distance equal to its radius from the center is B_2. Find B_1/B_2. 2

Ans: $2\sqrt{2}$

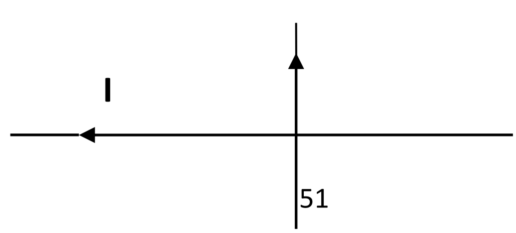
6* A current is flowing in a circular coil of radius 'r' and magnetic field at its center is B_0. At what distance from the center on the axis of the coil, the magnetic field will be $B_0/8$? 2

Ans: $x = \sqrt{3}r$

7* A straight wire of length$'\frac{\pi}{2}'m$, is bent into a circular shape. if the wire were to carry a current of 5 A, calculate the magnetic field due to it, before bending, at a point 0.01 times the radius of the circle formed from it. Also calculate the magnetic field at the center of the circular loop formed, for the same value of current. 3

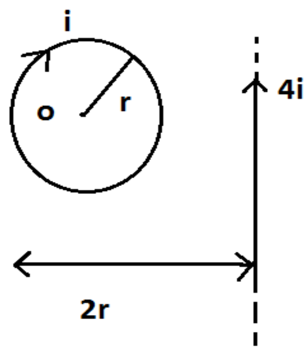
Ans: $B_1 = 4 \times 10^{-4}$ T, $B_2 = 1.256 \times 10^{-5}$ T

8 Two insulated wires perpendicular to each other in the same plane carry equal currents as shown in figure. Is there a region where the magnetic field is zero? If so, where is the region? If not, explain why the field is not zero? 3



I

9 What is the net magnetic field at point 0 for the current distribution shown here?



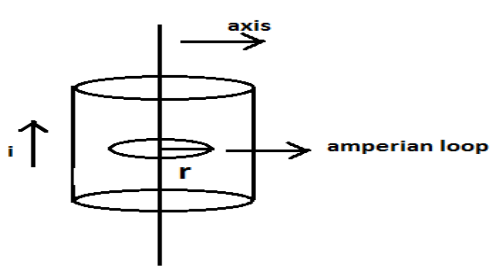
ans $(\mu_0 I / 2r) = (\mu_o i/\pi r)$ 3

AMPERE'S CIRCUITAL LAW AND APPLICATIONS

1 A long straight solid metal wire of radius 'R' carries a current 'I', uniformly distributed over its circular cross section. Find the magnetic field at a distance 'r' from the axis of the wire (a) inside and (b) outside the wire
Ans; (a) $\mu_0\mu_r Ir/2\pi R^2$ (b) $\mu_0 2I/4\pi r$ 2

2 A solenoid is 1m long and 3 cm in mean diameter. It has 5 layers of windings of 800 turns each and carries a current of 5 A. Find Magnetic Field Induction at the center of the solenoid. 2
Ans: 2.5×10^{-2} T, parallel to the axis of the solenoid.

3 Find the value of magnetic field inside a hollow straight current carrying conductor at a distance r from axis of the loop. 2

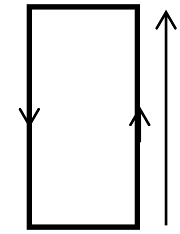


Ans B=0

FORCE BETWEEN TWO PARALLEL CURRENTS, TORQUE ON A CURRENT LOOP, MOVING COIL GALVANOMETER

1* A rectangular loop of size 25 cm x 10 cm carrying a current of 15A is placed

2 cm away from a long, straight conductor carrying a current of 25 A. What is the direction and magnitude of the net Force acting on the loop?



Ans: F =7.8175 x 10^{-4} N

2* A long straight conductor PQ , carrying a current of 60 A, is fixed horizontally. Another long conductor XY is kept parallel to PQ at a distance of 4 mm, in air. Conductor XY is free to move and carries a current 'I' . Calculate the magnitude and direction of current 'I' for which the magnetic repulsion just balances the weight of the conductor XY.
2

Ans: I = 32. 67 A, The current in XY must flow opposite to that in PQ, because only then the force will be repulsive.

3 A circular coil of 200 turns, radius 5 cm carries a current of 2.5 A. It is suspended vertically in a uniform horizontal magnetic field of 0.25 T, with the plane of the coil making an angle of 60^0 with the field lines. Calculate the magnitude of the torque that must be applied on it to prevent it from turning.
2

Ans: 0.49Nm

4* A Galvanometer of resistance 3663 ohm gives full scale deflection for a certain current I_g.Calculate the value of the resistance of the shunt which when joined to the galvanometer coil will result in 1/34 of the total current passing through the galvanometer. Also find the total resistance of the Galvanometer and shunt.

Ans: 111 ohm, 107.7 A.

MAGNETISM AND MATTER

BAR MAGNET

1 A short bar magnet has magnetic moment of 50 A m^2. Calculate the magnetic field intensity at a distance of 0.2 m from its centre on (1) its axial line (2) its equitorial line.

Ans: $B_1 = 1.25 \times 10^{-3}$ T , $B_2 = 0.625 \times 10^{-3}$ T.

2 Calculate the torque acting on a magnet of length 20 cm and pole strength 2×10^{-5} Am, placed in the earth's magnetic field of flux density 2×10^{-5} T, when (a) magnet is parallel to the field (b) magnet is perpendicular to the field.

Ans: (a) Zero (b) 0.8×10^{-10} Nm

MAGNETISM AND GAUSS LAW

1 What is the significance of Gauss's law in magnetism?

Ans: Magnetic monopoles do not exist.

THE EARTH'S MAGNETISM

1 How the value of angle of dip varies on moving from equator to Poles?

2 A compass needle in a horizontal plane is taken to geographic north / south poles. In what direction does the needle align?

3 The horizontal component of earth's magnetic field is 0.2 G and total magnetic field is 0.4 G. Find the angle of Dip.

Ans: 60.25^0

4* A long straight horizontal table carries a current of 2.5 A in the direction 10^0 south of west to 10^0 north of east. The ,magnetic meridian of the place happens to be 10^0 west of the geographic meridian. The earth's magnetic field at the locations 0.33G and the angle of dip is zero. Ignoring the thickness of the cable, locate the line of neutral points.

Ans: r = 1.5 cm ($B_H = B \cos \delta$, $B_H = \mu_0 I / 2\pi r$)

5 The vertical component of earth's magnetic field at a place is √3 times the horizontal component. What is the value of angle of dip at this place?

Ans: 60^0

6* A ship is sailing due west according to mariner's compass. If the declination of the place is 15^0east, what is the true direction of the ship?

Ans: 75^0 west of north.

IMPORTANT TERMS IN MAGNETISM

1 A magnetising field of 1600 A/m produces a magnetic flux of 2.4×10^{-5} Wb in a bar of iron of cross section 0.2 cm^2. Calculate permeability and susceptibility of the bar.

Ans: Permeability = 7.5×10^{-4} T A^{-1} m, Susceptibility =596.1

2 The maximum value of permeability of μ-metal is 0.126 Tm/A. Find the maximum relative permeability and susceptibility.

Ans: 10^5 each.

MAGNETIC PROPERTIES OF MATERIALS

1 The susceptibility of magnesium at 300K is 1.2×10^5. At what temperature will the susceptibility be equal to 1.44×10^{-5} .

Ans: 250 K

2 An iron bar magnet is heated to 1000^0C and then cooled in a magnetic field free space. Will it retain its magnetism?

3 What is the net magnetic moment of an atom of a diamagnetic material?

Ans : Zero

4 Which materials have negative value of magnetic susceptibility?

Ans : Diamagnetic materials.

5 Why permanent magnets are made of steel while the core of the transformer is made of soft iron?

6* An iron rod of volume 10^{-4} m^3 and relative permeability 1000 is placed inside a long solenoid wound with 5 turns/cm. If a current of 0.5A is passed through the solenoid , find the magnetic moment of the rod.

7* The susceptibility of a magntic mateial is 0.9853. Identify the type of the magnetic material.Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field.

Ans : paramagnetic

8 Two similar bars, made from two different materials P and Q are placed one by one in a non uniform magnetic field. It is observed that (a) the bar P tends to move from the weak to the strong field region. (b) the bar Q tends to move from the strong to the weak field region. What is the nature of the magnetic materials used for making these two bars?

VALUE BASED QUESTIONS:

1. Sandeep's mother had put lot of clothes for washing in the washing machine, but the machine did not start and an indicator was showing that the lid did not close. Sandeep seeing his mother disturbed thought that he would close the lid by force but realized that the mechanism was different. It was a magnetic system. He went to the shop and got a small magnetic door closer and put it on the lid. The machine started working. His mother was happy that Sandeep helped her to save Rs.500/- also.
   - What was the value developed by Sandeep?
   - What values did his mother impart to Sandeep?

2. Tushar was using a galvanometer in the practical class. Unfortunately it fell from his hand and broke. He was upset, some of his friends advised him not to tell the teacher but Tushar decided to tell his teacher. Teacher listened to him patiently and on knowing that the act was not intentional, but just an accident, did not scold him and used the opportunity to show the internal structure of galvanometer to the whole class.
   (i) What are the values displayed by Tushar.
   (ii) Explain the principle, Construction and working of moving coil galvanometer.

3. Two girls Pooja and Ritu were very good observers and performed in the school function using their cassette player. One day when they were performing, tape got stuck up and the music stopped. But Pooja was determined not to let down the performance so she sang the song instead of dancing and Ritu completed the dance.
   - What were the values displayed by Pooja and Ritu?
   - What kind of Ferro magnetic material is using for coating magnetic tapes used in cassette players or building memories stories in modern computers?

4. ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENTS

GIST

1 The phenomenon in which electric current is generated by varying magnetic fields is called electromagnetic induction

2 Magnetic flux through a surface of area A placed in a uniform magnetic field B is defined as

Φ_B = B.A = BACosθ where θ is the angle between B and A.

3 Magnetic flux is a scalar quantity and its SI unit is weber (Wb). Its dimensional formula is $[\Phi] = ML^2T^{-2}A^{-1}$.

4 Faraday's laws of induction states that the magnitude of the induced e.m.f in a circuit is equal to the time rate of change of magnitude flux through the circuit.

$$\varepsilon = -\frac{d\phi_B}{dt}$$

5 According to Lenz law, the direction of induced current or the polarity of the induced e.m.f is such that it tends to oppose the change in magnetic flux that produces it. (The negative sign in Faraday's law indicates this fact.)

6 Lenz law obeys the principle of energy conservation.

7 The induced e.m.f can be produced by changing the (i) magnitude of B (ii) area A (iii) angle θ between the direction of B and normal to the surface area A.

8 When a metal rod of length l is placed normal to a uniform magnetic field B and moved with a velocity v perpendicular to the field, the induced e.m.f is called motional e.m.f produced across the ends of the rod which is given by ε = Blv.

9 Changing magnetic fields can setup current loops in nearby metal bodies (any conductor). Such currents are called eddy currents. They dissipate energy as heat which can be minimized by laminating the conductor.

10 Inductance is the ratio of the flux linkage to current.

11 When a current in a coil changes it induces a back e.m.f in the same coil. The self induced e.m.f is given by $\varepsilon = -L\frac{dI}{dt}$ where L is the self-inductance of the coil. It is a measure of inertia of the coil against the change of current through it. Its S.I unit is henry (H).

12 A changing current in a coil can induce an e.m.f in a nearby coil. This relation,

$\varepsilon = -M_{12}\frac{di_2}{dt}$, shows that Mutual inductance of coil 1 with respect to coil 2 (M_{12}) is due to change of current in coil 2. ($M_{12} = M_{21}$).

13 The self-inductance of a long solenoid is given by $L = \mu_0 n^2 A l$ where A is

the area of cross-section of the solenoid, l is its length and n is the number of turns per unit length.

14 The mutual inductance of two co-axial coils is given by $M_{12} = M_{21} = \mu_0 n_1 n_2 Al$ where n_1& n_2 are the number of turns per unit length of coils 1 & 2. A is the area of cross-section and l is the length of the solenoids.

15 Energy stored in an inductor in the form of magnetic field is $U_B = \frac{1}{2} L i_{max}^2$ and

Magnetic energy density $U_B = \frac{B^2}{2\mu_0}$

16 In an A.C. generator, mechanical energy is converted to electrical energy by virtue of electromagnetic induction.

* Rotation of rectangular coil in a magnetic field causes change in flux (Φ = NBACosωt).
* Change in flux induces e.m.f in the coil which is given by

ε= -dΦ/dt = NBAωSinωt ε $\varepsilon = \varepsilon_0$Sinωt

* Current induced in the coil *$I = \varepsilon/R = \varepsilon_0 Sin\omega t/R = I_0 Sin\omega t$*

17 An alternating voltage $\varepsilon=\varepsilon_0$Sinωt, applied to a resistor R drives a current *$I = I_0 Sin\omega t$ in* the resistor, *$I_0 = \varepsilon_0 /R$* where *ε_0& I_0* are the peak values of voltage and current. (also represented by *V_m & I_m)*

18 The root mean square value of a.c. may be defined as that value of steady current which would generate the same amount of heat in a given resistance in a given time as is done by the a.c. when passed through the same resistance during the same time.

$I_{rms} = I_0/\surd 2 = 0.707 i_0$

Similarly, $v_{rms} = v_0/\surd 2 = 0.707 v_0$.

For an a.c. $\varepsilon = \varepsilon_m$ Sin ωt applied to a resistor, current and voltage are in phase.

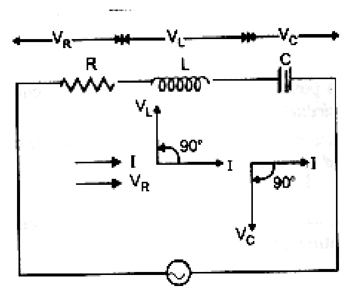
19 In case of an a.c. circuit having pure inductance current lags behind e.m.f by a phase angle 90°. $\varepsilon = \varepsilon_m$ Sin ωt and i = i_m Sin (ωt-Π/2)

$I_m = \varepsilon_m/X_L$; X_L = ωL is called inductive reactance.

20 In case of an a.c. circuit having pure capacitance, current leads e.m.f by a phase angle of 90°.

$\varepsilon = \varepsilon_m$Sinωt and I= I_mSin(ωt+π/2) where

$I_m = \varepsilon_m/X_C$ and X_C = 1/ωC is called capacitive reactance.



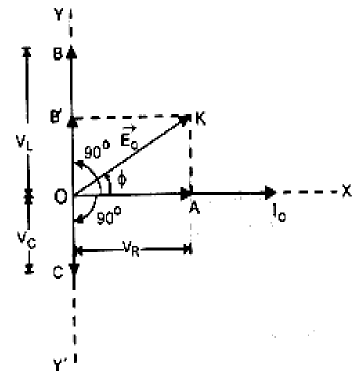
21 In case of an a.c. circuit having R, L and C, the total or effective

resistance of the circuit is called impedance (Z).

$Z = \varepsilon_m / I_m = \sqrt{R^2 + (X_C - X_L)^2}$

$\tan\Phi = \frac{X_C - X_L}{R}$ where ϕ is the phase difference between current and voltage.

$\varepsilon = \varepsilon_m \sin\omega t$, $I = I_m \sin(\omega t + \Phi)$



23 Average power loss over a complete cycle in an LCR circuit is

$P = \varepsilon_{rms} I_{rms} \cos\Phi$

* In a purely resistive circuit $\Phi = 0$; $P = V_{RMS} I_{RMS}$.

* In a purely inductive circuit $\Phi = \Pi/2$; $P = 0$.

* In a purely capacitive circuit $\Phi = \Pi/2$; $P = 0$.

24 In an LCR circuit, the circuit admits maximum current if $X_C = X_L$, so that Z = R and resonant frequency $\omega_r = \frac{1}{\sqrt{LC}} and \vartheta_R = \frac{1}{2\pi\sqrt{LC}}$

25 Q factor of series resonant circuit is defined as the ratio of voltage developed across the inductance or capacitance at resonance to the applied voltage across 'R',

$Q = \frac{\omega_r L}{R} or \frac{1}{\omega_r CR}$ also $Q = \frac{\omega_r}{2\Delta\omega}$ where $2\Delta\omega$ is bandwidth.

26 for a transformer, $\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} = K$

In an ideal transformer, $\varepsilon_P I_P = \varepsilon_S I_S$. i.e

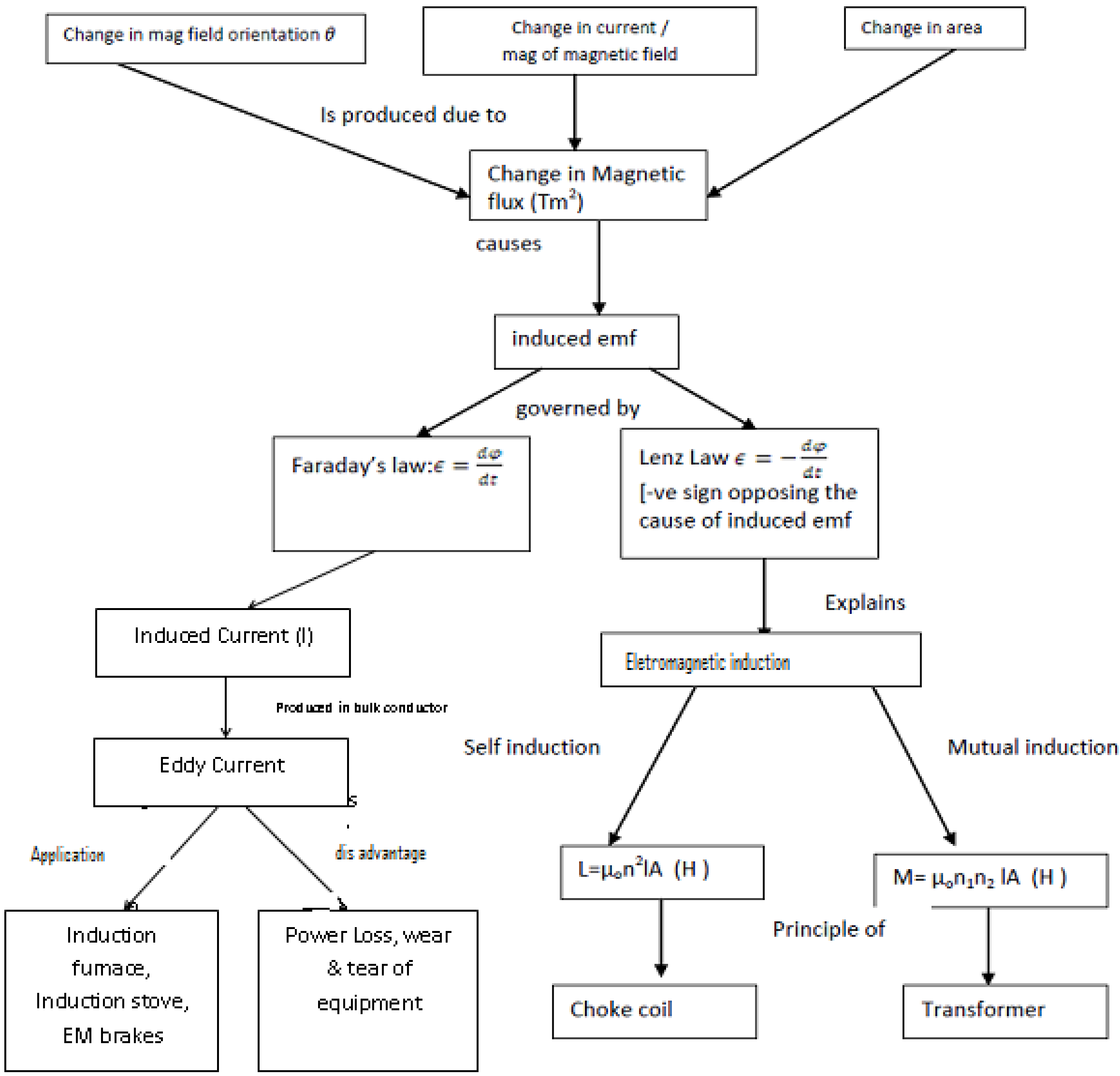
If $N_S > N_P$; $\varepsilon_S > \varepsilon_P$ & $I_S < I_P$ – step up. If $N_P > N_S$; $\varepsilon_P > \varepsilon_S$ & $I_P < I_S$ – step down.

27 A circuit containing an inductor L and a capacitor C (initially charged) with no a.c. source and no resistors exhibits free oscillations of energy between the capacitor and inductor. The charge q satisfies the equation

$$\frac{d^2q}{dt^2} + \frac{1}{LC} q = 0$$

CONCEPT MAP

EMI and application


Change in mag field orientation θ
Change in current / mag of magnetic field
Change in area
Is produced due to
Change in Magnetic flux (Tm²)
causes
induced emf
governed by
Faraday's law: $\epsilon = \frac{d\varphi}{dt}$
Lenz Law $\epsilon = -\frac{d\varphi}{dt}$ [-ve sign opposing the cause of induced emf
Induced Current (I)
Explains
Eletromagnetic induction
Produced in bulk conductor
Eddy Current
Self induction
Mutual induction
Application
dis advantage
$L=\mu_o n^2 lA$ (H)
$M=\mu_o n_1 n_2 lA$ (H)
Principle of
Induction furnace, Induction stove, EM brakes
Power Loss, wear & tear of equipment
Choke coil
Transformer

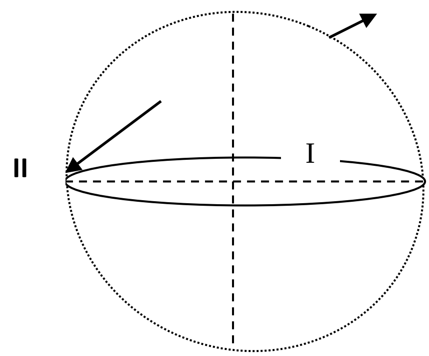
(I) Parameters of various combinations of components in ac circuits

S. No.	Circuit containing	Alt. e.m.f fed	Alt. current developed	Impedance Z	Phase relation between E and I	Average Power	Power factor
1.	Resistance only	$E=E_0 \sin \omega t$	$I = I_0 \sin \omega t$	$Z = R$	In phase	$I_v^2 R$	$\cos \phi = 1$
2.	Pure inductor	$E=E_0 \sin \omega t$	$I = I_0 \sin (\omega t - 90^\circ)$	$Z = X_L = \omega L$	I lags behind E by 90°	Zero	$\cos \phi = 0$
3.	Pure capacitor	$E=E_0 \sin \omega t$	$I = I_0 \sin (\omega t + 90^\circ)$	$Z = X_C = \frac{1}{\omega C}$	I leads E by 90°	Zero	$\cos \phi = 0$
4.	RL circuit	$E=E_0 \sin \omega t$	$I = I_0 \sin (\omega t - \theta)$	$Z = \sqrt{R^2 + X_L^2}$	$\tan \phi = \frac{X_L}{R}$ (current lags)	$E_v I_v \cos \phi$	$\cos \phi = \frac{R}{\sqrt{R^2 + X_L^2}}$
5.	RC circuit	$E=E_0 \sin \omega t$	$I = I_0 \sin (\omega t + \theta)$	$Z = \sqrt{R^2 + X_C^2}$	$\tan \phi = \frac{X_C}{R}$ (current leads)	$E_v I_v \cos \phi$	$\cos \phi = \frac{R}{\sqrt{R^2 + X_C^2}}$
6.	RLC circuit	$E=E_0 \sin \omega t$	$I = I_0 \sin (\omega t \pm \theta)$	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	$\tan \phi = \frac{X_C - X_L}{R}$	$E_v I_v \cos \phi$	$\cos \phi = \frac{R}{\sqrt{R^2+(X_L-X_C)^2}}$

QUESTIONS

MAGNETIC FLUX, INDUCED E.M.F,

1 Two concentric circular coils are perpendicular to each other. Coil I carries a current i. If this current is changed, will this induce a current in the coil II? 1

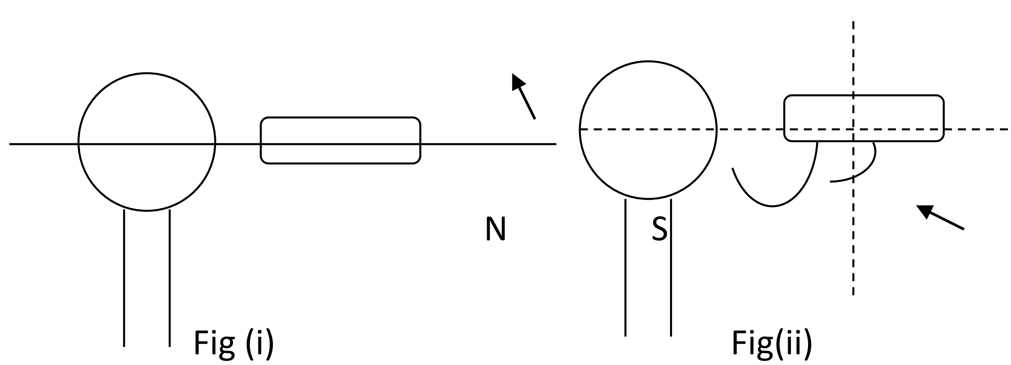


[No- Field due to one coil is parallel to the plane of the second coil. So flux does not change.]

2 A closed loop of wire is being moved with constant velocity without changing its orientation inside a uniform magnetic field. Will this induce a current in the loop? 1

[Ans: No there is no change in Φ_B]

3 A cylindrical bar magnet is kept along the axis of a circular coil and near it as shown in the fig. Will there be any induced current at the terminals of the coil when the magnet is rotated a) about its own axis b) about an axis perpendicular to the length of the magnet? 1



Ans Fig. (i) No e.m.f will be induced, as these is no change in flux.

Fig (ii) Yes, Φ changes continuously. So e.m.f is induced in the coil.

4 A conducting wire is kept along the N→S direction and is allowed to fall freely. Will an e.m.f be induced in the wire? 1
(Yes)

5 A conducting wire is kept along the E→W direction and is allowed to fall freely. Will an e.m.f be induced in the wire? 1
(Yes)

6 A vertical magnetic pole falls down through the plane of magnetic meridian. Will any e.m.f be induced between its ends? 1
Ans: No, because the pole intercepts neither B_V or B_H

7 A wheel with a certain number of spokes is rotated in a plane normal to earth's magnetic field so that an emf is induced between the axle and rim of the wheel, keeping all other things same, number of spokes is changed. How is the e.m.f affected? 1
(Hint: Number of spokes does not affect the net emf)

8 What are eddy currents? 1

9 Explain any two applications of eddy current. 2

10 The magnetic flux linked with a coil passing perpendicular to the plane of the coil changes with time $\Phi = 4t^2 + 2t + 3$, where "t" is the time in seconds. What is magnitude of e.m.f induced at t = 1 second? 3
Ans: ($e = d\Phi/dt = \frac{d}{dt}\left(4t^2 + 2t + 3\right)$, $e = 8t + 2$ If t = 1s e= 10V)

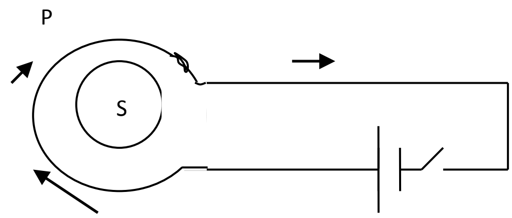
11 A wheel fitted with spokes of radius 'r' is rotating at a frequency of n revolutions per second in a plane perpendicular to magnetic field B Tesla. What is the e.m.f induced between the axle and rim of the wheel [2] 3

$\Phi = BA$

$e = d(BA)/dt = B\, dA/dt$, $dA/dt = \Pi r^2 x\, n$

$e = B. \Pi r^2 n$

12 Two coils P and S are arranged as shown in the figure. 2
(i) What will be the direction of induced current in S when the switch is closed?
(ii) What will be the direction of induced current in S when the switch is opened?



Ans: (i) anticlockwise (ii) clockwise

13 A conducting circular loop is placed in a uniform magnetic field B = 0.020T with its plane perpendicular to the field. Somehow, the radius of the loop starts shrinking at a constant rate of 1mm/s. Find the induced current in the loop at an instant when the radius is 2cm. 2
Ans. ($\Phi = \Pi r^2 B$ $d\Phi/dt = 2\Pi r B\, dr/dt$ $e = 25\mu V$

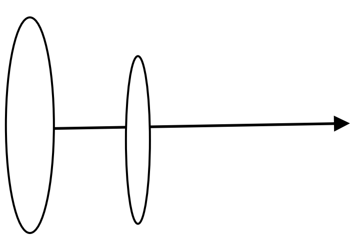
14 A 12V battery is connected to a 6Ω; 10 H coil through a switch drives a constant current in the circuit. The switch is suddenly opened. Assuming that it took 1ms to open the switch calculate the average e.m.f induced across the coil. 2
Ans. (I initial=2A I final= 0 ε=-Ldi/dt = 20000V)

15 A coil of mean area 500 cm^2 having 1000 turns is held perpendicular to a uniform magnetic field of 0.4 G. The coil is turned through 180 ^{o} in 1/10 seconds. Calculate the average induced e.m.f. 2
Ans. (0.04 V)

16 A conducting rod of length l with one end pivoted is rotated with a uniform angular speed ω in a Vertical plane normal to uniform magnetic field B. Deduce an expression for e.m.f induced in this rod. 2

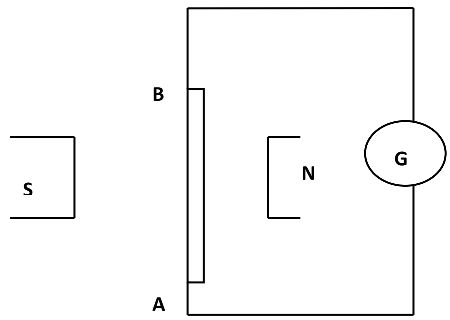
17 Two identical co-axial coils carry equal currents. What will happen to the current in each loop if the loops approach each other? 2

(2)



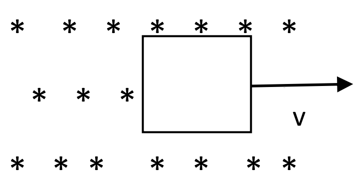
Ans. (Acc to Lenz's law current in each coil will decrease)

18 Obtain the direction of induced current and e.m.f when the conductor AB is moved at right angles to a stationary magnetic field (i) in the upward direction (ii) in the downward direction. (i) B to A (ii) A to B) 2



19 A fan blade of length 0.5 m rotates perpendicular to a magnetic field of 5×10^{-5} T. If the e.m.f induced between the centre and the end of the blade is 10^{-2} V .Find the rate of rotation. 3
Ans. ($e=B\, dA/dt$; $dt= 1/n$; $n=254.7$ rev/s)

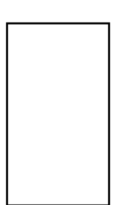
20 The figure shows a square loop having 100 turns an area of 2.5×10^{-3} m^2 and a resistance of 100Ω . The magnetic field has a magnitude of B= 0.4 T. Find the work done in pulling the loop out of the field slowly and uniformly in 1 second. 3



Also draw graph showing the variation of power delivered when the loop is moved from P to Q to R. (1×10^{-6}J)

21 Two coils have a mutual inductance of 0.005H. The current changes in the first coil according to the equation $I= I_0 \sin \omega t$ where I_0 =10A and $\omega=100\Pi$ rad/s. Calculate the maximum value of e.m.f in the second coil. (5π volts) 3

22 A long rectangular conducting loop of width L mass m and resistance R is placed partly above and partly below the dotted line with the lower edge parallel to it. With what velocity it should continue to fall without any acceleration? 3



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($mg = B^2l^2v/r$; $v=mgr/ B^2l^2$)

INDUCTANCE

1 Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. Find the mutual inductance between them assuming $R_2 << R_1$. 2

($M=\mu_0 \pi R_2^2 /2R_1$)

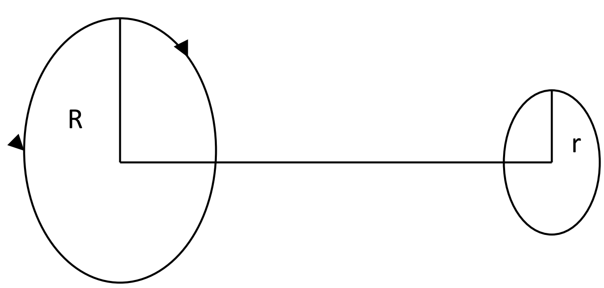
2 Prove that the total inductance of two coils connected in parallel is 2

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2}$$

3 Two circular loops are placed with their centres at fixed distance apart. How would you orient the loops to have (i) maximum (ii) minimum Mutual inductance? 2

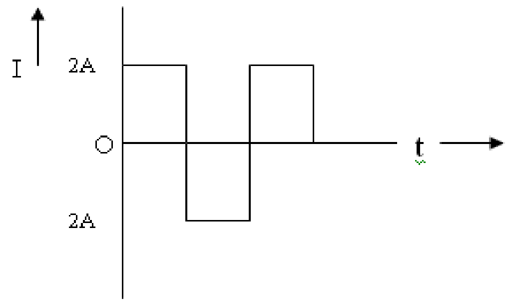
4 A coil of wire of certain radius has 600 turns and inductance of 108mH. What will be the inductance of another similar coil with 500 turns? (75mH) 2

5 Obtain the mutual inductance of a pair of coaxial circular coils kept separated by a distance as shown in fig:- 2



ALTERNATING CURRENT - RMS CURRENT AND VOLTAGE

1 Find the RMS value of A.C shown in the figure. 1



Ans:- √2A

2 The instantaneous value of e.m.f is given by ε= 300sin 314t. What is the rms value of emf ? 1

Ans:- ε_0=300 units ε_{rms}=212.1 units

3 Why a 220 V AC is considered to be more dangerous than 220 V DC? 1

Ans: peak value of AC is more than rms value which is equal to 311V.

4 An AC current flows through a circuit consisting of differerent elements connected in series. 1

(i) Is the applied instantaneous voltages equal to the algebraic sum of instantaneous voltages across the series elements of the circuit?
(ii) Is it true for rms voltages?
Ans: (i) yes (ii) no

5 A capacitor blocks DC. Why? 1
Ans: $X_C=1/(2\pi fC)$, for D.C f=0, therefore $X_c=\infty$

6 What is the phase relationship between e.m.f across L and C in a series LCR circuit connected to an A.C source? 1
Ans:-The phase difference between V_L and $V_C=180^0$

7 Two alternating currents are given by $I_1=I_0\text{Sin}\omega t$ and $I_2= I_0\text{Sin}(\omega t+\pi/3)$. Will the rms value of I_1 & I_2 be equal or different? 1

Ans: The rms value will be equal.

8 An alternating current is given by $i=i_1\text{Cos}\omega t+i_2\text{Sin}\ \omega t$. Find the rms current in the circuit. (2) 2

Ans: $\sqrt{\frac{(i_1^2+i_1^2)}{2}}$

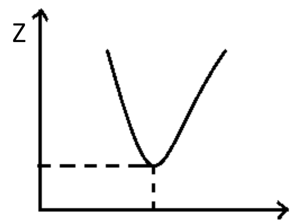
9 An alternating current having a peak value of 14A is used to heat a metal wire. What is the value of steady current which can produce the same heating effect as produced by AC? Why? Ans: i_{rms}=10A 2

10 If a constant current of 2.8A exists in a resistor, what is the rms value of current? Why? (2) 2

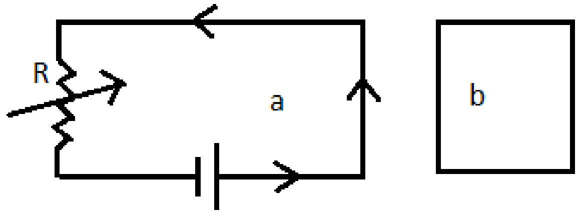
Ans: 2.8A

11 Sketch a graph showing the variation of impedance of LCR circuit with the frequency of applied voltage. 1

(1)



12 If resistance R in circuit 'a' be decreased, wnat will be the direction of induced current in the circuit 'b'. 2



AC CIRCUITS

1 What is meant by wattless current? 1

2 Define: Q factor in LCR series circuit 1

3 Why is choke coil preferred over resistor to reduce a.c? 1

4 How do R, X_L and X_C get affected when the frequency of applied AC is doubled? 3

Ans: a) R remains unaffected

b) X_L=2πfL, so doubled

c) X_C=1/2πfC, so halved

5 For circuits for transporting electric power, a low power factor implies 2

large power loss in transmission line. Why? (2)

Ans: $i_{rms} = \frac{P}{V_{rms} Cos\phi}$

6 In an AC circuit there is no power consumption in an ideal inductor. Why? 2

Ans: P= $V_{rms} I_{rms}$ Cos π/2 =0

7 An LCR series circuit is connected to an AC source. Which of its components dissipates power? 2

L or C or R? Justify your answer.

Ans: Resistance, Power in L and C = 0

8 An electric lamp connected in series with a capacitor and an AC source is glowing with certain brightness. How does the brightness of the lamp change on reducing the capacitance? 2

Ans: Brightness decreases. (As C decreases, X_C increases. Hence Z increases and I decreases.)

9 The power factor of an AC circuit is lagging by a factor 0.5. What does it mean? (2) 2

Ans: CosΦ=0.5, ie, Φ =60^0. This implies that the current lags behind applied voltage by a phase angle of 60^0

10 The peak value of an AC is 5A and its frequency is 60Hz. Find its rms value. How long will the current take to reach the peak value starting from zero? 2

Ans: I_{rms}= 3.5A . Time period T=(1/60)s . The current takes one fourth of the time period to reach the peak value starting from zero. t =T/4 =(1/240)s.

11 The voltage and current in a series AC circuit are given by V= V_0 Cosωt & I= I_0 Sinωt. What is the power dissipated in the circuit? 2

Ans:- I=I_0Sinωt & V=V_0Sin(ωt+π/2), since V leads current by a phase angle π/2, it is an inductive circuit . So, P=0

12 When an AC source is connected to a capacitor with a dielectric slab between its plates, will the rms current increase or decrease or remain constant? 2

Ans: The capacitance increases, decreasing the reactance X_c . Therefore the rms current increases.

13 Can peak voltage across an inductor be greater than the peak voltage supplied to an LCR? 2

Ans: Yes, at the time of break of a circuit, a large back e.m.f is set up across the circuit.

14 Write any two differences between impedance and reactance. 2

15 A 100 Ω resister is connected to 220V, 50 cycles per seconds. What is (i) peak potential difference (ii) average potential difference and (iii) rms current? 2

Ans. ε_o=311.08V, ε_m =197.9V, I_v= 2.2 A

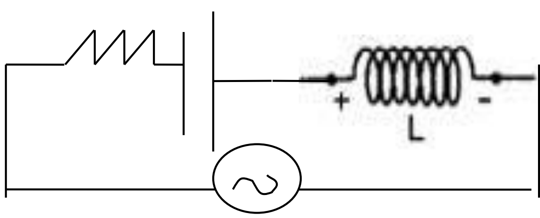
16 Define and derive the root mean square value of a.c voltage 3

RESONANCE in LCR Circuits

1 An inductor of inductance 100mH is connected in series with a resistance, a variable capacitance and an AC source of frequency 2 kHz. What should be the value of the capacitance so that maximum current may be drawn into the circuit? 2

Ans: $1/\omega C=\omega L$; $C=1/\omega^2 L$=63nF.

2 In the circuit shown below R represents an electric bulb. If the frequency of the supply is doubled, how the valves of C and L should be changed so that the glow in the bulb remains unchanged? 2



Hint: $X_L=2\pi fL$ $X_C=1/2\pi fC$

3 Draw phasor diagram for an LCR circuit for the cases (i) the voltage across the capacitor is greater than that across the inductor (ii) voltage across inductor is greater than that across the capacitor. 2

4 Does current in AC circuit lag, lead or remain in phase with voltage of frequency υ applied to a series LCR circuit when (i) $\upsilon = \upsilon_r$ (ii) $\upsilon < \upsilon_r$ (iii) $\upsilon > \upsilon_r$, where υ_r resonant frequency? 1

5 11kw of electric power can be transmitted to a distant station at (i) 220V and (ii) 22kV. Which of the two modes of transmission should be preferred and why? 2

6 In an AC circuit V and I are given by V=100Sin100t volts and I= 100 Sin(100t+π/3)mA respectively. What is the power dissipated in the circuit? 2

Ans: V_0=100V I_0=100A $\Phi = \pi/3$ $P=V_{rms} I_{rms} \cos\Phi$=2500W

7 The potential across a generator is 125V when it is suppling10A. When it 2

supplies 30A, the potential is 120V. What is the resistance of the armature and induced e.m.f?

Ans: E=127.5V

8 In an LCR circuit the potential difference between terminals of inductance 60V, between terminals of capacitor 40V and between the terminals of resistor is 40V. Find the supply voltage. (3) 3

Ans: In series LCR circuit voltage across capacitor and inductor are in opposite phase, so net voltage across the combination of L and C becomes 60-30=30V. Total voltage across R and L = 50V

9 The natural frequency of an LC circuit is 1,25,000 Hz. Then the capacitor C is replaced by another capacitor with a dielectric medium k, which decreases the frequency by 25 KHz. What is the value of k? 3

Ans: $\upsilon_1=1/2\pi\sqrt{LC}$ $\upsilon_2=1/2\pi\sqrt{kLC}$ $k=(\upsilon_1/\upsilon_2)^2=(1.25)^2=1.56$.

10 Obtain the resonant frequency and Q factor of a series LCR circuit with L= 3H, C= 27μF and R= 7.4 Ώ. Write two different ways to improve quality factor of a series LCR circuit 3

Ans: Q=45,ω_0=111rad/s

11 An A.C source of voltage $V= V_m \sin\omega t$ is connected one-by-one to three circuit elements 5

X, Y and Z. It is observed that the current flowing in them

i. is in phase with applied voltage for X
ii. Lags applied voltage in phase by π /2 for elements Y.
iii. Leads the applied voltage in phase by π /2 for element Z.

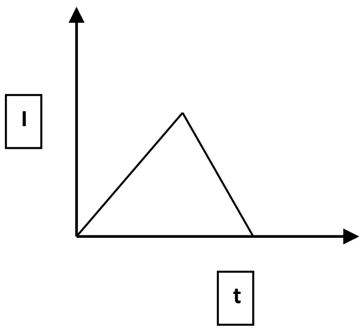
Identify the three circuit elements.

TRANSFORMER

1 Why is the core of a transformer laminated? 1

2 Why can't a transformer be used to step up dc voltages? 1

3 The graph below shows the variation of I with t. If it is given to the primary of a transformer, what is the nature of induced e.m.f in the secondary? 3



(Hint: e has constant positive value in the first part and a constant

negative value in the second part)

1. The turn ratio of a transformer is 10. What is the e.m.f in the secondary if 2V is supplied to primary?
2. A transformer has an efficiency of 80% It works at 4kW and 100V. If the secondary voltage
   Is240V find the primary current.
(40 A)

4 When a voltage of 120V is given to the primary of a transformer the current in the primary is 1.85mA. Find the voltage across the secondary when it gives a current of 150mA. The efficiency of the transformer is 95% 3

(1406V)

GENERATOR

1 If the speed of rotation of armature is increased twice how would it affect the (a) maximum e.m.f produced (b) frequency of the e.m.f? 1

(e=NBAω ;f=ω/2Π)

2 A coil of area $0.2m^2$ and 100 turns rotating at 50 revolutions per second with the axis perpendicular to the field. If the maximum e.m.f is 7kV determine the magnitude of magnetic field. 2

(1.1 Tesla)

3 An ac generator consists of a coil of 50 turns and an area of $2.5m^2$ rotating at an angular speed of 60 rad/s in a uniform magnetic field of B= 0.3T between two fixed pole pieces. The resistance of the circuit including that of the coil is 500Ώ 3

(i) What is the maximum current drawn from the generator?

(ii)What is the flux through the coil when current is zero?

(iii)What is the flux when current is maximum?

(4.5A, 375Wb, zero)

VALUE BASED QUESTIONS

1. Lakshmi, Ritu and Kajal lived in a resettlement colony where they observed most houses stole power from transmission lines using hooks. They had learnt in school about fire caused due to electric short circuit. They decided to make people aware of the risks involved and also the importance of paying their electricity bills. They got all their friends and responsible elders together and with the help of the electricity board, succeeded in changing the situation.

• What values did Lakshmi, Ritu and Kajal have?

• A low voltage supply from which one needs high currents must have a very low internal resistance, why?

• A high tension supply of say 6 KV must have a very large internal resistance. Why?

2. Rahul and Rohit bought an electric iron. They had a 2 pin plug. Rahul was keen to start using the new iron with the 2 pin plug. However, Rohit insisted that they buy a 3 pin plug before using it. Rahul got angry. Rohit patiently explained the importance of using a 3 pin plug and the earthing wire. He said that if the metallic body of the iron came in contact with the live wire at 220 volts, they would get an electric shock. If earthed, the current would go to the earth and the potential of the metallic body would not rise. The iron would then be safe to use. Hearing Rohit, Rahul calmed down and agreed.

• What values did Rahul and Rohit have?

• Which has greater resistance – 1 K watt electric heater or 100 watt electric bulb, both marked 220 volts?

3. Sachin had gone to meet his grandfather who was staying in a village. In the evening, they were both watching TV, when suddenly the lights went off. Grandfather told Sachin that the fuse must have blown up as all their neighbors had electricity. Luckily Sachin knew how to change a fuse. His grandfather was happy and told him that if he had been alone, he would have had to spend the night in the dark without a fan. Sachin felt and made up his mind to replace the fuse with a circuit breaker which uses a solenoid with a core so that his grandfather would not have any problems in future.

• What values did Sachin have?

• The main power supply of a house is through a 5 ampere fuse. How many 100 watt bulbs can be used in the house simultaneously at 220 volts?

<u>5. ELECTRO MAGNETIC WAVES</u>

<u>GIST</u>

1. Conduction current and displacement current together have the property of continuity.
2. Conduction current & displacement current are precisely the same.
3. Conduction current arises due to flow of electrons in the conductor. Displacement current arises due to electric flux changing with time.
4. $\boldsymbol{I_D = \varepsilon_0 \int \frac{d\phi_E}{dt}}$
5. Maxwell's equations

- **<u>Gauss's Law in Electrostatics</u>**

  $\oint \vec{E}.\overrightarrow{dS}=\frac{Q}{\varepsilon_0}$
- **<u>Gauss's Law in Magnetism</u>**

  $\oint \vec{B}.\overrightarrow{dS}=0$
- **<u>Faraday's -Lenz law of electromagnetic induction.</u>**

  $\oint \vec{E}\,.\overrightarrow{dl}=\int \frac{\vec{B}}{dt}.\overrightarrow{dS}$
- **<u>Ampere's – Maxwell law</u>**

  $\int \vec{B}\,.\overrightarrow{dl} = \mu_0 I + \mu_0 \varepsilon_0 \int \frac{\vec{E}}{dt}\,.\overrightarrow{dS}$

6. **<u>Electromagnetic Wave :-</u>** The wave in which there are sinusoidal variation of electric and magnetic field at right angles to each others as well as right angles to the direction of wave propagation.
7. Velocity of EM waves in free space: $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ 3×10^8 m/s
8. The Scientists associated with the study of EM waves are Hertz, Jagdish Chandra Bose & Marconi.
9. EM wave is a transverse wave because of which it undergoes polarization effect.
10. Electric vectors are only responsible for optical effects of EM waves.
11. The amplitude of electric & magnetic fields are related by $\frac{E}{B} = c$
12. Oscillating or accelerating charged particle produces EM waves.
13. Orderly arrangement of electro magnetic radiation according to its frequency or wavelength is electromagnetic spectrum.
14. **<u>Hint to memorise the electromagnetic spectrum in decreasing order of its frequency.</u>**

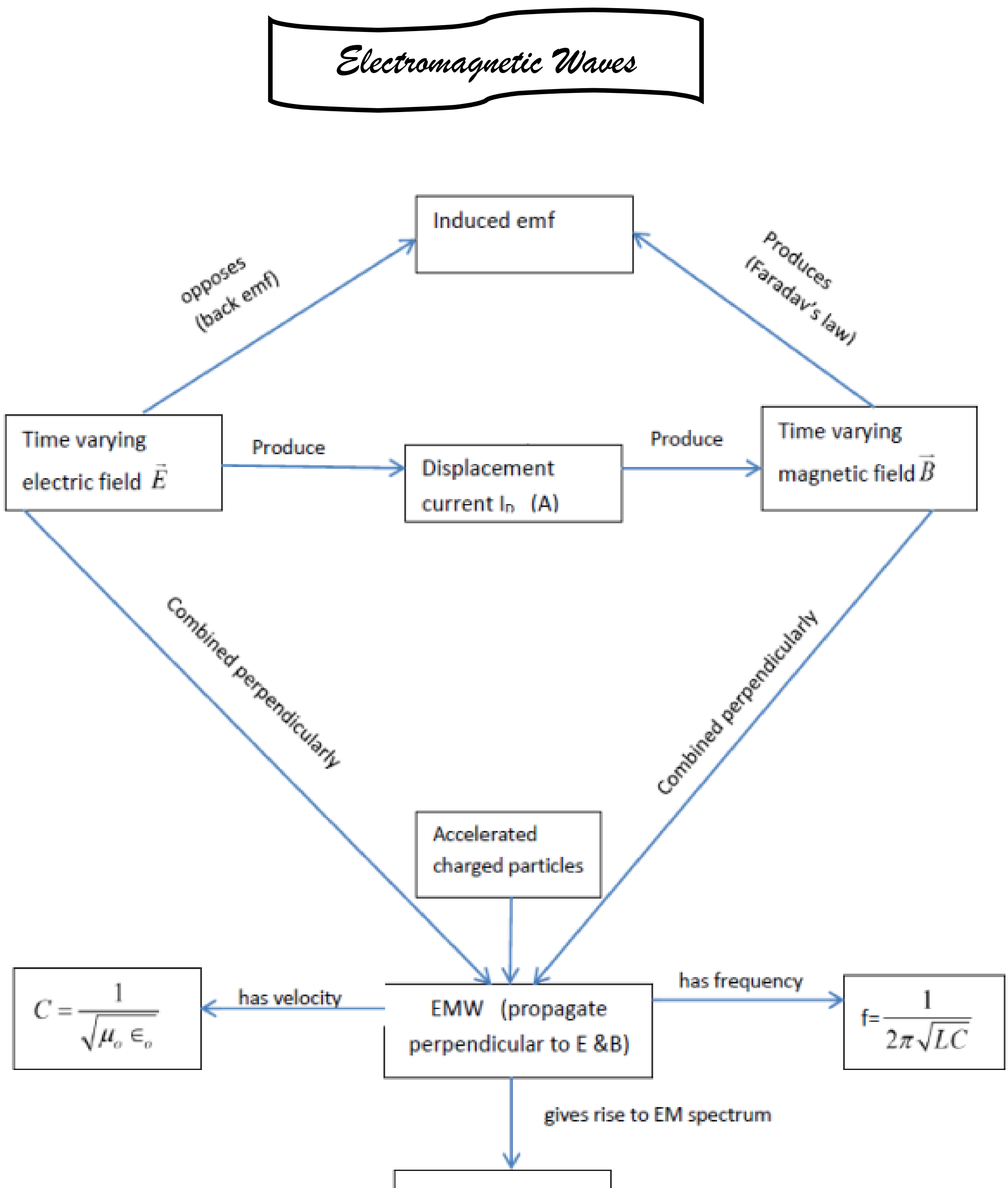
    <u>G</u>andhiji's <u>X</u>-rays <u>U</u>sed <u>V</u>igorously In<u>M</u>edical <u>R</u>esearch
15. EM waves also carry energy, momentum and information.

ELECTRO MAGNETIC SPECTRUM, ITS PRODUCTION, DETECTION AND USES IN GENERAL

Type	Wave length Range Frequency Range	Production	Detection	Uses
Radio	>0.1m 10^9 to 10^5Hz	Rapid acceleration / deceleration of electrons in aerials	Receiver's aerials	Radio, TV Communication
Micro-wave	0.1mm 10^{11} to10^9 Hz	Klystron valve or magnetron valve	Point contact diodes	Radar, TV communication
Infrared	1mm to 700nm 10^{11} to10^{14} Hz	Vibration of atom or molecules	Thermopiles, Bolometer Infrared Photographic Film	Green House effect, looking through haze, fog and mist, Ariel mapping.
Light	700nm to 400nm $8x10^{14}$ Hz	Electron in an atom during transition	Eye, Photocell, Photographic Film	Photography, Illuminations, Emit & reflect by the objects.
Ultra-violet	400nm to 1nm $5x10^{14}$ to $8x10^{14}$	Inner Shell electron in atom moving from one energy level to a lower energy level	Photocell & photographic film	Preservation of food items, Detection of invisible writing, finger print in forensic laboratory. Determination of Structure of molecules & atoms.

X-rays	1nm to 10^{-3}nm 10^{16} to 10^{21} Hz	X-ray tube or inner shell Electrons	Photographic film, Geiger tube, ionization chamber.	Study of crystal structure & atom, fracture of bones.
Gamma ray	$<10^{-3}$nm 10^{18} to 10^{22} Hz	Radioactive decay of the nucleus	Photographic film, Geiger tube, ionization chamber	Nuclear reaction & structure of atoms & Nuclei. To destroy cancer cells.

CONCEPT MAP


Electromagnetic Waves
Induced emf
opposes
(back emf)
Produces
(Faraday's law)
Time varying
electric field $\vec{E}$
Produce
Displacement
current I_D (A)
Produce
Time varying
magnetic field $\vec{B}$
Combined perpendicularly
Combined perpendicularly
Accelerated
charged particles
$C=\frac{1}{\sqrt{\mu_o \in_o}}$
has velocity
EMW (propagate
perpendicular to E &B)
has frequency
$f=\frac{1}{2\pi\sqrt{LC}}$
gives rise to EM spectrum

VALUE BASED QUESTIONS

1. A fluorescent tube seller boasts of the quality of his fittings. He offers cheaper fittings with beautiful choke fitted on it.The customer installs it and finds the tube working fine but giving strong humming sound . He and his wife found the hum to be tolerable but their young children said that it is too high to be tolerated. What do you think about the cause of hum? Comment on the character of the seller.

2. Clinical microscopes are used to diagnose diseases based on blood and urine samples.Mr. Bajaj does not believe in such tests. He prefers to go to doctors who diagnose on the basis of pulse check only. He fell ill and his temperature persisted for more than a month. Anurag a student of class twelfth resides near Mr. Bajaj house, convinced Mr. Bajaj and got his examination conducted. How X ray are produced? What are the values exhibited by Anurag?

3. Sushma's mother suffers from cancer of third stage. She has been advised a therapy in which cancerous growth will be burnt by atomic radiations. She is told that her beautiful hair will fall in this therapy and she is liable to become bald. Sushma's mother refuses the therapy which is otherwise must for her. Sushma talked to her mother explaining the need of the therapy and could convince her. What are the values exhibited by Sushma? Which electromagnetic radiation is used in cancer treatment?

6. OPTICS

RAY OPTICS

GIST

1 **REFLECTION BY CONVEX AND CONCAVE MIRRORS.**

- Mirror formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$, where u is the object distance, v is the image distance and f is the focal length.
- Magnification $m=-\frac{v}{u}=\frac{f-v}{f}=\frac{f}{f-u}$.

m is **-ve** for **real images** and **+ve** for **virtual images**.

2 **REFRACTION**

- Ray of light bends when it enters from one medium to the other, having different optical densities.
- Sun can be seen before actual sunrise and after actual sunset due to Atmospheric refraction
- An object under water (any medium) appears to be raised due to refraction when observed inclined

$n=\frac{\text{Re}al\ depth}{apparent\ depth}$ and

Shift in the position (apparent) of object is

X = t { 1 – 1/n) where t is the actual depth of the medium

- Snell's law states that for a given colour of light, the ratio of sine of the angle of incidence to sine of angle of refraction is a constant, when light travels from rarer to denser,

$\frac{Sini}{\sin r}=\frac{n_2}{n_1}$

- Absolute refractive index is the ratio between the velocities of light in vacuum to the velocity of light in medium. For air n=1.

$n=\frac{c}{v}$

3 • When a ray of light travels from denser to rarer medium and if the angle of incidence is greater than critical angle, the ray of light is reflected back to the denser medium. This phenomenon is called

Total internal reflection. $SinC = \frac{n_R}{n_D}$

- Diamond has a high refractive index, resulting with a low critical angle ($C=24.4^0$). This promotes a multiple total internal reflection causing its brilliance and luster. Some examples of total internal reflection are formation of mirage and working of an optical fibre.

4 When light falls on a convex refracting surface(light travelling from rarer to denser medium), it bends and the relation between U, V and R is given by $\frac{n_2}{V} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

5 Lens maker's formula or thin lens formula is given by

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For Convex Lens R_1 +ve ;R_2 –ve Concave lens R_1-ve; R_2 +ve The way in which a lens behaves as converging or diverging depends upon the values of n_L and n_m.

6 When two lenses are kept in contact the equivalent focal length is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \ \& \ P = P_1 + P_2$$

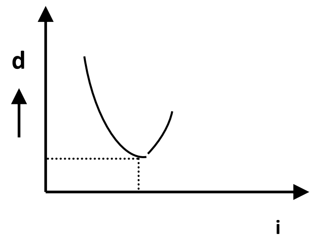
7 The lens formula is given by $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

8 When light passes through a glass prism it undergoes refraction.

The expression for refractive index is $n = \frac{Sin\left(\frac{A + D_m}{2}\right)}{Sin\left(\frac{A}{2}\right)}$

As the angle of incidence increases, the angle of deviation decreases, reaches a minimum value and then increases. This minimum value is called angle of minimum deviation "D_m".

9



Where d is minimum, i=e, refracted ray lies parallel to the base. For a small angled prism d=(n-1)A.

10 When white light (poly chromatic or composite) is passed through a glass prism, It splits up into its component colours (Monochromatic). This phenomenon is called Dispersion.

11 Rainbow is formed due to a combined effect of dispersion, refraction and reflection of sunlight by spherical water droplets of rain.

12 Scattering of light takes place when size of the particle is very small when compared to the wavelength of light

Intensity of scattered light is $I \alpha \frac{1}{\lambda^4}$

The following properties or phenomena can be explained by scattering.

Sky is blue.

Sky is reddish at the time of sunrise and sunset

Infra-red photography used in foggy days.

Yellow light used in vehicles on foggy days.

Red light used in signals.

1 One half of the reflecting surface of a concave mirror is coated with black paint. How will the image be affected?

Brightness decreases

2 Why a concave mirror is preferred for shaving?
Enlarged VIRTUAL

3 Mirrors in search lights are parabolic and not spherical. Why?
Produce intense parallel beam) eliminating spherical aberration

4 Using the mirror formula show that a virtual image is obtained when an object is placed in between the principal focus and pole of the concave mirror.

$\frac{1}{v}=\frac{1}{u}-\frac{1}{f}$ u<f $\Rightarrow \frac{1}{u}>\frac{1}{f} \Rightarrow v$ is +ve)

5 Using the mirror formula show that for a concave mirror, when the object is placed at the centre of curvature, the image is formed at the centre of curvature.

6 Find the position of an object, which when placed in front of a concave mirror of focal length 20cm, produces a virtual image which is twice the size of the object.
Ans. 10cm

7 Plot a graph between 1/u and 1/v for a concave mirror. What does the slope of the graph yield?
Ans. Straight line, slope =u/v=1/m

8 **REFRACTION AND LENSES**
Which of the following properties of light: Velocity, wavelength and frequency, changes during the phenomenon (i) reflection (ii) refraction
Ans. (i) No change (ii) velocity, wavelength change)

9 A convex lens is combined with a concave lens. Draw a ray diagram to show the image formed by the combination, for an object placed in between f and 2f of the convex lens. Compare the Power of the convex and concave lenses so that the image formed is real.
Ans: f of convex lens must be less than f of concave lens to produce real image. So power of Convex greater than that of concave)

10 Derive a relation between the focal length and radius of curvature of a Plano convex lens made of glass. Compare the relation with that of a concave mirror. What can you conclude? Justify your answer.
Ans. (f=2R) both are same. But applicable always in mirrors, but for lenses only in specific cases, the relation can be applied.)

11 In the given figure an object is placed at O in a medium (n_2>n_1). Draw a ray diagram for the image formation and hence deduce a relation between u, v and R

$$\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$$

12 Show that a concave lens always produces a virtual image, irrespective of the position of the object.

Ans. $v = \dfrac{uf}{u+f}$ *But u is – ve and f is – ve for concave lens*

Hence v is always -ve. that is virtual

13 Sun glasses are made up of curved surfaces. But the power of the sun glass is zero. Why?

Ans. It is convex concave combination of same powers. So net power zero

14 A convex lens is differentiated to n regions with different refractive indices. How many images will be formed by the lens?

Ans. n images but less sharp

15 A convex lens has focal length f in air. What happens to the focal length of the lens, if it is immersed in (i) water (n=4/3) (ii) a medium whose refractive index is twice that of glass.

Ans. 4f, -f

16 Calculate the critical angle for glass air surface, if a ray falling on the surface from air, suffers a deviation of 15^0 when the angle of incidence is 40^0.

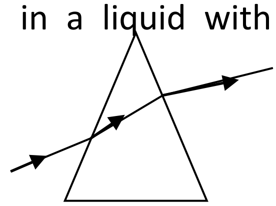
Find n by Snell's law and then find c=41.14^0

17 Two thin lenses when in contact produce a net power of +10D. If they are at 0.25m apart, the net power falls to +6 D. Find the focal lengths of the two lenses

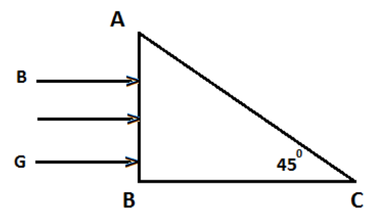
Ans. 0.125m, 0.5m)

18 A glass prism has an angle of minimum deviation D in air. What happens to the value of D if the prism is immersed in water? Ans. Decreases

19 Draw a ray diagram for the pat followed by the ray of light passing through a glass prism immersed in a liquid with refractive index greater than glass.



Three rays of light red (R) green (G) and blue (B) are incident on the surface of a right angled prism as shown in figure. The refractive indices for the material of the prism for red green and blue are 1.39, 1.43 and 1.47 respectively. Trace the path of the rays through the prism. How will the situation change if the rays were falling normally on one of the faces of an equilateral prism?

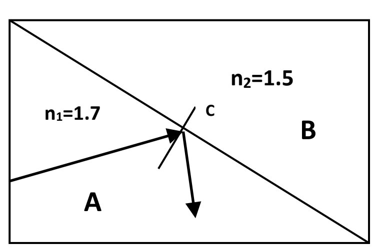


(Hint Calculate the critical angle for each and if the angle of incidence on the surface AC is greater, then TIR will take place.)

20 Show that the angle of deviation for a small angled prism is directly proportional to the refractive index of the material of the prism. One of the glass Prisms used in Fresnel's biprism experiment has refractive index 1.5. Find the angle of minimum deviation if the angle of the prism is 3^0. (3)

(D= (n-1) A, 1.5^0)

21 . In the given diagram, a ray of light undergoes total internal reflection at the point C which is on the interface of two different media A and B with refractive indices1.7 and 1.5 respectively. What is the minimum value of angle of incidence? Can you expect the ray of light to undergo total internal reflection when it falls at C at the same angle of incidence while entering from B to A. Justify your answer?

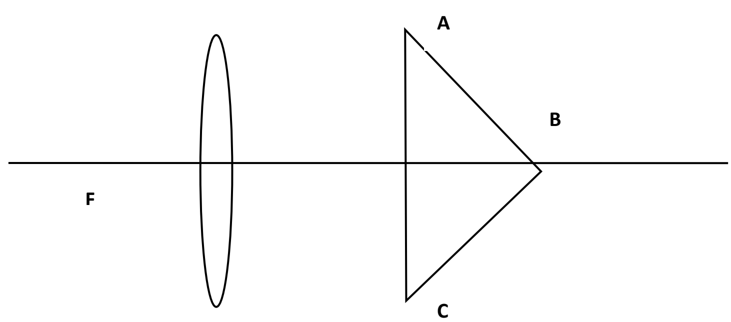


Ans. Use $SinC = \frac{n_r}{n_d} = 0.88$ *and* C=61.7^0 so i=61.8^0 no for TIR ray of light must travel from denser to rarer from B to A)

22 The velocity of light in flint glass for wavelengths 400nm and 700nm are 1.80x10^{8}m/s and 1.86x10^8 m/s respectively. Find the minimum angle of deviation of an equilateral prism made of flint glass for the given wavelengths.

(For 400nm D=52^0 and for 700nm D=48^0)

23 In the given diagram a point object is kept at the Focus F of the convex lens. The ray of light from the lens falls on the surfaces AB and BC of a right angled glass prism of refractive index 1.5 at an angle 42^0.Where will be the final image formed? Draw a ray diagram to show the position of the final image formed. What change do you expect in your answer if the prism is replaced by a plane mirror?



C=41.8^0 Ans- at F itself, no change

OPTICAL INSTRUMENTS

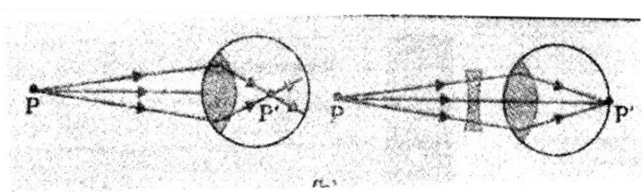
GIST

1 ➢ Human eye:

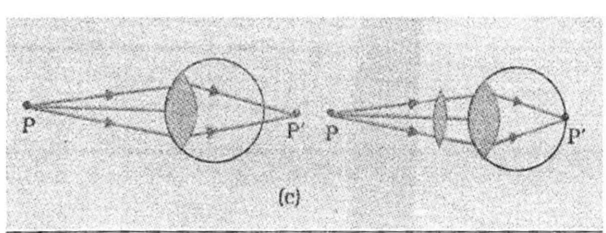
- Eye lens: crystalline
- Cilliary muscles: lens is held in position by these.
- Iris: Circular contractible diaphragm with an aperture near the centre.
- Pupil: the circular aperture is pupil. It adjusts controlling light entering the eye.
- Power of accommodation: ability of pupil for adjusting focal length.
- Far point: the maximum distant point that an eye can see clearly.
- Near point: closest distant that eye lens can focus on the retina.
- Range of vision: distant between near point and far point.

2 ➢ Defects of vision:

Myopia: image formed in front of the retina. Correction-using concave lens.

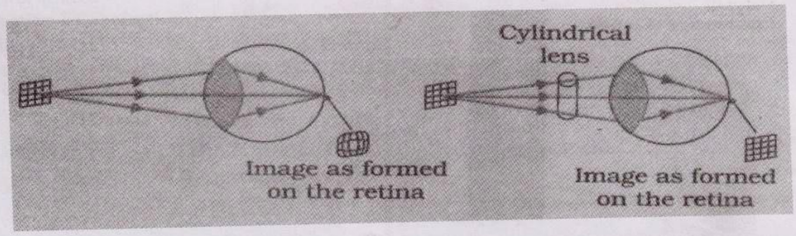


Hypermetropia- image behind the retina. Correction-using convex lens.



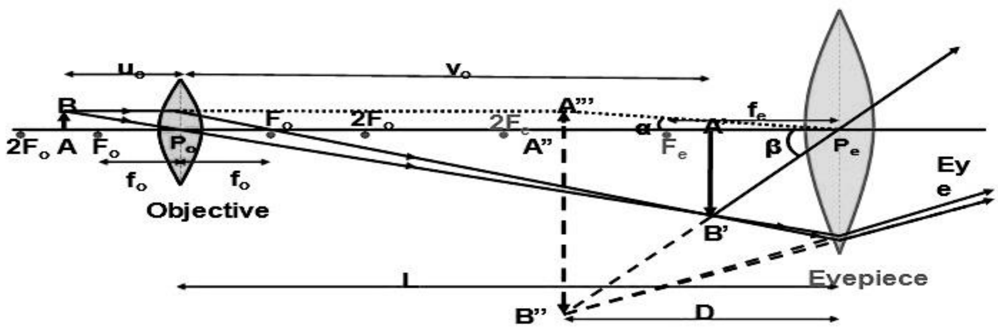
Presbiopia-low power of accommodation. Correction-bifocal lens.

- Astigmatism-cornea has different curvature in different direction. Correction-using cylindrical lens



Astigmatism-cornea has different curvature in different direction. Correction-using cylindrical Lens.

3 **Compound Microscope:**



Objective: The converging lens nearer to the object.
Eyepiece: The converging lens through which the final image is seen.
Both are of short focal length. Focal length of eyepiece is slightly greater than that of the objective.

4

Angular Magnification or Magnifying Power (M):

$$M = M_e \times M_o$$

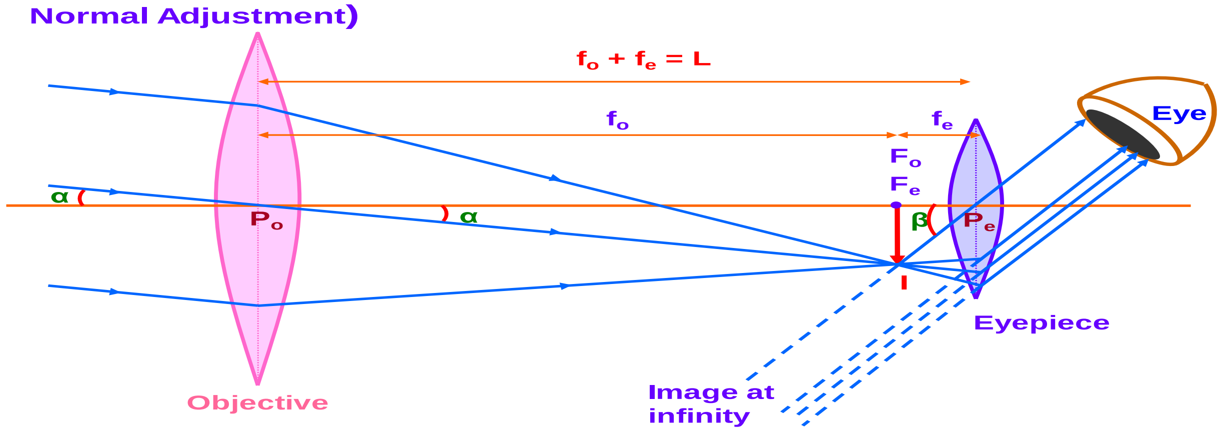
$$M = \frac{v_o}{-u_o}\left(1 + \frac{D}{f_e}\right) \qquad M = \frac{-L}{f_o}\left(1 + \frac{D}{f_e}\right)$$

or

$$M \approx \frac{-L}{f_o} \times \frac{D}{f_e}$$

(Normal adjustment i.e. image at infinity)

5 **Astronomical Telescope: (Image formed at infinity – Normal Adjustment)**



Focal length of the objective is much greater than that of the eyepiece.

Aperture of the objective is also large to allow more light to pass through it.

6 **Angular magnification or Magnifying power of a telescope in normal adjustment**

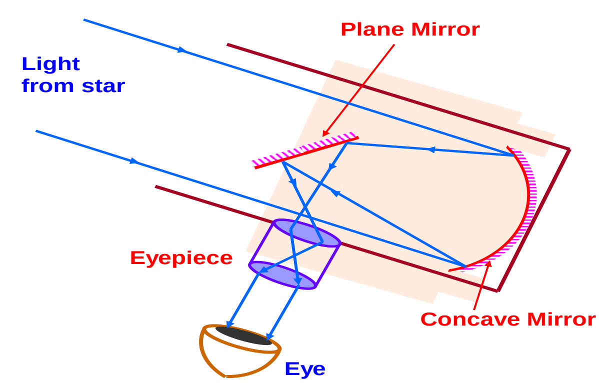
$$M = \frac{\beta}{\alpha} \qquad M = \frac{-f_o}{f_e}$$

($f_o + f_e = L$ is called the length of the telescope in normal adjustment).

7 **Newtonian Telescope: (Reflecting Type)**

Magnifying Power:

$M = \frac{f_o}{f_e}$



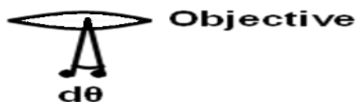
8 Cassegrain telescope refer from NCERT / refer Page no 83

Resolving Power = $\frac{1}{\Delta d}$ = $\boxed{\frac{2\,\mu \sin\theta}{\lambda}}$

Resolving power depends on i) wavelength λ, ii) refractive index of the medium between the object and the objective and iii) half angle of the cone of light from one of the objects θ.

Resolving Power of a Telescope:

Resolving Power = $\frac{1}{d\theta}$ = $\boxed{\frac{a}{1.22\,\lambda}}$



Resolving power depends on i) wavelength λ, ii) diameter of the objective a.

QUESTIONS

MICROSCOPE AND TELESCOPE

*1. You are given following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope? 2

Lens	Power (P)	Aperture (A)
L1	3D	8 cm
L2	6D	1 cm
L3	10D	1 cm

Ans- The objective of an astronomical telescope should have the maximum diameter and its eyepiece should have maximum power. Hence, L1 could be used as an objective and L3 could be used as eyepiece.

2. Draw a ray diagram of a reflecting type telescope. State two advantages of this telescope over a refracting telescope. 2

3. Draw a ray diagram of an astronomical telescope in the normal adjustment position, state two drawbacks of this type of telescope. 2

4. Draw a ray diagram of a compound microscope. Write the expression for its magnifying power. 2

5. The magnifying power of an astronomical telescope in the normal adjustment position is 100. The distance between the objective and the eyepiece is 101 cm. Calculate the focal lengths of the objective and of the eye-piece. 2

6. How does the 'resolving power' of an astronomical telescope get affected on (i) Increasing the aperture of the objective lens? (ii) 2

Increasing the wavelength of the light used?

7. What are the two ways of adjusting the position of the eyepiece while observing the 5

Final image in a compound microscope? Which of these is usually preferred and why?

Obtain an expression for the magnifying power of a compound microscope. Hence explain why (i) we prefer both the 'objective' and the 'eye-piece' to have small focal length? and (ii) we regard the 'length' of the microscope tube to be nearly equal to be separation between the focal points of its objective and its eye-piece? Calculate the magnification obtained by a compound microscope having an objective of focal length 1.5cm and an eyepiece of focal length 2.5 cm and a tube length of 30.

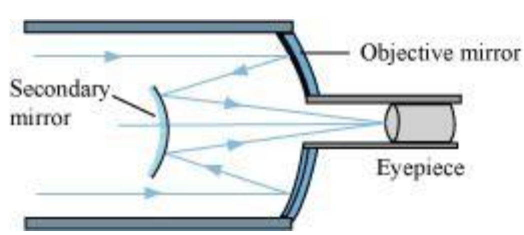
8. What are the two main considerations that have to be kept in mind while designing the 'objective' of an astronomical telescope? 5

Obtain an expression for the angular magnifying power and the length of the tube of an astronomical telescope in its 'normal adjustment' position.

An astronomical telescope having an 'objective' of focal length 2m and an eyepiece of focal length 1cm is used to observe a pair of stars with an actual angular separation of 0.75. What would be their observed angular separation as seen through the telescope?

Hint- observed angular separation = 0.75' ×200 = 150'

*9. Cassegraintelescope uses two mirrors as shown inFig. Sucha telescope is built withthe mirrors20 mm apart. If theradius of curvature of thelarge mirror is 220mmand the small mirror is 140mm,where willthe final image of anobjectat infinitybe? Thefollowingfigure shows a Cassegraintelescope consistingof a concavemirrorand a convexmirror.



Distance betweenthe objective mirrorand thesecondary mirror,d = 20 mm

Radiusof curvatureof the objectivemirror,R_1=220 mm

Hence,focallength of the objectivemirror, $f_1 = \frac{R_1}{2} = 110 \text{ mm}$

Radiusof curvatureof the secondarymirror,R_1=140 mm

Hence,focallength of the secondary mirror, $f_2 = \frac{R_2}{2} = \frac{140}{2} = 70 \text{ mm}$

Theimage of an object placedat infinity,formed by theobjectivemirror, will actas a virtual object for thesecondary mirror.

Hence,the virtualobjectdistancefor the secondarymirror, $u = f_1 - d$

$= 110 - 20$

$= 90 \text{ mm}$

Applyingthe mirrorformulafor the secondarymirror,we can calculate image distance(v)as:

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f_2}$$

$$\frac{1}{v} = \frac{1}{f_2} - \frac{1}{u}$$

$$= \frac{1}{70} - \frac{1}{90} = \frac{9-7}{630} = \frac{2}{630}$$

$$\therefore v = \frac{630}{2} = 315 \text{ mm}$$

Hence, the final image will be formed315 mmawayfrom thesecondary mirror.

5

DEFECTS OF VISION

1. Amyopic person has beenusingspectacles of power −1.0 dioptre for distant vision.Duringold age healso needs to use separate reading glass of power + 2.0 dioptres. Explain whatmay have happened.

   Ans -

   Thepower of the spectaclesusedby the myopic person,*P* = −1.0 D

   Focallengthof the spectacles, $f = \frac{1}{P} = \frac{1}{-1 \times 10^{-2}} = -100 \text{ cm}$

   Hence,the farpoint of theperson is 100 cm. He might havea normalnear point of 25 cm.Whenhe uses the spectacles, the objects placed atinfinity producevirtualimages at 100 cm.He uses the abilityof accommodation of theeye-lensto see theobjects placedbetween 100 cmand 25 cm.

   During oldage, theperson uses reading glasses of $P' = +2 \text{ D}$

   (power, P=100/50)

   Theability of accommodationis lost in oldage.This defect is calledpresbyopia.As a result, he is unable to seeclearly theobjects placedat 25 cm.

5

2. Amanwith normal nearpoint (25 cm)reads a book withsmallprint using amagnifyingglass: a thinconvex lens of focallength 5 cm. 5

   (a) What is theclosest and the farthestdistanceatwhichhe should keepthe lens fromthe pages so that he canread the book when viewingthrough the magnifyingglass?

(b) Whatis the maximum and theminimumangular magnification (magnifying power) possible using theabove simple microscope?

Ans -

(a) Focallengthof the magnifying lass f
= 5 cm
Least distance of distance vision,
d = 25 cm
Closest objectdistance= *u*
Image distance, *v*= −*d* = −25 cm

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$$

$$= \frac{1}{-25} - \frac{1}{5} = \frac{-5-1}{25} = \frac{-6}{25}$$

$$\therefore u = -\frac{25}{6} = -4.167 \text{ cm}$$

Accordingto thelens formula,we have:
Hence,the closestdistanceat whichthe person canread thebook is 4.167 cm. For theobjectat thefarthestdistant(*u*’), the imagedistance $(v') = \infty$ According to the lens formula,we have:

$$\frac{1}{f} = \frac{1}{v'} - \frac{1}{u'}$$

$$\frac{1}{u'} = \frac{1}{\infty} - \frac{1}{5} = -\frac{1}{5}$$

$$\therefore u' = -5 \text{ cm}$$

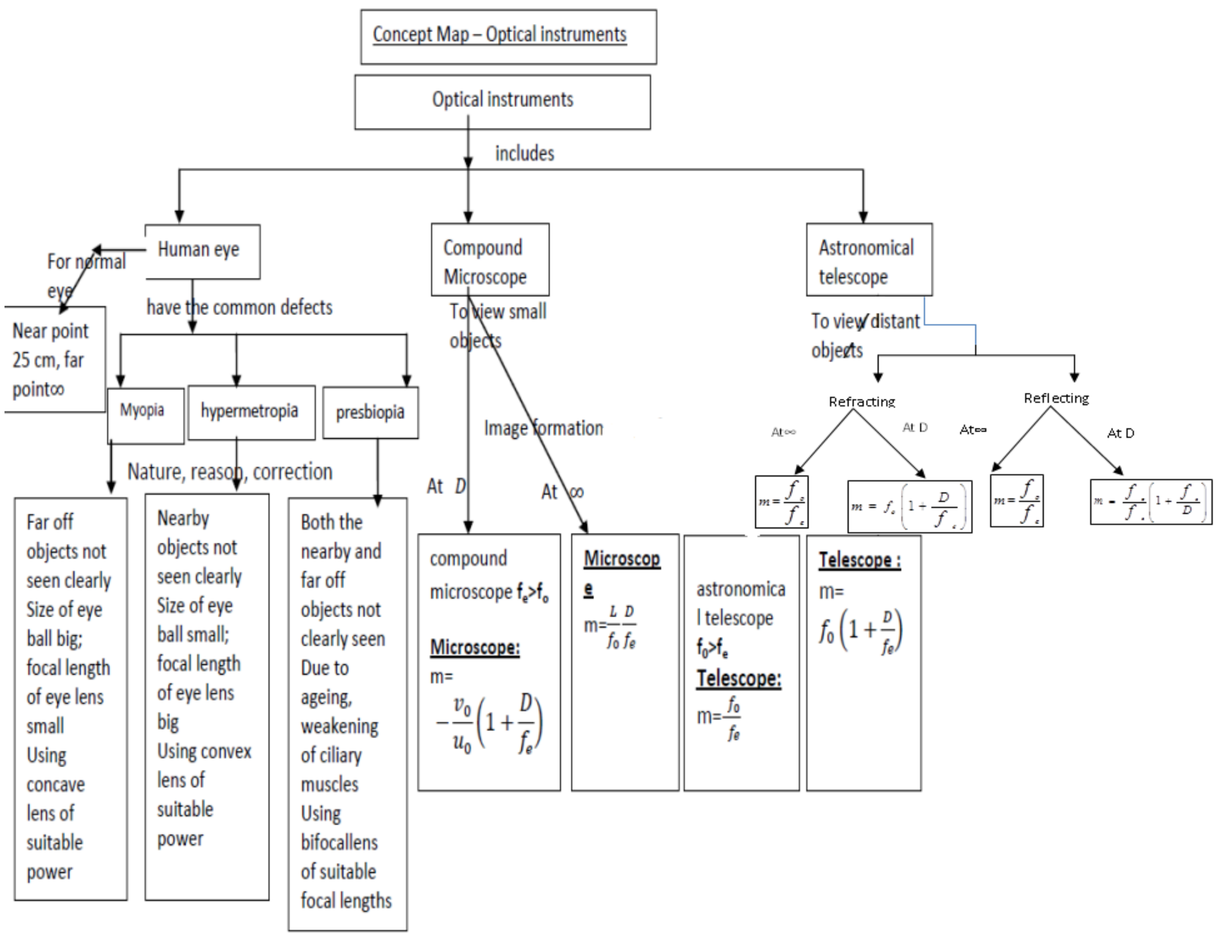
Hence,the farthest distance atwhich theperson can readthe book is 5cm.
(b) Maximum angular magnification is given by therelation:

$$\alpha_{\max} = \frac{d}{|u|}$$

$$= \frac{25}{\frac{25}{6}} = 6$$

CONCEPT MAP

Optical Instruments



Wave Optics

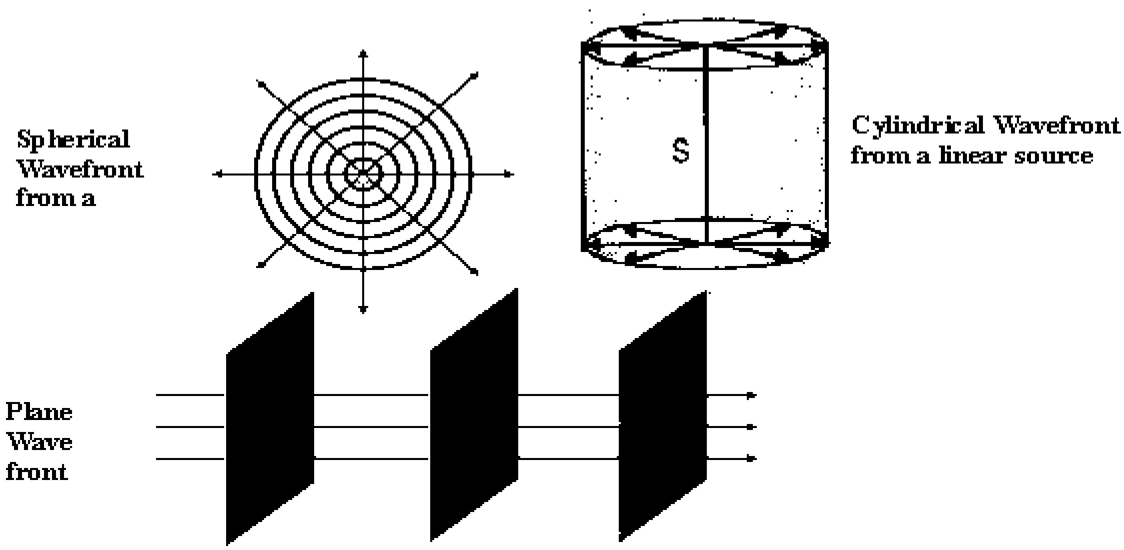
GIST

Wavefront:

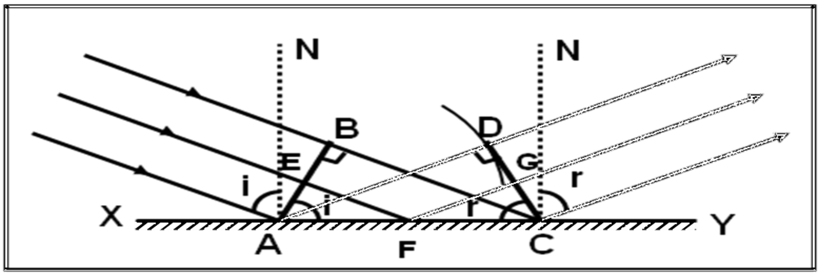
A wavelet is the point of disturbance due to propagation of light.

A wavefront is the locus of points (wavelets) having the same phase of oscillations.

A line perpendicular to a wavefront is called a 'ray'.



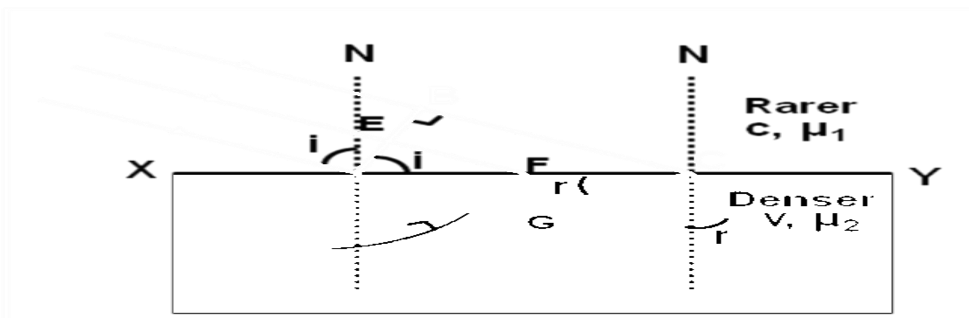
Laws of Reflection at a Plane Surface (On Huygens' Principle):



AB – Incident wavefront CD – Reflected wavefront XY – Reflecting surface

$\sin i - \sin r = 0.$ i.e. $\sin i = \sin r$ or $i = r$

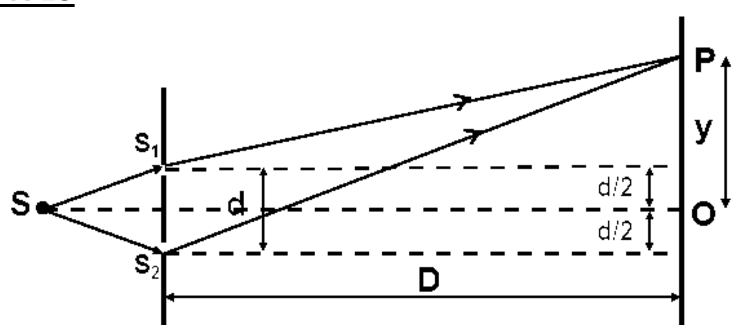
Laws of Refraction at a Plane Surface (On Huygens' Principle):



AB – Incident wavefront CD – Refracted wavefront XY – Refracting surface

$$\frac{\sin i}{c} - \frac{\sin r}{v} = 0 \quad \text{or} \quad \frac{\sin i}{c} = \frac{\sin r}{v} \quad \text{or} \quad \frac{\sin i}{\sin r} = \frac{c}{v} = \mu$$

INTERFERENCEOF WAVES



The waves from S_1 and S_2 reach the point P with some phase difference and hence path difference

$\Delta = S_2P - S_1P$

$S_2P^2 - S_1P^2 = [D^2 + \{y + (d/2)\}^2] - [D^2 + \{y - (d/2)\}^2]$

$(S_2P - S_1P)(S_2P + S_1P) = 2\,yd$ $\quad\Delta\,(2D) = 2\,yd$ $\quad\Delta = yd / D$

Comparison of intensities of maxima and minima:

$$\frac{I_{max}}{I_{min}} = \frac{(a + b)^2}{(a - b)^2} = \frac{(a/b + 1)^2}{(a/b - 1)^2}$$

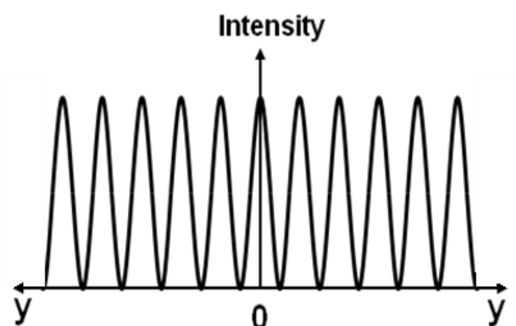
Relation between Intensity (I), Amplitude (a) of the wave and Width (w) of the slit:

$I \ \alpha \ a^2$

$a \ \alpha \ \sqrt{w}$

$$\frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2} = \frac{w_1}{w_2}$$

Distribution of Intensity:

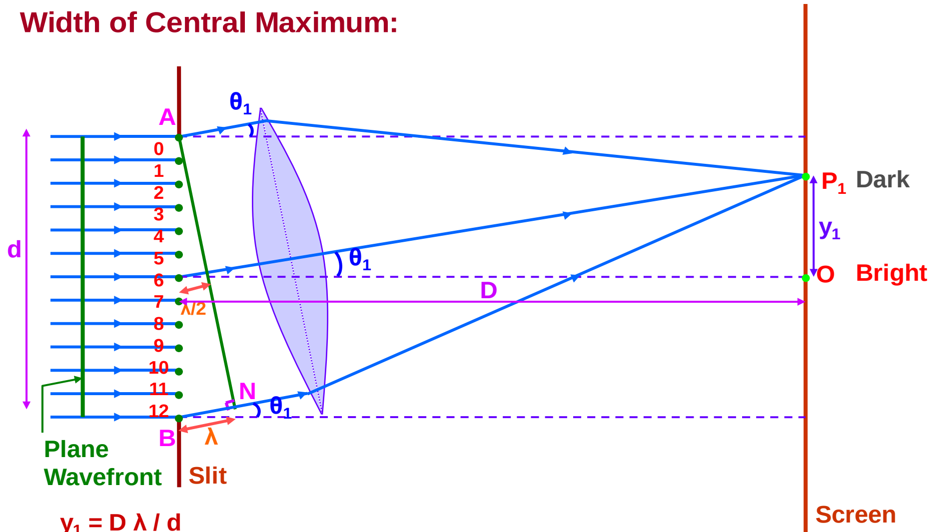


Conditions for sustained interference:

1. The two sources producing interference must be coherent.
2. The two interfering wave trains must have the same plane of polarisation.
3. The two sources must be very close to each other and the pattern must be observed at a larger distance to have sufficient width of the fringe. (D λ / d)
4. The sources must be monochromatic. Otherwise, the fringes of different colours will overlap.
5. The two waves must be having same amplitude for better contrast between bright and dark fringes.

DIFFRACTION OF LIGHT AT A SINGLE SLIT ;

Width of Central Maximum:



$y_1 = D \lambda / d$

Since the Central Maximum is spread on either side of O, the width is

$\beta_0 = 2D \lambda / d$

Fresnel's Distance:

$y_1 = D \lambda / d$

At Fresnel's distance, $y_1 = d$ and $D = D_F$

So, $D_F \lambda / d = d$ or $D_F = d^2 / \lambda$

<u>POLARISATION OF LIGHT WAVES :</u>

Malus' Law:

When a beam of plane polarised light is incident on an analyser, the intensity I of light transmitted from the analyser varies directly as the square of the cosine of the angle θ between the planes of transmission of analyser and polariser.

(2)

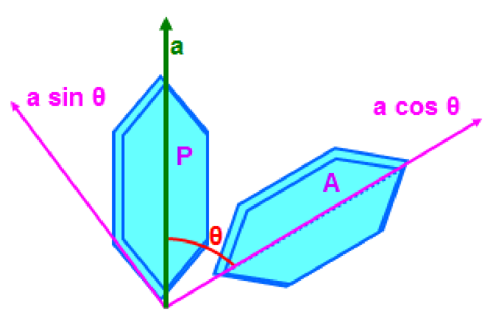
Intensity of transmitted light from the analyser is

$I \propto \cos^2 \theta$

$I = k (a \cos \theta)^2$

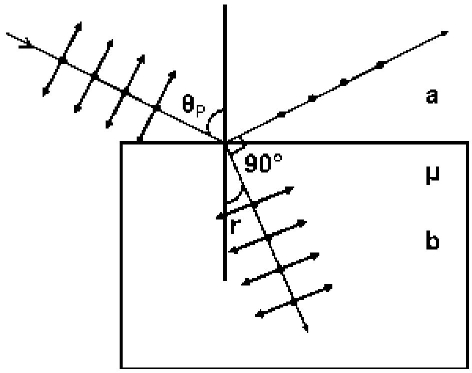
or $I = k a^2 \cos^2 \theta$

$I = I_0 \cos^2 \theta$



(where $I_0 = k a^2$ is the intensity of light transmitted from the polariser)

Polarisation by Reflection and Brewster's Law:



$$\theta_P + r = 90^\circ \quad \text{or} \quad r = 90^\circ - \theta_P$$

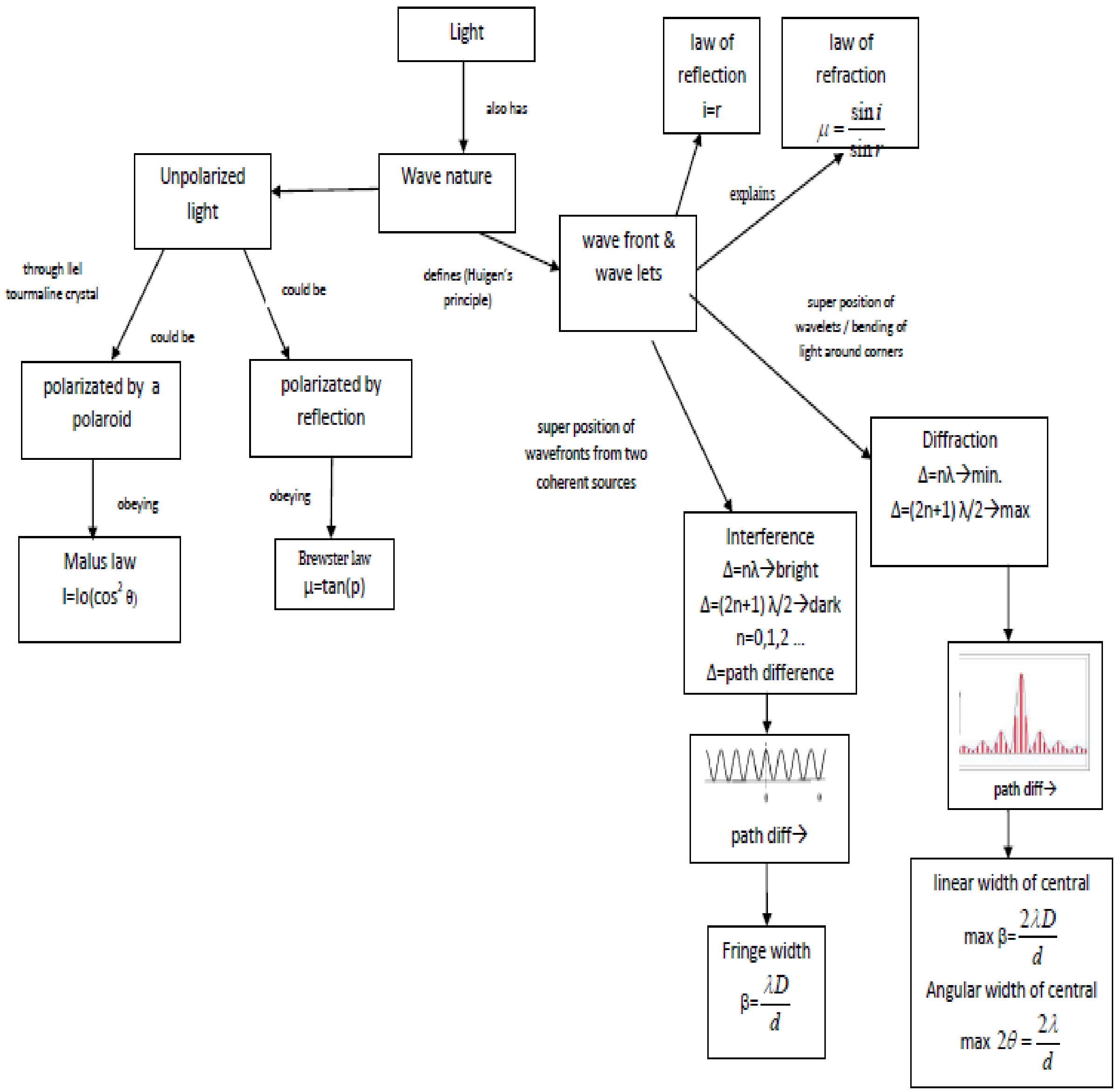
$${}_a\mu_b = \frac{\sin \theta_P}{\sin r}$$

$${}_a\mu_b = \frac{\sin \theta_P}{\sin 90^\circ - \theta_P}$$

$$\boxed{{}_a\mu_b = \tan \theta_P}$$

CONCEPT MAP

WAVE NATURE OF LIGHT



Light
also has
Wave nature
Unpolarized light
through llel tourmaline crystal
could be
could be
polarizated by a polaroid
polarizated by reflection
obeying
obeying
Malus law
I=Io(cos^2 θ)
Brewster law
μ=tan(p)
defines (Huigen's principle)
wave front & wave lets
law of reflection
i=r
law of refraction
$\mu = \frac{\sin i}{\sin r}$
explains
super position of wavelets / bending of light around corners
super position of wavefronts from two coherent sources
Interference
Δ=nλ→bright
Δ=(2n+1) λ/2→dark
n=0,1,2 ...
Δ=path difference
path diff→
Fringe width
β=$\frac{\lambda D}{d}$
Diffraction
Δ=nλ→min.
Δ=(2n+1) λ/2→max
path diff→
linear width of central max β=$\frac{2\lambda D}{d}$
Angular width of central max $2\theta = \frac{2\lambda}{d}$

QUESTIONS

Huygen's Principle

1. Draw a diagram to show the refraction of a plane wave front incident on a convex lens and hence draw the refracted wave front. 1
2. What type of wavefront will emerge from a (i) point source, and (ii) distance light source? 1
3. Define the term wave front? Using Huygen's construction draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection. 3
4. Define the term 'wavefront'. Draw the wavefront and corresponding rays in the case of a (i) diverging spherical wave (ii) plane wave.Using Huygen's construction of a wavefront, explain the refraction of a plane wavefront at a plane surface and hence deduce Snell's law. 3

Interference

1. How does the angular separation of interference fringes change, in Young's experiment, when the distance between the slits is increased? 1
   Ans-when separation between slits (d) is increased, fringe width β decreases.
2. How the angular separation of interference fringes in young would's double slit experiment change when the distance of separation between the slits and the screen is doubled? 1
   Ans-No effect (or the angular separation remains the same)

*3. Indouble-slitexperiment using light of wavelength 600 nm,the angular width of afringe formedon adistant screenis 0.1º.Whatis the spacingbetweenthe two slits? 2
Ans- Thespacing between theslits is 3.44×10^{-4} m

*4. If the path difference produced due to interference of light coming out of two slits for yellow colour of light at a point on the screen be 3λ/2, what will be the colour of the fringe at that point? Give reasons. 2
Ans. The given path difference satisfies the condition for the minimum of intensity for yellow light, Hence when yellow light is used, a dark fringe will be formed at the given point. If white light is used, all components of white light except the yellow one would be present at that point.

5. State two conditions to obtain sustained interference of light. In Young's 3

double slit experiment, using light of wavelength 400 nm, interference fringes of width 'X' are obtained. The wavelength of light is increased to 600 nm and the separation between the slits is halved. In order to maintain same fringe with, by what distance the screen is to be moved? Find the ration of the distance of the screen in the above two cases.
Ans-Ratio-3:1

6. Two narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? Draw intensity pattern obtained in the two cases. Also write two differences between the patterns obtained in the above two cases. 3

*7. In Young's double-slit experiment a monochromatic light of wavelength λ, is used. The intensity of light at a point on the screen where path difference is λ is estimated as K units. What is the intensity of light at a point where path difference is λ /3? 3
Ans-K/4

*8. Abeam of light consistingof two wavelengths,650 nm and 520 nm, is used toobtaininterference fringesin aYoung's double-slitexperiment.**(a)**Find thedistance of thethird brightfringeon the screenfrom the centralmaximum for wavelength 650 nm.**(b)**What is theleastdistancefrom thecentralmaximumwherethe brightfringes due toboth the wavelengths coincide? 3

Ans-a)

$$x = n\lambda_1\left(\frac{D}{d}\right)$$

For third bright fringe, $n = 3$

$$\therefore x = 3 \times 650\frac{D}{d} = 1950\left(\frac{D}{d}\right) \text{ nm}$$

b)

$$x = n\lambda_2\frac{D}{d}$$

$$= 5 \times 520\frac{D}{d} = 2600\frac{D}{d} \text{ nm}$$

3

*9 A narrow monochromatic beam of light of intensity I is incident a glass plate. Another identical glass plate is kept close to the first one and parallel to it. Each plate reflects 25% of the incident light and transmits 3 the reaming. Calculate the ratio of minimum and maximum intensity in the interference pattern formed by the two beams obtained after reflection from each plate.

Ans. Let I be the intensity of beam I incident on first glass plate. Each plate reflects 25% of light incident on it and transmits 75%.

Therefore,

I1 =I; and I2 = 25/100I = I/4;I3 =75/100 I = 3/4I;I4 = 25/100 I3 = 1⁄4 x 3⁄4 I = 3/16 I

I5= 7/100 I4= 3⁄4 x 3/16 I = 9/64 I

Amplitude ratio of beams 2 and 5 is R = √ I2/I5 = √I/4 x 64/91 = 4/3

Imin/ Imax = [r-1/r+1]2 = [4/3-1 / 4/3+1]2 = 1/49 = 1:49

*10 In a two slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance D from the slits. If the screen is moved 5 x 10^{-2} m towards the slits, the charge in fringe width is 3 x 10^{-5} m. If the distance between the slit is 10^{-3} m. Calculate the wavelength of the light used.

Ans. The fringe width in the two cases will be β = Dλ/d;β '= D'λ/d

β - β' = (D-D')λ/d; or wavelength λ = (β - β')d / (D-D') But D-D' = 5 x 10^{-2} m

β - β' = 3 x 10^{-5} m , d= 10^{-3}m;λ = 3 x 10^{-5} x 10^{-3} / 5 x 10^{-2} = 6 x 10^{-7}m= 6000A

11. Two Sources of Intensity I and 4I are used in an interference experiment. Find the intensity at points where the waves from two sources superimpose with a phase difference (i) zero (ii) π/2 (iii) π.

Ans-The resultant intensity at a point where phase difference is Φ is $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \Phi$

As I1 =I and I_2 = 4I therefore I_R = I +4I+2√1.4I Cos Φ = 5I +4I cos Φ

(i) when Φ =0 , I R = 5I +4I cos 0 = 9 I;(ii) when Φ =π/2 , I R = 5I +4I cos π/2 = 5 I

(iii) when Φ =π , I R = 5I +4I cos π = I

12. What are coherent sources of light? Two slits in Young's double slit experiment are illuminated by two different sodium lamps emitting light of the same wavelength. Why is no interference pattern observed? 5

(b) Obtain the condition for getting dark and bright fringes in Young's experiment. Hence write the expression for the fringe width.

(c) If S is the size of the source and its distance from the plane of the two slits, what should be the criterion for the interference fringes to be seen?

Ans-c) $\frac{S}{d} < \frac{\lambda}{a}$

13. What are coherent sources? Why are coherent sources required to produce interference of light? Give an example of interference of light in everyday life. In Young's double slit experiment, the two slits are 0.03 cm apart and the screen is placed at a distance of 1.5 m away from the slits. The distance between the central bright fringe and fourth bright fringe is 1 cm. Calculate the wavelength of light used. 5

Ans-(Numerical part)

$$\lambda = \frac{dx}{4D} = \frac{0.03\times10^{-2}\times1\times10^{-2}}{4\times1.5} = 5\times10^{-7}\ \text{m}$$

14. What is interference of light? Write two essential conditions for sustained interference pattern to be produced on the screen. Draw a graph showing the variation of intensity versus the position on the screen in Young's experiment when (a) both the slits are opened and (b) one of the slit is closed. What is the effect on the interference pattern in Young's double slit experiment when: (i) Screen is moved closer to the plane of slits? (ii)Separation between two slits is increased. Explain your answer in each case. 5

Diffraction

*1. Why a coloured spectrum is seen, when we look through a muslin cloth and not in other clothes? **2**

Ans. Muslin cloth is made of very fine threads and as such fine slits are formed. White light passing through these silts gets diffracted giving rise to colored spectrum. The central maximum is white while the secondary maxima are coloured. This is because the positions of secondary maxima (except central maximum) depend on the wavelength of light. In a coarse cloth, the slits formed between the threads are wider and the diffraction is not so pronounced. Hence no such spectrum is seen.

2. A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 'a'. If the distance between the slits and the screen is 0.8 m and the distance of 2nd order maximum from the centre of the screen is 15 mm, calculate the width of the slit. **2**

Ans-Difference between interference and diffraction: Interference is due to superposition of two distinct waves coming from two coherent sources. Diffraction is due to superposition of the secondary wavelets generated from different parts of the same wavefront.

Numerical: Here, λ = 600 nm = 600 × 10−19 = 6 × 10−7 m

D = 0.8 m, x = 15 mm = 1.5 × 10−3 m,n = 2, a = ?

$$\because a\frac{x}{D} = n\lambda$$

$$a = \frac{n\lambda D}{x} = \frac{2\times6\times10^{-7}\times0.8}{1.5\times10^{-3}}$$

$$= \frac{9.6\times10^{-4}}{1.5} = 6.4\times10^{-4}\ \text{mm}$$

3. Why light ways do not diffracted around buildings, while radiowaves diffract easily? **2**

Ans- For diffraction to take place the wave length should be of the order of the size of the obstacle. The radio waves (particularly short radio waves) have wave length of the order of the size of the building and other obstacles coming in their way and hence they easily get diffracted. Since wavelength of the light waves is very small, they are not diffracted by the buildings.

4. Draw the diagram showing intensity distribution of light on the screen for diffraction of light at a single slit. How is the width of central maxima affected on increasing the (i) Wavelength of light used (ii) width of the slit? What happens to the width of the central maxima if the whole apparatus is immersed in water and why? **3**

5. State the condition under which the phenomenon of diffraction of light takes place. Derive an expression for the width of central maximum due to diffraction of light at a single slit. A slit of width 'a' is illuminated by a monochromatic light of wavelength 700 nm at normal incidence. Calculate the value of 'a' for position of **5**

* (i) first minimum at an angle of diffraction of 30°

(iii) first maximum at an angle of diffraction of 30°

Ans-i) $a = \frac{\lambda}{\sin\theta} = \frac{700}{\sin 30} = 1400\,\text{nm}$

ii) $a = \frac{3\lambda}{2\sin\theta} = \frac{3\times700}{2\times\sin 30} = 2100\,\text{nm}$

Polarisation

1. At what angle of incidence should a light beam strike a glass slab of refractive index √3, such that the reflected and the refracted rays are 1

perpendicular to each other?
Ans-i=60^0

2

2. What is an unpolarized light? Explain with the help of suitable ray diagram how an unpolarized light can be polarized by reflection from a transparent medium. Write the expression for Brewster angle in terms of the refractive index of denser medium. 3

3. The critical angle between a given transparent medium and air is denoted by i_c, A ray of light in air medium enters this transparent medium at an angle of incidence equal to the polarizing angle(i_p). Deduce a relation for the angle of refraction (r_p) in terms of i_c. 3

4 What is meant by 'polarization' of a wave? How does this phenomenon help us to decide whether a given wave is transverse or longitudinal in nature? 5

QUESTIONS (HOTS)

VERY SHORT ANSWER QUESTIONS (1 MARK)

1. Air bubble is formed inside water. Does it act as converging lens or a diverging lens? 1

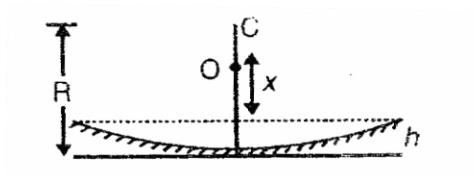
   Ans : [Diverging lens]

2. A water tank is 4 meter deep. A candle flame is kept 6 meter above the level. μ for water is $4/3$. Where will the image of the candle be formed?.

   Ans : [6m below the water level] 1

SHORTANSWER QUESTIONS (2 MARKS)

1. Water is poured into a concave mirror of radius of curvature 'R' up to a height h as shown in figure 1. What should be the value of x so that the image of object 'O' is formed on itself? 2



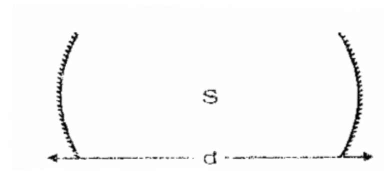
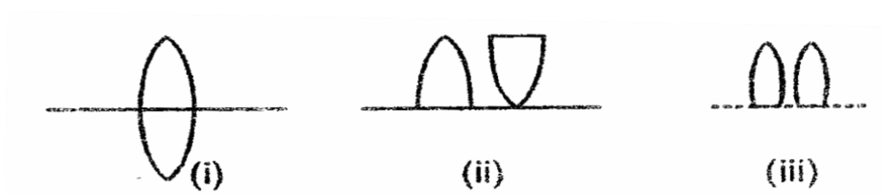


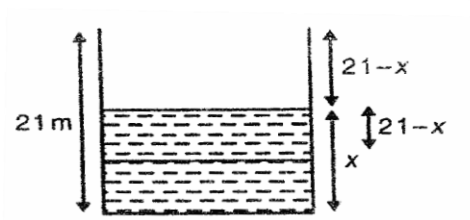
Fig 1 Fig 2

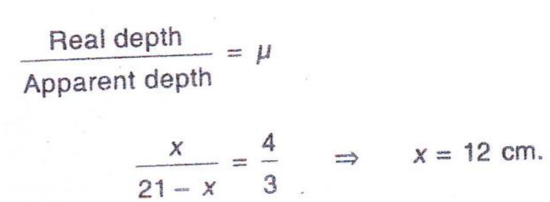
2. A point source S is placed midway between two concave mirrors having equal focal length *f* as shown in Figure 2. Find the value of *d* for which only one image is formed. 2

3. A thin double convex lens of focal length *f* is broken into two equals halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii).

2







$$\frac{\text{Real depth}}{\text{Apparent depth}} = \mu$$

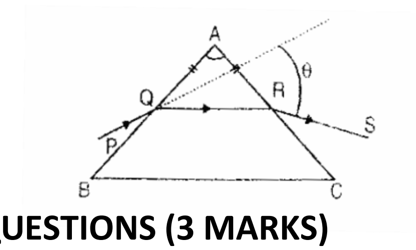
$$\frac{x}{21 - x} = \frac{4}{3} \Rightarrow x = 12 \text{ cm.}$$

4. How much water should be filled in a container 21cm in height, so that it appears half filled when viewed from the top of the container $\left({}^{a}\mu_{\omega} = 4/3\right)$? 2

5. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in figure and emerges from the other refracting face AC as RS such

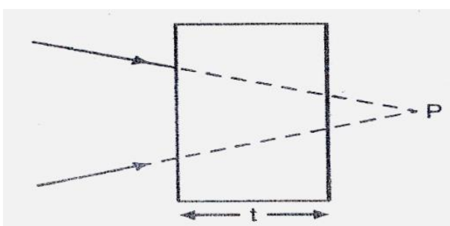
that AQ= AR. If the angle, of prism A= 60° and μ of material of prism is $\sqrt{3}$ then find angle θ. 2

Hint : This a case of min .deviation $\theta = 60^\circ$



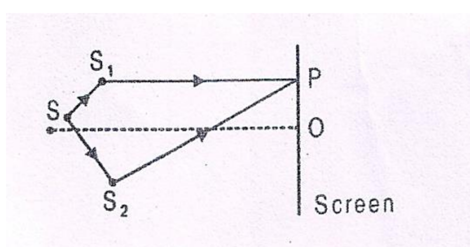
SHORT ANSWER QUESTIONS (3 MARKS)

1. A converging beam of light is intercepted by a slab of thickness t and refractive index μ. By what distance will the convergence point be shifted? Illustrate the answer. 3



$$X = \left(1 - \frac{1}{\mu}\right)t$$

2. In double slit experiment SS_2 is greater than SS_1 by 0.25λ. calculate the path difference between two interfering beam from S_1 and S_2 for maxima on the point P as shown in Figure. 3



VALUE BASED QUESTIONS

1. Ravi is using yellow light in a single silt diffraction experiment with silt width of 0.6 mm. The teacher has replaces yellow light by x-rays. Now he is not able to observe the diffraction pattern. He feels sad. Again the teacher replaces x-rays by yellow light and the diffraction pattern appears again. The teacher now explains the facts about the diffraction and
   - Which value is displayed by the teacher ?
   - Give the necessary condition for the diffraction.

2. Aditya participated in a group discussion in his school on "Human eye and its defects" in the evening he noticed that his father is reading a book by placing it at a distance of 50 cm or more from his eye. He advised him for his eye check-up.
   - Suggest the focal length/power of the reading spectacle for him, so that he may easily read the book placed at 25 cm from eye.
   - Name the value displayed by Aditya.
3. Vinod was watching a program on the topic MOON on the Discovery channel. He came to know from the observations recorded from the surface of Moon that the sky appears dark from there. He got surprised and wanted to know the reason behind it. He discussed it with his friends, and they had the reasons as
   1. Phenomenon of refraction of light 2.Phenomenon of scattering of light and explained the topic to him in detail.

      (i) Name the value that was displayed by Vinod

      (ii) what values were displayed by his friends

7. DUAL NATURE OF MATTER & RADIATION

GIST

ELECTRON EMISSION

1. There are three types of electron emission, namely, Thermionic Emission, Photoelectric Emission and Field Emission.
2. The minimum energy required by an electron to escape from the metal surface is called work function.
3. Work function is conveniently expressed in electron volts (e V)
4. One electron volt is the energy gained or lost by an electron while passing through a potential difference of one volt.

PHOTOELECTRIC EFFECT

1. The minimum energy required by an electron to come out from metal surface is called the work function of a metal.

2. Photo electric effect is the phenomenon of electrons by metals when illuminated by light of suitable frequency

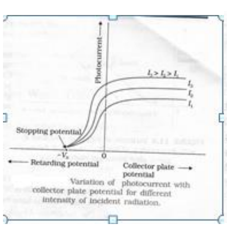
3. Photo electric current depends on

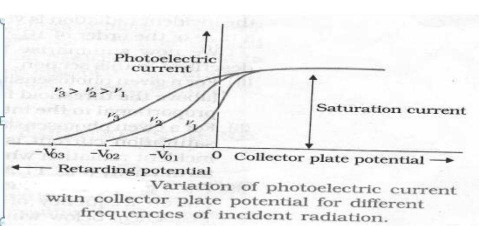
i) The intensity of incident light

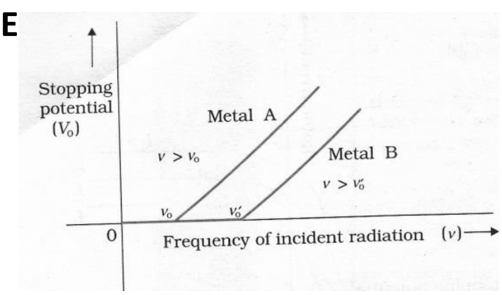
ii) The potential difference applied between two electrodes

iii) The nature of the emitter material

EXPERIMENTAL STUDY OF PHOTOELECTRIC E







1. The minimum negative potential given to the anode plate for which the photo electric current becomes zero is called stopping potential.

2. The stopping potential V_o depends on i) The frequency of incident light and ii) the nature of emitter material. For a given frequency of incident light, the stopping potential is independent of its intensity.

$eV_o = (1/2) m v_{max}^2 = K_{max}$

2. Below a certain frequency (threshold frequency) γ_0 , characteristics of the metal , no photo electric emission takes place, no matter how large the intensity may be.

EINSTEIN'S PHOTO ELECTRIC EQUATION: ENERGY QUANTUM OF RADIATION

1. Light is composed of discrete packets of energy called quanta or photons.
2. The energy carried by each photon is $E = h\nu$, where ν is the frequency and momentum $p= h/\lambda$. The energy of the photon depends on the frequency γ of the incident light and not on its intensity.
3. Photo electric emission from the metal surface occurs due to absorption of a photon by an electron
4. Einstein's photo electric equation: $K_{max} = h\nu - \phi_0$ or $eV_0 = h\nu - \phi_0$.

PARTICLE NATURE OF LIGHT: THE PHOTON

1. Radiation has dual nature: wave and particle. The wave nature is revealed in phenomenon like interference, diffraction and polarization. The particle nature is revealed by the phenomenon photo electric effect.
2. By symmetry, matter also should have dual nature: wave and particle. The waves associated with the moving material particle are called matter waves or De Broglie waves.
3. The De Broglie wave length (λ) associated with the moving particle is related to its moment p as: $\lambda = h/p = h/mv$
4.An equation for the De Broglie wavelength of an electron accelerated through a potential V.

Consider an electron with mass 'm' and charge 'e' accelerated from rest through a potential V.

$K = eV$

$K = 1/2mv^2 = p^2/2m$

$P^2 = 2mK$

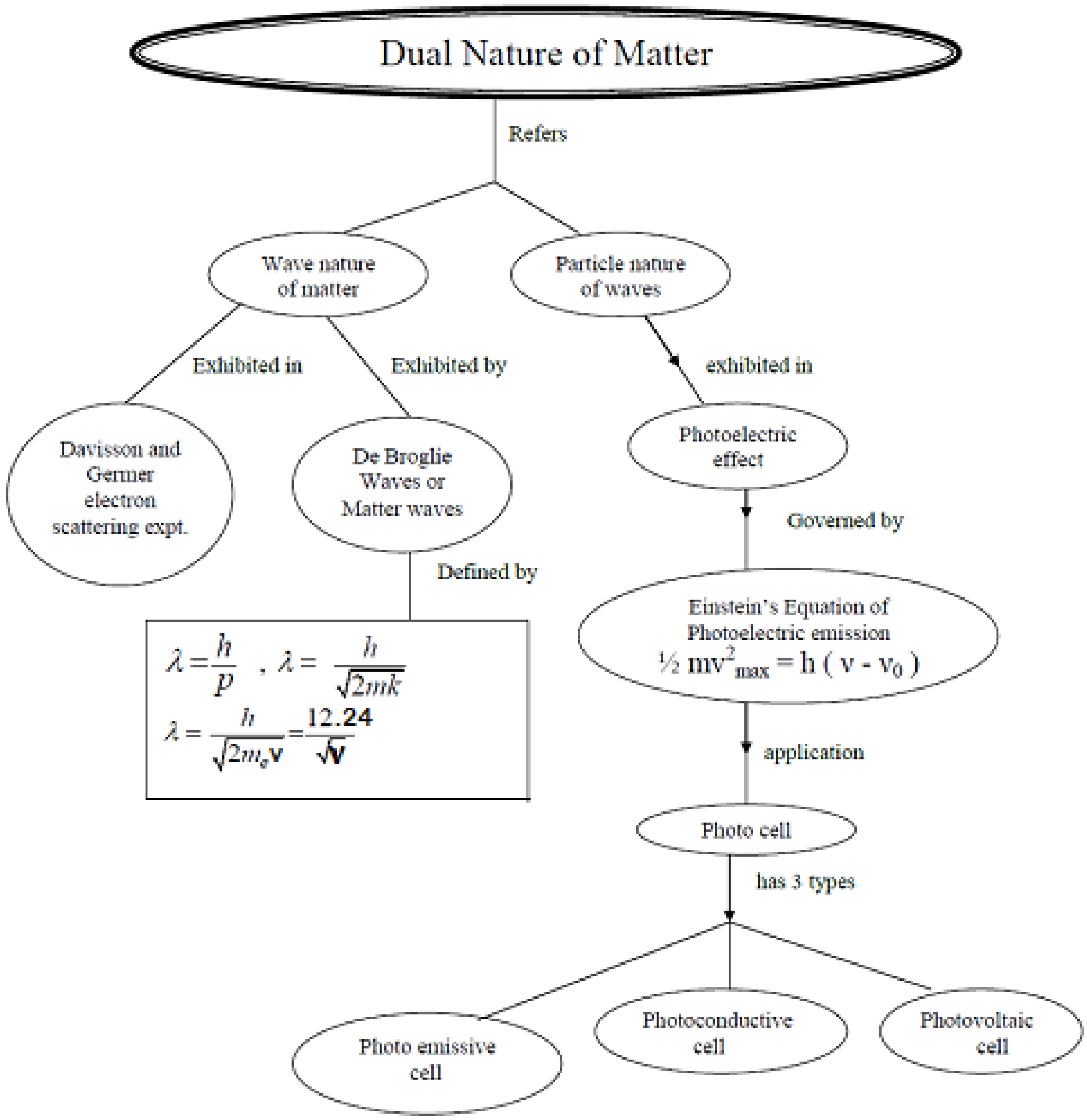
$P = \sqrt{2mK} = \sqrt{2meV}$

$\lambda = h/ \sqrt{2meV}$

Substituting numerical values of h, m and e

$\lambda = (1.227/\sqrt{V})$ nm.

CONCEPT MAP



Dual Nature of Matter
Refers
Wave nature of matter
Particle nature of waves
Exhibited in
Exhibited by
exhibited in
Davisson and Germer electron scattering expt.
De Broglie Waves or Matter waves
Photoelectric effect
Defined by
Governed by
$\lambda = \frac{h}{p}$, $\lambda = \frac{h}{\sqrt{2mk}}$
$\lambda = \frac{h}{\sqrt{2m_e V}} = \frac{12.24}{\sqrt{V}}$
Einstein's Equation of Photoelectric emission
$\frac{1}{2} mv^2_{max} = h(\nu - \nu_0)$
application
Photo cell
has 3 types
Photo emissive cell
Photoconductive cell
Photovoltaic cell

QUESTIONS

ELECTRON EMISSION, PHOTO ELECTRIC EFFECT

1* If the intensity of incident radiation in a photoelectric experiment is doubled what, happens to kinetic energy of emitted photo electrons? 1

2∗ Calculate the frequency associated with photon of energy 3.3×10^{-10} J?
Ans: $\nu = 5 \times 10^{23}$Hz. 1

3 What is the momentum of a photon of energy 1 MeV? 1
Energy E = 1 MeV = 1.6×10^{-13}J, p = E/c= 5.33×10^{-22} Kgm/s

4∗ What happens to the velocity of emitted electrons when the wave length of incident light is decreased? 1

5 If the frequency of incident radiation in a photocell is increased, does it affect the stopping potential? If so how? 1

6 On what factor does the energy carried by a quantum of light depend? 1

7∗ The threshold wave length for photoelectric emission from a given surface is 5200Å. Will photo electric emission takes place, if an ultra violet radiation of one watt power is incident on it? 1

8 Name the element with highest work function and also the element with lowest work function.
Highest work function – Platinum (5.65eV)
Lowest work function – Caesium (2.14eV) 2

9∗ Calculate the work function of a metal in eV if its threshold wavelength is 6800Å.
Ans: Work function = hc / λ_0 = 1.825eV. 2

10 Work function of aluminium is 4.2eV. If two photons each of energy 2.5eV are incident on its surface, will the emission of electrons take place? 2

11 A source of light is placed at a distance of 50cm from a photocell and the cut off potential is found to be V_0. If the distance between the light source and the cell is made 20cm, what will be the new cut off potential?
Ans: Stopping potential is still V_o. 2

EINSTEIN'S PHOTO ELECTRIC EQUATION :ENERGY QUANTUM OF

RADIATION

12 Which of the two photons is more energetic: red light or violet light? 1

13 What will be the stopping potential when a photon of 25eV is incident of metal surface of work function 6eV? Ans : 19 volt 1

14 Why is alkali metal surfaces better suited as photosensitive surfaces?1

15 Blue light can eject electrons from a photo-sensitive surface while orange light can not. Will violet and red light eject electrons from the same surface?

16 Two metals A & B have work functions 4eV & 10eV respectively. In which case the threshold wave length is higher? 1

17* A radio transmitter at a frequency of 880 kHz and a power of 10kW. Find the number of photons emitted per second. 2
Ans: n = energy emitted per second/energy of one photon = 1.716×10^{31}.

18 A parallel beam of light is incident normally on a plane surface absorbing 40% of the light and reflecting the rest. If the incident beam carries 10W of power, find the force exerted by it on the surface. 2
Ans : 5.33×10^{-8} N

19* No photoelectrons are emitted from a surface, if the radiation is above 5000 Å. With an unknown wavelength, the stopping potential is 3V. Find the wave length. 3
Ans : 2262Å

20* Illuminating the surface of a certain metal alternately with light of wave lengths0.35µm and 0.54µm, it was found that the corresponding maximum velocities of photoelectrons have a ratio 2. Find the work function of that metal. 3
Ans: 5.64eV

21* A beam of light consists of four wavelengths 4000Å, 4800Å, 6000Å & 7000Å, each of intensity $1.5 mW/m^2$. The beam falls normally on an area $10^{-4} m^2$ of a clean metallic surface of work function 1.9eV.Assuming no loss of kinetic energy, calculate the number of photoelectrons emitted per second.
Ans :E_1 = 3.1eV, E_2 = 2.58eV, E_3 = 2.06eV, E_4 = 1.77eV 3
Only the first three wave lengths can emit photo electrons.
Number of photo electrons emitted per second = IA ($1/E_1+1/E_2+1/E_3$)
= 1.12×10^{12}.
(Hint – convert eV into joule before substitution)

22 In an experiment on photo electric emission , following observations were made;
(i) wave length of incident light = 1.98×10^{-7}m

(ii) stopping potential = 2.5 V.
Find (a) kinetic energy of photo electrons with maximum speed
(b) work function & (c) threshold frequency 3
Ans; (a) K_{max} = 2.5eV (b) work function = 3.76eV
(c) threshold frequency = 9.1x 10^{14}Hz

WAVE NATURE OF MATTER

1 What is the de Broglie wavelength (in Å) associated with an electron accelerated through a potential of 100 V?1
Ans: λ = 1.227 A^{o}

2 Matter waves associated with electrons could be verified by crystal diffraction experiments .Why? 1
Ans: The wave length of the matter waves associated with electrons has wave lengths comparable to the spacing between the atomic planes of their crystals. 1

3 How do matter waves differ from light waves as regards to the velocity of the particle and the wave? 1
Ans: In case of matter waves, the wave velocity is different from the particle velocity. But in case of light, particle velocity and wave velocity are same.

4 An electron and an alpha particle have same kinetic energy. Which of these particles has the shortest de- Broglie wavelength? 1
Ans: Alpha particle

5 The de Broglie wavelength of an electron is 1 A^0. Find the velocity of the electron. 1
Ans: 7.3 x 10^{6} m/s

6* Find the ratio of wavelength of a 10 k eV photon to that of a 10 keV electron.
Ans: 10 (Hint: λ_{photon} = 1.24 A^0, $\lambda_{electron}$ = 0.1227 A^0) 2

7* A proton and an alpha particle are accelerated through the same potential difference. Find the ratio of the wavelengths associated with the two. 2
Ans: (Hint $\lambda = h/ \sqrt{2meV}$), $\lambda_p : \lambda_\alpha = 2\sqrt{2} : 1$

8 Why macroscopic objects in our daily life do not show wave like properties?
OR
Why wave nature of particles is significant in the sub-atomic domain only? 2
Macroscopic objects in our daily life do not show wave like properties because the wave length associated with them is very small and beyond the scope of any measurement.
In the sub- atomic world, masses of the particles are extremely small leading to a wave length that is measurable.

9* Show that Bohr's second postulate 'the electron revolves around the nucleus only in certain fixed orbits without radiating energy can be explained on the basis of de Broglie hypothesis of wave nature of electron. 2

Ans. The de Broglie wavelength for electron in orbit mvr = nh/ 2π

This is Bohr's second postulate. As complete de-Broglie wavelength may be in certain fixed orbits, non-radiating electrons can be only in certain fixed orbits.

10* The de-Broglie wavelength associated with an electron accelerated through a potential difference V is λ. What will be the de-Broglie wavelength when the accelerating p.d. is increased to 4V? 2

$$\lambda \ \alpha \ \frac{1}{\sqrt{\text{V}}}, \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{\text{V}_2}{\text{V}_1}} = \frac{\lambda}{\lambda_2} = \sqrt{\frac{4}{1}} \Rightarrow \ \lambda_2 = \frac{\lambda}{2}$$

11 Determine the accelerating potential required for an electron to have a de-Broglie wavelength of 1 Å 2

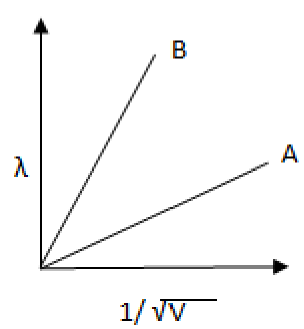
Ans: V = 150.6 V

12 An electron, an alpha particle and a proton have the same kinetic energy, which one of these particles has (i) the shortest and (ii) the largest, de-Broglie wavelength? 2

Ans:

$$\lambda = \frac{h}{\sqrt{2mE_k}} \ \ \alpha \ \frac{1}{\sqrt{\text{m}}}$$

13 The two lines A and B shown in the graph plot the de-Broglie wavelength λ as function of 1/ √V (V is the accelerating potential) for two particles having the same charge. Which of the two represents the particle of heavier mass? 2



Ans: Slope of the graph is h/√2me.

Slope of A is smaller, so A represents heavier particle.

14* Find the ratio of de-Broglie wavelength of molecules of Hydrogen and Helium which are at temperatures 27^0C and 127^0C respectively. 3

Ans: de- Broglie wavelength is given by $\lambda_{H2} / \lambda_{He} = \sqrt{(m_{He} T_{He}/m_H T_H} = \sqrt{(8/3)}$

VALUE BASED QUESTIONS

1. Rahim, a class XI student of KV, visited his uncle and hears the burglar alarm on opening the entrance door; his aunt welcomes him. He goes upstairs and asks his uncle who is a Physics Lecturer, about the principle working of a burglar alarm. He discusses this with his class mates and decides to present a program on 'Burglar Alarm' in the morning assembly.

    a) How will you define the inquisitiveness of Rahim?

    b) State the laws of photoelectric emission

(**ANS:** curiosity to learn, interest in the subject, sharing knowledge; b) Refer NCERT book)

2. In an experiment of photoelectric effect, Nita plotted graphs for different observation between photo electric current and anode potential but her friend Kamini has to help her in plotting the correct graph. Neeta Thanked Kamini for timely help.

a) What value was displayed were Kamini and Neeta.

b) Draw the correct graph between I and V

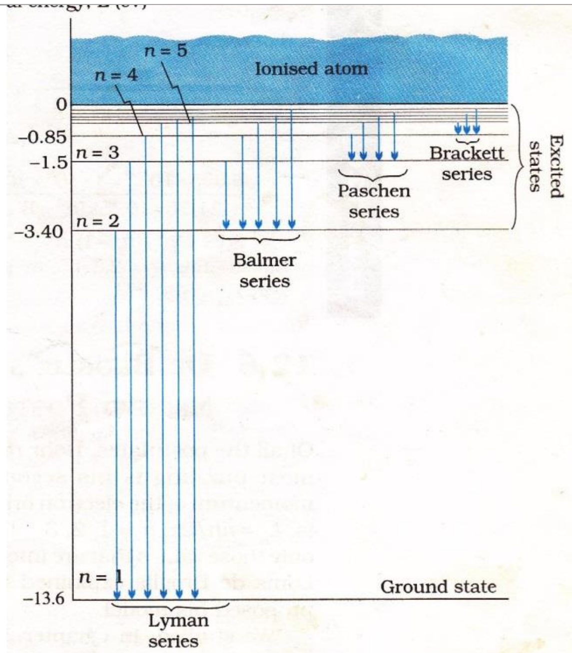
ANS: a) sharing and caring

b) Refer NCERT

8. ATOMS & NUCLEI

GIST	
Thomson's model of atom- Every atom consists of fuels charged sphere in which electrons are embedded like seeds in water melon.	Its drawbacks: couldn't explain large angle scattering & the origin of spectral series.
Rutherford's model of atom- i) Every atom consists of a tiny central core, called the atomic nucleus, in which the entire positive charge and almost entire mass of the atom are concentrated. ii) The size of nucleus is of the order of 10^{-15}m , which is very small as compared to the size of the atom which is of the order of 10^{-10}m. iii)The atomic nucleus is surrounded by certain number of electrons. As atom on the whole is electrically neutral, the total negative charge of electrons surrounding the nucleus is equal to total positive charge on the nucleus. iv)These electrons revolve around the nucleus in various circular orbits as do the planets around the aun. The centripetal force required by electron for revolution is provided by the electrostatic force of attraction between the electrons and the nucleus.	Limitations: couldn't explain the stability of the nucleus & the emission of line spectra of fixed frequencies.

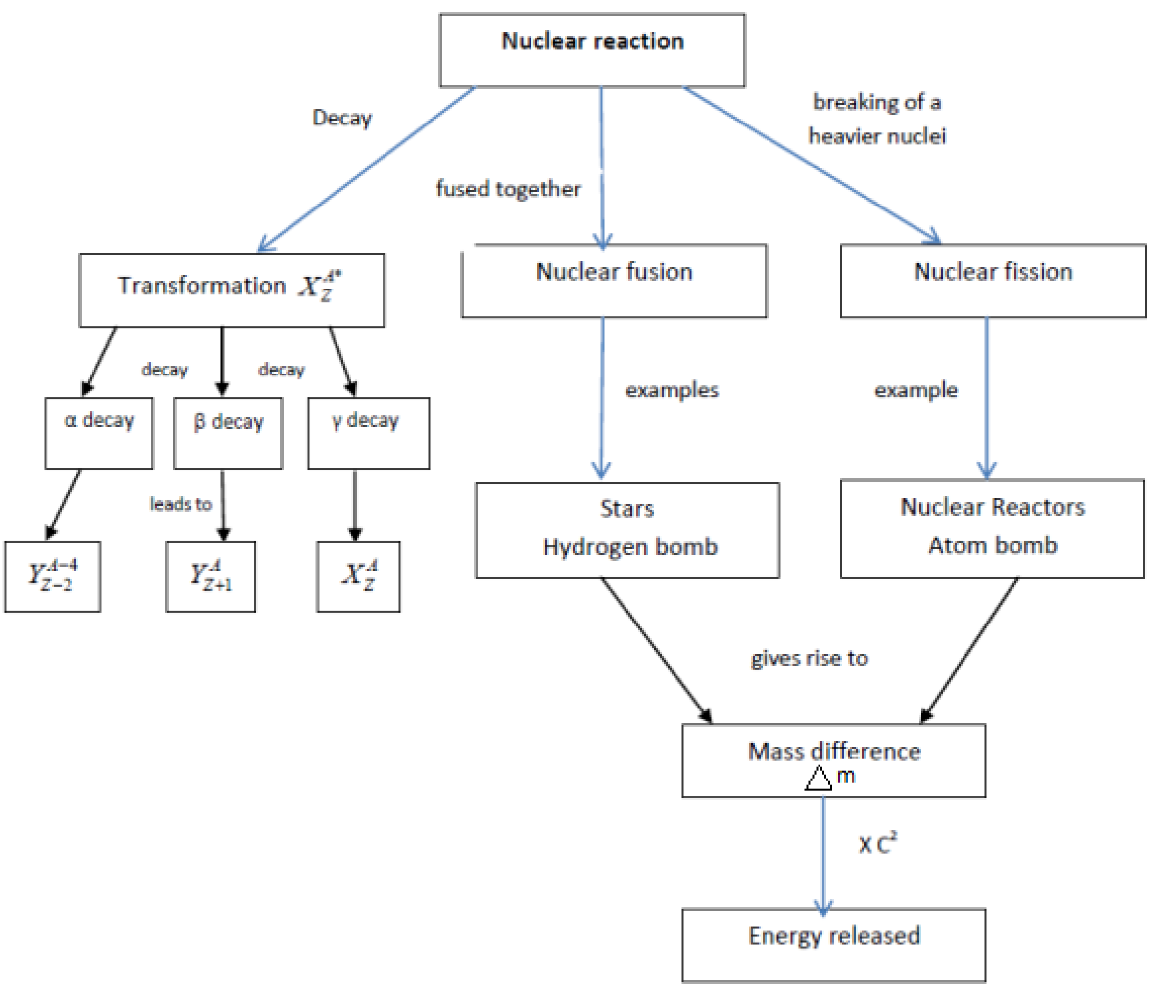
Distance of closest approach of the alpha particle in the α particle scattering experiment	$r_0 = \frac{2kZe^2}{1/2mv^2}$
Impact parameter of the alpha particle	$b = \frac{kZe^2 \cot\theta/2}{1/2mv^2}$
Bohr's model of atom	Limitations-applicable only for hydrogen like atoms & couldn't explain the splitting of spectral lines. (not consider electro static force among the electrons)
Orbit radius of the electron around the nucleus	$r=e^2/4\pi\epsilon_0 mv^2$, $v=2\pi ke^2 / nh$, $r=n^2h^2mke^2$
Energy of the electron in the nth orbit of hydrogen atom	$E_n= -me^4/8\epsilon_0^2n^2h^2 = -13.6/n^2$ eV $E=-2.18*10^{-18}$ J / n^2
Angular momentum of electron in any orbit is integral multiple of $h/2\pi$	$L = mvr = nh/2\pi$, n=1,2,3,…
Wave number $\bar{\nu}$	$1/\lambda = R(1/n_1^2 - 1/n_2^2)$ $R=1.097 * 10^{+7} m^{-1}$

	
Atomic Number (Z)	No of protons in a nucleus
Mass Number (A) Number of neutrons	No. of nucleons(protons + neutrons) in a nucleus A-Z
Nuclear radius	$R=R_0 A^{1/3}$
Nuclear density	$P= 3m/4\pi R_0^3$
Isotopes	Same Z & different A Ex, $^1H_2$,$^1H_3$,$^1h_1$, & C^{12},C^{14},C^{16}
Isobars	Same A & different Z [$_{18}Ar^{40}$,$_{20}Co^{40}$] & ($_1H^3$, $_2H^3$)
Isotones Map defect △ m	Same no. of neutrons Mass of neutrons – $_1H^3$, $_2He^4$
Binding energy E_b	$E=\triangle m \triangle c^2$ (m= mass of reactants – mass of products) 1 a.m.u.= 931.5 Mev
Radioactive decay law	$dN/dt=-\lambda N$ $-dW/dt= R=$ Activity unit Bq.
No: of nuclei remaining un-decayed at any instant of time	$N =N_0e^{-\lambda t}$ OR $N=N_0(½)^n$, $n = t/t_{1/2}$

Half life	$t_{1/2} = \frac{0.693}{\lambda}$
Mean life	$\tau = 1/\lambda$
3 types of radiations	Alpha,beta,gamma
Nuclear fission	Splitting of a heavy nucleus into lighter elements.This process is made use of in Nuclear reactor & Atom bomb Nuclear Reactor is based upon controlled nuclear chain reaction and has 1) Nuclear fuel 2) modulator 3) control rods 4) coolant 5) shielding
Nuclear fusion	Fusing of lighter nuclei to form a heavy nucleus.This process takes place in Stars & Hydrogen bomb. <u>Controlled Thermonuclear Fusion</u> In a fusion reactor- a) high particle density is required b) high plasma temperature of 10^9K c) a long confinement time is required

CONCEPT MAP

Nuclear energy



QUESTIONS

ALPHA PARTICLE SCATTERING

1. What is the distance of closest approach when a 5Mev proton approaches a gold nucleus (Z=79) (1)

Ans $r_{0}= \frac{1}{4\pi\varepsilon_\circ} \frac{Ze^2}{F_2}$ = 2.3 * 10^{-14}m.

2. Which has greater ionizing power: alpha or beta particle? (1)

BOHR'S ATOMIC MODEL

1. In Bohr's theory of model of a Hydrogen atom, name the physical quantity which equals to an integral multiple of h/2∏? (1)

***Ans**: Angular momentum*

2. What is the relation between 'n' & radius 'r' of the orbit of electron in a Hydrogen atom according to Bohr's theory? (1)

***Ans**: $r \propto n^2$*

3. What is Bohr's quantization condition? (1)

*4. For an electron in the second orbit of hydrogen, what is the moment of linear momentum as per the Bohr's model? (2)

***Ans**: L=2(h/2∏) =h/∏ (moment of linear momentum is angular momentum)*

5. Calculate the ratio of energies of photons produced due to transition of electron of hydrogen atoms from 2^{nd} level to 1^{st} and highest level to second level.E_{2-1} = Rhc[$1/n_1^2 - 1/n^2$] = ¾ Rhc

E∞ - E1 = Rhc($1/2^2 - 1/\infty$) = Rhc / 4 (3)

SPECTRAL SERIES

*1. What is the shortest wavelength present in the Paschen series of hydrogen spectrum? (2)

***Ans**: n_1=3, n_2=infinity, λ=9/R=8204Å*

2. Calculate the frequency of the photon which can excite an electron to -3.4 eV from -13.6 eV. ***Ans**: 2.5×10^{15}Hz* (2)

3. The wavelength of the first member of Balmer series in the hydrogen spectrum is 6563Å.Calculate the wavelength of the first member of Lyman series in the same spectrum.

***Ans**: 1215.4Å* (2)

4. The ground state energy of hydrogen atom is -13.6eV.What is the K.E & P.E of the electron in this state? (2)

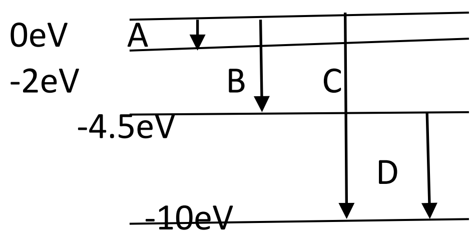
***Ans**: K.E=-E=13.6 eV, P.E=-2K.E=-27.2 eV*

*5. Find the ratio of maximum wavelength of Lyman series in hydrogen spectrum to the maximum wavelength in Paschen Series? (2)

***Ans**: 7:108*

*6. The energy levels of an atom are as shown below. a) Which of them will result in the transition of a photon of wavelength 275 nm? b) Which transition corresponds to the emission of radiation maximum wavelength?

(3)



***Ans**: E=hc/λ=4.5eV, transition B Eα1/λ, transition A*

*7. The spectrum of a star in the visible & the ultraviolet region was observed and the wavelength of some of the lines that could be identified were found to be 824Å,970Å,1120Å,2504Å,5173Å &6100Å.Which of these lines cannot belong to hydrogen spectrum? (3)

***Ans**: 970Å*

(3)

9. What is the energy possessed by an ē for n=∞ ?

Ans E=0 (1)

10. Calculate the ratio of wavelength of photon emitted due to transition of electrons of hydrogen atom from

i) Second permitted level to first level

ii) Highest permitted level to second level (3)

11. The radius of inner most electron orbit of H_2 atom is 5.3 x 10^{-11}m. What are radii for n=2, 3, 4? Ans: $r_n = n^2 r_1$(3)

COMPOSITION OF NUCLEUS

1. What is the relation between the radius of the atom & the mass number?(1)

***Ans**: size α $A^{1/3}$*

2. What is the ratio of the nuclear densities of two nuclei having mass numbers in the ratio 1:4?

***Ans**: 1:1* (1)

3. How many electrons, protons & neutrons are there in an element of atomic number (Z) 11& mass number (A) 24?

Hint: $n_e = n_p = 11$, $n_n = (A - Z) = 24 - 11 = 13$

4. Select the pairs of isotopes & isotones from the following: (2)

i. $^{13}C_6$ ii. $^{14}N_7$ iii. $^{30}P_{15}$ iv. $^{31}P_{15}$

***Ans**: isotopes-iii &iv ,isotones-i& ii*

5. By what factor must the mass number change for the nuclear radius to become twice? $\sqrt[3]{2}$ *or* $2^{\frac{1}{3}}$ *timeA* (2)

NUCLEAR FORCE & BINDING ENERGY.

1. What is the nuclear force? Mention any two important properties of it. (2)

2. Obtain the binding energy of the nuclei $^{56}Fe_{26}$ & $^{209}Bi_{83}$ in MeV from the following data: m_H=1.007825amu, m_n=1.008665amu, m($^{56}Fe_{26}$)=55.934939amu, m($^{209}Bi_{83}$)=208.980388amu, 1amu=931.5MeV

3. Which nucleus has the highest binding energy per nucleon? (3)

***Ans**: Fe →492.26MeV,8.79MeV/A Bi →1640.3MeV,7.85 MeVHence* $^{56}Fe_{26}$

4. From the given data, write the nuclear reaction for α decay of $^{238}_{92}U$ and hence calculate the energy released. $^{238}_{92}U$ = 238.050794u $^{4}_{2}He$ = 4.00260u $^{234}_{90}Th$ = 234.04363u (3)

5Binding Energy of $_8O^{16}$ & $_{17}C^{35}$ one 127.35 Mev and 289.3 Mev respectively. Which of the two nuclei is more stable stability & BE/N? (2)

RADIOACTIVITY

1. How is a β particle different from an electron? (1)

2. Draw graph between no. of nuclei un-decayed with time for a radioactive substance (1)

3. Among the alpha, beta & gamma radiations, which are the one affected by a magnetic field? (1)

***Ans**: alpha & beta*

4. Why do α particles have high ionizing power? (1)

***Ans**: because of their large mass & large nuclear cross section*

5. Write the relationship between the half life & the average life of a radioactive substance. (1)

***Ans**:* $T = 1.44 t_{1/2}$

6. If 70% of a given radioactive sample is left un-decayed after 20 days, what is the % of original sample will get decayed in 60 days? (2)

7. How does the neutron to proton ratio affected during (i)β decay ii) α decay(2)

8. A radioactive sample having N nuclei has activity R. Write an expression for its half life in terms of R & N. (2)

Ans: *$R=N\lambda$, $t_{1/2}=0.693/\lambda=0.693N/R$*

9. Tritium has a half life of 12.5 years against beta decay. What fraction of a sample of pure tritium will remain un-decayed after 25 years? (2)

Ans: *$N_0/4$*

10. What percentage of a given mass of a radioactive substance will be left un-decayed after 5 half-life periods? (2)

Ans: *$N/N_0=1/2^n=1/32=3.125\%$*

11. A radioactive nucleus 'A' decays as given below:

$$A \xrightarrow{\beta} A_1 \xrightarrow{\gamma} A_2$$

If the mass number & atomic number of A_1 are 180 & 73 respectively, find the mass number & atomic number of A & A_2 (2)

Ans: *A—180 & 72, A2—176 & 71*

12. Two nuclei P & Q have equal no: of atoms at t=0.Their half lives are 3 & 9 hours respectively. Compare the rates of disintegration after 18 hours from the start. (2)

Ans: *3:16*

*13. Two radioactive materials X_1& X_2 have decay constants 10λ & λ respectively. If initially they have the same no: of nuclei, find the time after which the ratio of the nuclei of X_1 to that of X_2 will be 1/e? Ans: $N=N_0e^{-\lambda t}$, $t=1/9\lambda$ (3)

*14. One gram of radium is reduced by 2.1mg in 5 years by decay. Calculate the half-life of Uranium.

Ans: *1672 years* (3)

*16. At a given instant there are 25% un-decayed radioactive nuclei in a sample. After 10 seconds the number of un-decayed nuclei reduces to 12.5 %.calculate the i) mean life of the nuclei ii) the time in which the number of the un-decayed nuclei will further reduce to 6.25 % of the reduced number.

Ans: *$t_{1/2}=10s$, $\lambda=.0693/s$, $\tau=1/\lambda=14.43s$, $N=1/16(N_0/8)\rightarrow t=4x10=40s$* (3)

17. Half lives of two substances A and B are 20 min and 40 min respectively. Initially the sample had equal no of nuclei. Find the ratio of the remaining no: of nuclei of A and B after 80 min.

Ans: 1:4 (3)

NUCLEAR REACTIONS

1. Why heavy water is often used in a nuclear reactor as a moderator? (1)

2. Why is neutron very effective as a bombarding particle in a nuclear reaction?(1)

***Ans**: Being neutral it won't experience any electrostatic force of attraction or repulsion.*

3. Why is the control rods made of cadmium? (1)

***Ans**: They have a very high affinity on neutrons.*

4. Name the phenomenon by which the energy is produced in stars. (1)

***Ans**: Uncontrolled Nuclear fusion*

5. Name the physical quantities that remain conserved in a nuclear reaction?(1)

6. What is neutron multiplication factor? For what value of this, a nuclear reactor is said to be critical? Ans: K=1 (2)

7. 4 nuclei of an element fuse together to form a heavier nucleus .If the process is accompanied by release of energy, which of the two: the parent or the daughter nuclei would have higher binding energy per nucleon. Justify your answer. (2)

8. If 200MeV energy is released in the fission of single nucleus of $^{235}_{92}U$, how much fission must occur to produce a power of 1 kW. (3)

VALUE BASED QUESTIONS

1. Medha's grandfather was reading article is newspaper. He read that after so many years of atomic bombing is Hiroshima or Nagasaki, Japan National census indicated that children born even now are genetically deformed. His grandfather was not able to understand the reason behind it. He asked his Granddaughter Medha who is studying in class XII science. Medha sat with her grandfather and showed him pictures from some books and explained the harmful effects of radiations.

(i) What are the values/ skills utilized by Kajal to make her grandfather understand the reason of genetically deformity?

(ii) Name the nuclear reactions that occurred is atom bomb.

2. Muthuswami a resident of Kundakulam was all set to leave everything and shift to another place in view of the decision of Govt. to start nuclear thermal power plant at Kundakulam. His granddaughter Prachi, a science student, was really upset on the ignorant decision of her grandfather. She could finally convince

him not to shift, since adequate safety measures to avoid any nuclear mishap have already been taken by the Govt. before starting nuclear thermal plants.

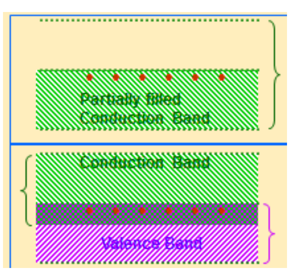
- What is the value displayed by Prachi in convincing her grandfather
- What is the principle behind working of nuclear reactor
- What are the main components of nuclear reactor

9. ELECTRONIC DEVICES

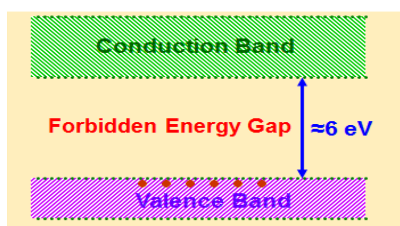
GIST

ENERGY BAND DIAGRAMS

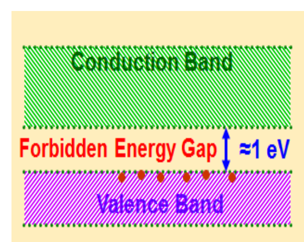
- In metals, the conduction band and valence band partly overlap each other and there is no forbidden energy gap.
- In insulators, the conduction band is empty and valence band is completely filled and forbidden gap is quite large = 6 eV. No electron from valence band can cross over to conduction band at room temperature, even if electric field is applied. Hence there is no conductivity of the insulators.
- In semiconductors, the conduction band is empty and valence band is totally filled. But the forbidden gap between conduction band and valence band is quite small, which is about 1 eV. No electron from valence band can cross over to conduction band. Therefore, the semiconductor behaves as insulator. At room temperature, some electrons in the valence band acquire thermal energy, greater than energy gap of 1 eV and jump over to the conduction band where they are free to move under the influence of even a small electric field. Due to which, the semiconductor acquires small conductivity at room temperature



Metals



Insulators



Semiconductors

Differences

Distinction between Intrinsic and Extrinsic Semiconductor

	Intrinsic		Extrinsic
1	It is pure semiconducting material and no impurity atoms are added to it	1	It is prepared by doping a small quantity of impurity atoms to the pure semiconducting material.
2	Examples are crystalline forms of pure silicon and germanium.	2	Examples are silicon and germanium crystals with impurity atoms of arsenic, antimony, phosphorous etc. or indium, boron, aluminum etc.
3	The number of free electron in conduction band and the number of holes in valence	3	The number of free electrons and holes is never equal. There is excess of electrons in n-type semiconductors and

	band is exactly equal and very small indeed.		excess of holes in p-type semiconductors.
4	Its electrical conductivity is low	4	Its electrical conductivity is high.
5	Its electrical conductivity is a function of temperature alone.	5	Its electrical conductivity depends upon the temperature as well as on the quantity of impurity atoms doped in the structure.

Distinction between n-type and p-type semiconductors

n-type semiconductors		p-type semiconductors	
1	It is an extrinsic semiconductors which is obtained by doping the impurity atoms of Vth group of periodic table to the pure germanium or silicon semiconductor.	1	It is an intrinsic semiconductors which is obtained by doping the impurity atoms of III group of periodic table to the pure germanium or silicon semiconductor.
2	The impurity atoms added, provide extra electrons in the structure, and are called donor atoms.	2	The impurity atoms added, create vacancies of electrons (i.e. holes) in the structure and are called acceptor atoms.
3	The electrons are majority carriers and holes are minority carriers.	3	The holes are majority carriers and electrons are minority carriers.
4	The electron density (n_e) is much greater than the hole density (n_h)i.e. $n_e >> (n_h)$	4	The hole density (n_e) is much greater than the electron density (n_h)i.e. $n_h >> n_e$
5	The donor energy level is close to the conduction band and far away from valence band.	5	The acceptor energy level is close to valence band and is far away from the conduction band.
6	The Fermi energy level lies in between the donor energy level and conduction band.	6	The Fermi energy level lies in between the acceptor energy level and valence band.

<u>P-n junction diode</u>

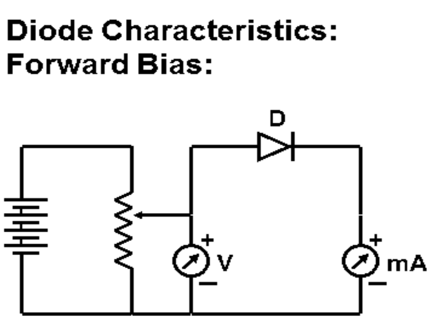
Two important processes occur during the formation of p-n junction diffusion and drift. The motion of majority charge carriers give rise to diffusion current.
Due to the space charge on n-side junction and negative space charge region on p-side the electric field is set up and potential barrier develops at the junction Due to electric field e- on p-side moves to n and holes from n-side to p-side which is called drift current.
In equilibrium state, there is no current across p-n junction and potential barrier across p-n junction has maximum value .
The width of the depletion region and magnitude of barrier potential depends on the nature of semiconductor and doping concentration on two sides of p-n junction.

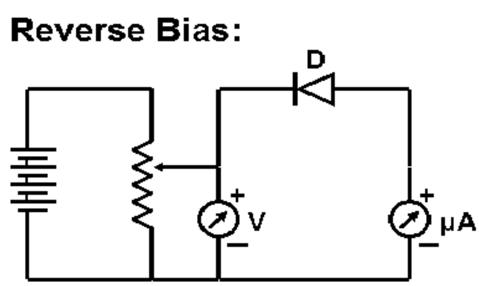
<u>Forward Bias</u>

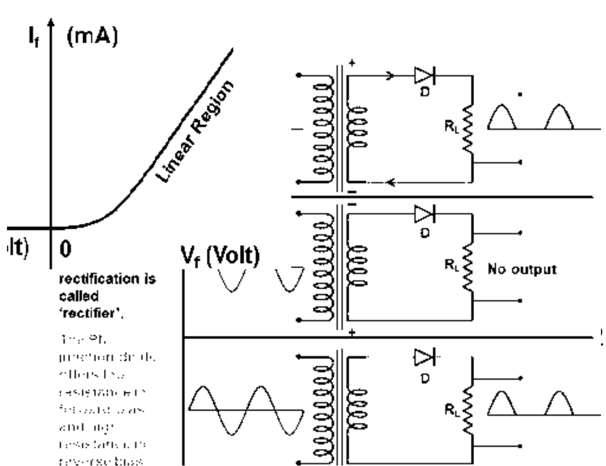
P-n junction is FB when p-type connected to the +ve of battery and n-type connected to –ve battery
Potential barrier is reduced and width of depletion layer decreases.

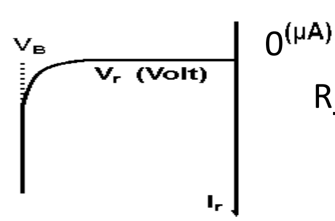
<u>Reverse Bias</u>

P-n junction in RB p-type connected to the –ve battery and n-type connected to +ve
Resistance of p-n junction is high to the flow of current.

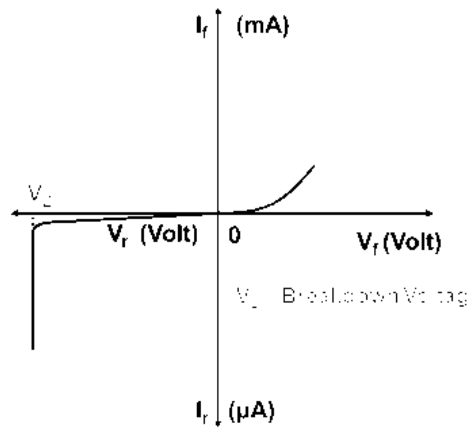


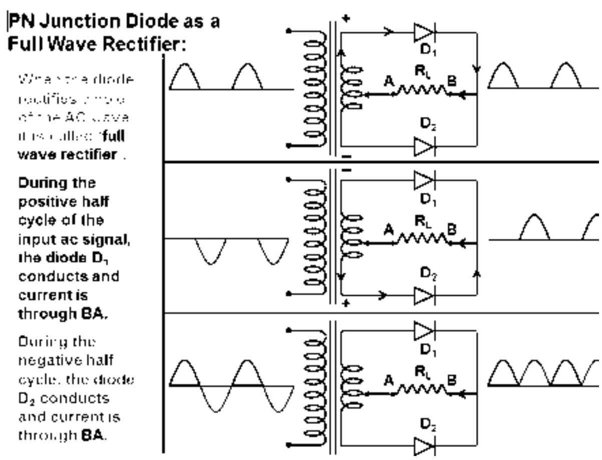




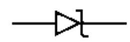


R**<u>rectification</u>**

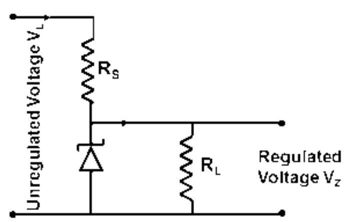




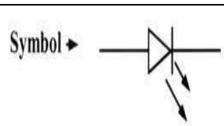
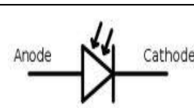
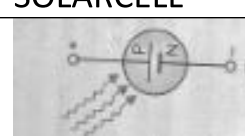
Zener Diode

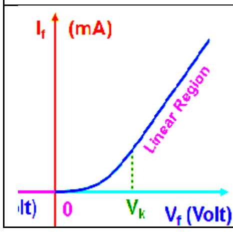
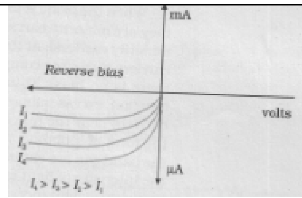
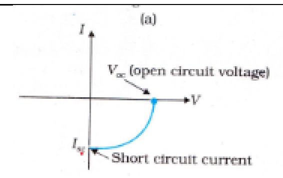


- Heavily doped
- Depletion Region is < 10^{-6} m
- Electric Field is very high (5×10^{6} V/m)
- Reverse biased
- Internal Field emission or field ionisation

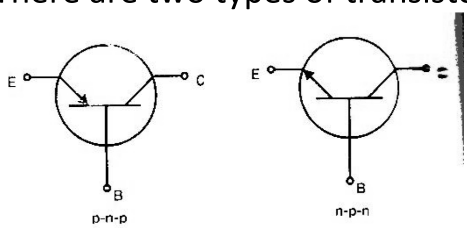


Zener Diode as a Voltage Regulator

LED	PHOTODIODE	SOLARCELL
		
Forward biased	Reverse biased	No external baising,It generates emf when

		solar radiation falls on it.
Recombination of electrons and holes take place at the junction and emits e m radiations	Energy is supplied by light to take an electron from valence band to conduction band.	Generation of emf by solar cells is due to three basic process generation of e-h pair,separation and collection
It is used in Burglar alarm, remote control	It is used in photo detectors in communication	It is used in satellites,space vechicles calculators.
		

- There are two types of transistor – NPN & PNP



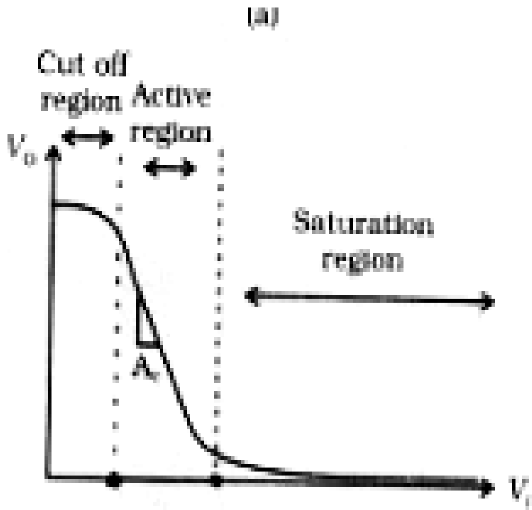
- Applications of transistor

(1) Transistor as a switch- (2) Transistor as an amplifier

- Transistor as an oscillator

Transistor- Switch

When a transistor is used in cut off or saturated state, it behaves as a switch.



Transistor-Amplifier_ An amplifier is a device which is used for increasing the amplitude of variation of alternating voltage or current or power,thus it produces an enlarged version of the input signal.

For Circuit diagram refer Ncert diagram

Common emitter amplifier

Current gain $\beta_{a.c} = \dfrac{\Delta I_C}{\Delta I_B}$

$$\beta_{d.c} = \frac{I_C}{I_B}$$

Voltage gain $A_v = \dfrac{V_o}{V_i} = -\beta_{ac} \times \dfrac{R_o}{R_i}$

Power gain $A_p = \dfrac{P_o}{P_i} = \beta_{ac} \times A_v$

Transistor-Oscillator-

- In an oscillator, we get ac output without any external input signal. In other words, the output in an oscillator is self- sustained. Oscillator converts D.C into A.C

Digital Electronics –Logic Gates

- The three basic Logic Gates are

(1) OR Gate

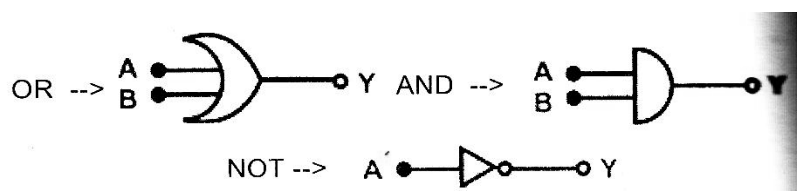
OUTPUT Y= A + B

(2) AND Gate

OUTPUT Y=A.B

(3) NOT GATE

OUTPUT Y=Y’

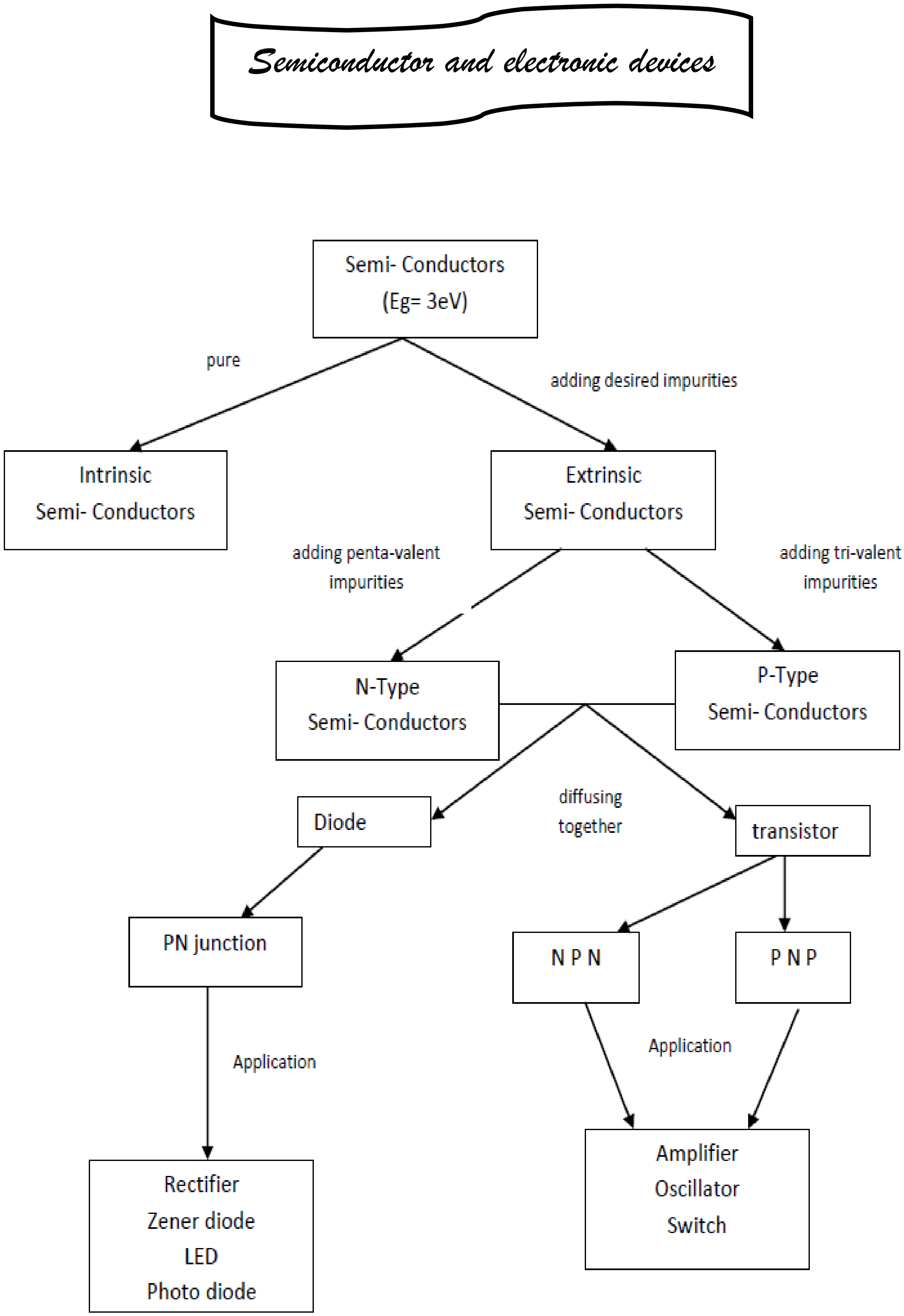


<u>COMBINATION OF GATES</u>

(1) NOR GATE--OUT PUT $Y = \overline{A+B}$

(2) NAND GATE--OUT PUT $Y= \overline{A .B}$

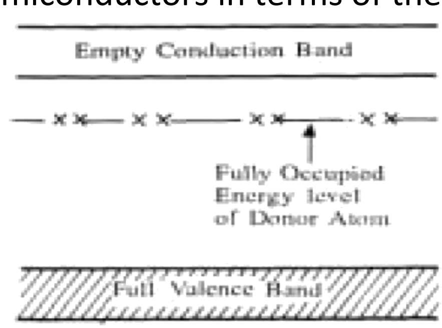
CONCEPT MAP

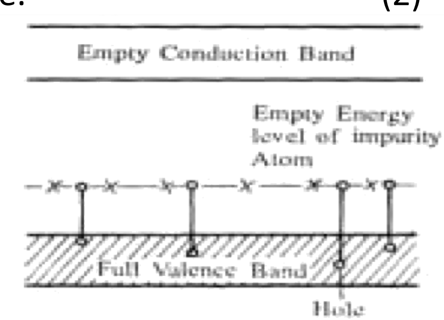

Semiconductor and electronic devices
Semi- Conductors
(Eg= 3eV)
pure
adding desired impurities
Intrinsic
Semi- Conductors
Extrinsic
Semi- Conductors
adding penta-valent
impurities
adding tri-valent
impurities
N-Type
Semi- Conductors
P-Type
Semi- Conductors
Diode
diffusing
together
transistor
PN junction
N P N
P N P
Application
Application
Rectifier
Zener diode
LED
Photo diode
Amplifier
Oscillator
Switch

QUESTIONS

SEMICONDUCTORS

1. What is the order of energy gap in an intrinsic semiconductor? (1)
2. How does the energy gap vary in a semiconductor when doped with penta - valent element? (1)
3. How does the conductivity change with temperature in semiconductor?(1)
4. What type of semiconductor we get when: Ge is doped with Indium? Si is doped with Bismuth? (1)
5. In a semiconductor concentration of electron is $8 \times 10^{13} cm^{-3}$ and holes $5 \times 10^{12} cm^{-2}$: is it P or
N type semiconductor? (1)
6. Draw energy gap diagram of a P Type semiconductor? (1)
7. What is Fermi energy level? (1)
8. Energy gap of a conductor, semiconductor, insulator are E1, E2, E3 respectively. Arrange them in increasing order. (1)
9. Name the factor that determines the element as a conductor or semiconductor? (1)
10. Why semiconductors are opaque to visible light but transparent to infrared radiations? (2)
Ans: The photons of infrared radiation have smaller energies, so they fall to excite the electrons in the valence band. Hence infrared radiations pass through the semiconductors as such; i.e. a semiconductor is transparent to infrared radiation
11. The ratio of number of free electrons to holes n_e/n_h for two different materials A and B are 1 and <1 respectively. Name the type of semiconductor to which A and B belongs. (2)
Ans: If $n_e/n_{h=1}$. Hence A is intrinsic semiconductor. If $n_e/n_h<1$, $n_e<n_h$ hence B is P-type.
12. Differentiate the electrical conductivity of both types of extrinsic semiconductors in terms of the energy band picture. (2)



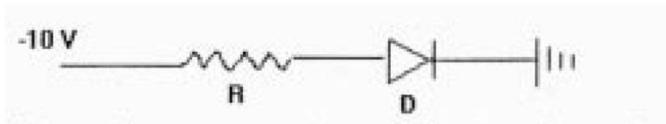


P-N JUNCTION DIODE

1. How does the width of depletion layer change, in reverse bias of a p-n junction diode? (1)

2. Draw VI characteristic graph for a Zener diode? (1)

3. In a given diagram, is the diode reverse (or) forward biased? (1)



Ans: Reverse biased.

4. Why Photo diode usually operated at reverse bias? (2)

5. State the factor which controls wave length and intensity of light emitted by LED. (2)

Ans: (i) Nature of semi-conductor

(ii) Forward Current

6. With the help of a diagram show the biasing of light emitting diode. Give two advantages over conventional incandescent Lamp. (2)

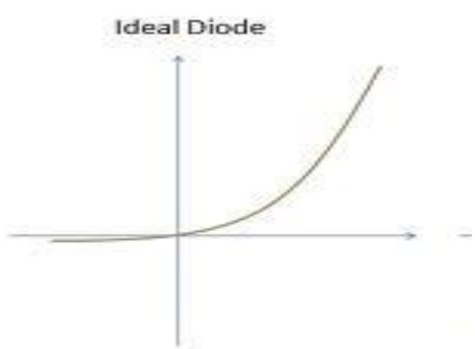
Ans: Mono chromatic, Consume less power.

8. Draw a circuit diagram to show, how is a photo diode biased? (2)

9. Pure SI at 300K have equal electron and holes concentration 1.5×10^{16} per m^3. Doping by Indium increases hole concentration to 4.5×10^{22} per m^3. Calculate new electron concentration.

Ans: $n_e n_h = n_i^2$ (2)

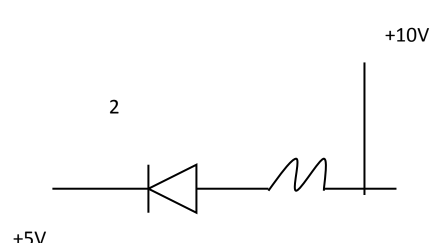
10. V-I characteristics of SI diode is given. Calculate diode resistance for bias voltage 2V. (2)

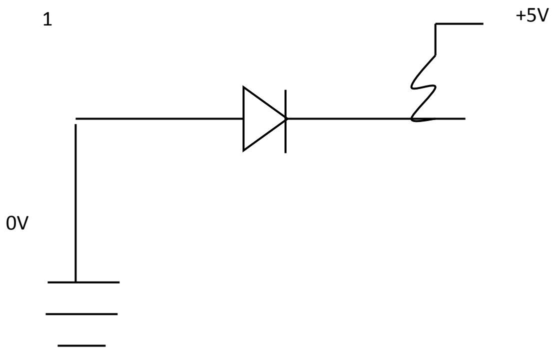


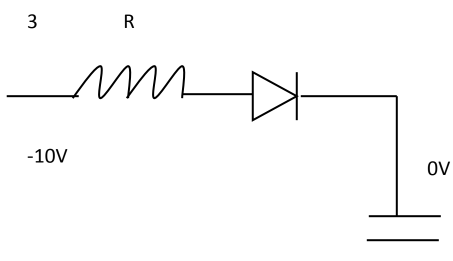
Ans: $R = V / I = 2/70 \times 10^{3}$ Ohms

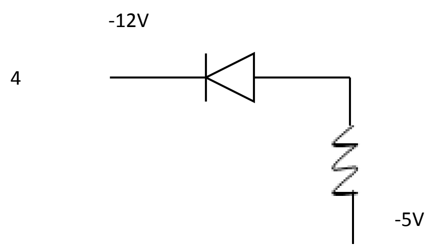
11. What is an ideal diode? Draw its output wave form.

13. In the following diagram, identify the diodes which are in forward biased and which are in reversed biased.









*14. A semiconductor has equal electron and hole concentrations of $6x10^8/m^3$. On doping with a certain impurity, the electron concentration increases to $9x10^{12}/ m^3$. (2)

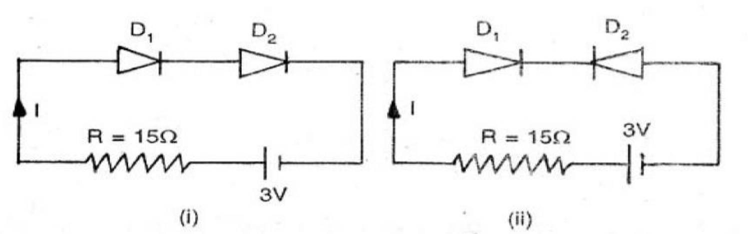
(i) Identify the new semiconductor obtained after doping.

(ii) Calculate the new hole concentrations.

Ans: (i) n-type semiconductor.

(ii) $n_e n_h = n_i^2 \Rightarrow n_h = \underline{6x10^8 x6x10^8 = \ \ }$ $4x10^4$ $perm^2$

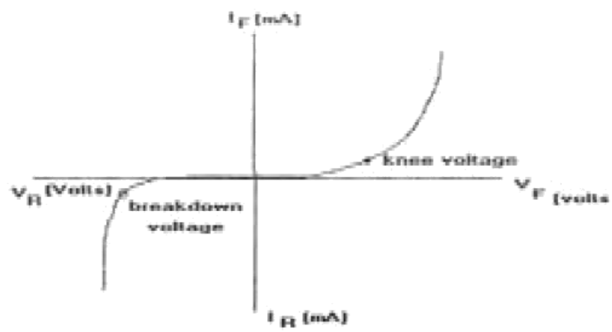
*15. Determine the current through resistance "R" in each circuit. Diodes D1 and D2 are identical and ideal. 2



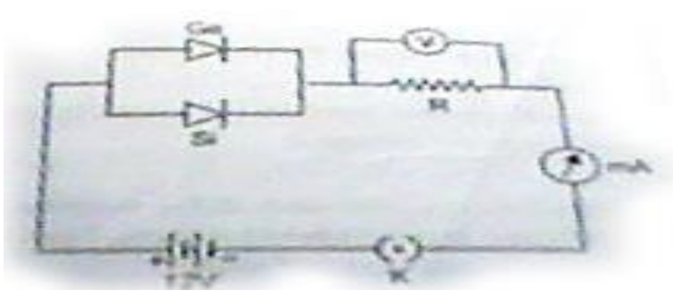
Ans: In circuit (i) Both D1 and D2 are forward biased hence both will conduct current and resistance of each diode is "0".Therefore I = 3/15 = 0.2 A

(i) Diode D1 is forward bias and D2 is reverse bias, therefore resistance of diode D1 is "0" and resistance of D2 is infinite. Hence D1 will conduct and D2 do not conduct. No current flows in the circuit.

16. From the given graph identify the knee voltage and breakdown voltage. Explain? (2)



*17. Germanium and silicon junction diodes are connected in parallel. A resistance R, a 12 V battery, a milli ammeter (mA) and Key(K) is closed, a current began to flow in the circuit. What will be the maximum reading of voltmeter connected across the resistance R? (2)



Ans: The potential barrier of germanium junction diode is 0.3v and silicon is 0.7V, both are forward biased. Therefore for conduction the minimum potential difference across junction diode is 0.3V.Max.reading of voltmeter connected across R=12-0.3=11.7V.

18.A Zener diode has a contact potential of .8Vin the absence of biasing .It undergoes breakdown for an electricfield of 10V/m at the depletion region of p-n junction.If the width of the depletion region is 2.4µm?What should be the reverse biased potential for the Zener breakdown to occur? 2

*18. A germanium diode is preferred to a silicon one for rectifying small voltages. Explain why? (2)

Ans: Because the energy gap for Ge (Eg = 0.7 ev) is smaller than the energy gap for Si (Eg = 1.1eV) or barrier potential for Ge<Si.

19. On the basis of energy band diagrams, distinguish between metals, insulators and semiconductors. (3)

SPECIAL DEVICES

*1. A photodiode is fabricated from a semiconductor with a band gap of 2.8eV.can it Can it detect a wavelength of 600nm?Justify? (2)

Ans: Energy corresponding to wavelength 600 nm is

$$E = hc/\lambda = \frac{6.6\times10^{-34} \times 3\times10^{8}}{600\times10^{-9}} \text{ joule} = 0.2\text{eV}.$$

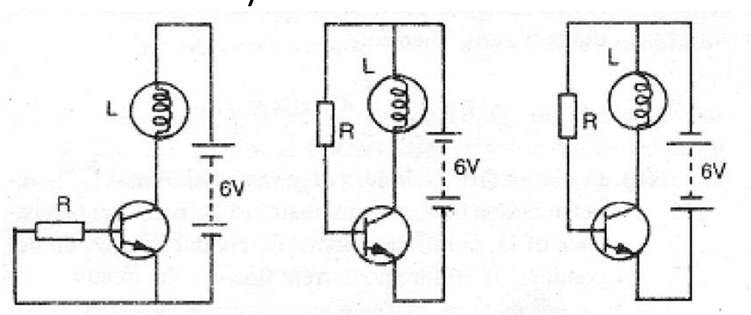
It cannot detect because $E<E_g$

2. Which special type of diode acts as voltage regulator? Give the symbol. Draw its V-I characteristics. (3)

TRANSISTORS

1. How does the dc current gain of a transistor change, when the width of the base region is increased? (1)

*2. In only one of the circuits given below, the lamp "L" glows. Identify the circuit? Give reason for your answer? (2)



(i) (ii) (iii)

Ans: In fig (i) emitter –base junction has no source of emf. Therefore Ic =0, bulb will not glow. In fig (ii) emitter – base junction is forward biased; therefore lamp "L" will glow.

(iii) emitter – base junction is received biased so the bulb will not glow.

*3. Why do we prefer NPN transistor to PNP for faster action? (2)

Ans: For faster action NPN Transistor is used. In an NPN transistor, current conduction is mainly by free electron, whereas in PNP type transistor, it is mainly holes. Mobility of electrons is greater than that of holes.

4. In which mode, the cut off, active or saturation, the transistor is used as a switch? Why? (2)

Ans: Cut off & saturation

5. In NPN transistor circuit, the collector current is 5mA. If 95% of the electrons emitted reach the collector region, what is the base current? (2)

Here,

I_c=95% of Ie = $(95 / 100)\, I_e$

$I_e = (100 / 95) \times 5$ mA = 5.26mA,

$I_e = I_c + I_b$

I_b = 0.25 mA

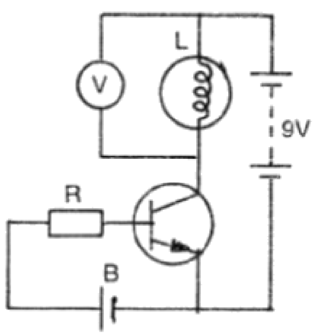
6. A student has to study the input and output characteristics of a n-p-n silicon transistor in the common emitter configuration. What kind of a circuit arrangement should she use for this purpose? Draw the typical shape of input characteristics likely to be obtained by that student.

(Ans: Fig 14.29, pg 493 & 494 NCERT-Part-2 physics

7. Which of input and output circuits of a transistor has a higher resistance and why? (3)

Ans: The output circuit of a transistor has a higher resistance. Hint: The ratio of resistance of output circuit (r_0) is 10^4 times that of input circuit ie $r_o = 10^4 r_i$;

*8. In the circuit diagram given below, a volt meter is connected across a lamp. What changes would occur at lamp "L" and voltmeter "V", when the resistor R is reduced? Give reason for your answer. (3)



Ans: In the given circuit, emitter –base junction of N-P-N transistor is forward biased.

When "R" decreases, I_E increases. Because $I_C = I_E - I_B$. Therefore I_C will also increase. Hence bulb will glow with more brightness and voltmeter reading will increase.

9. The base current of a transistor is 105 μA and collector current is 2.05 mA. (3)

a) Determine the value of β, Ie, and α

b) A change of 27 μA in the base current produces a change of 0.65 mA in the collector current. Find β a.c.

$Ib = 105 \times 10^{-6} A$ $Ic = 2.05 \times 10^{-3} A$

$\beta = Ic / Ib = 19.5$

Also,

$Ie = Ib + Ic = 2.155 \times 10^{-3} A$

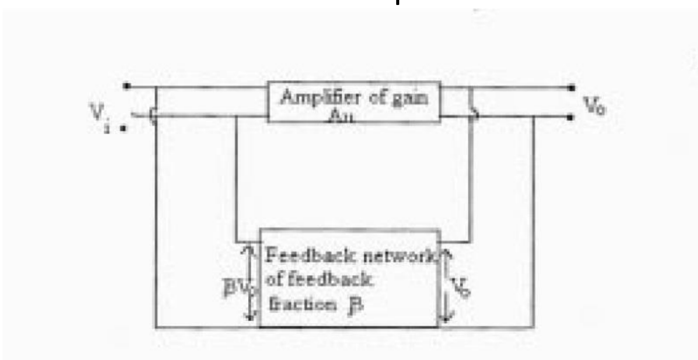
$\alpha = Ic / Ie = 0.95$

$\Delta Ib = 27\mu A = 27 \times 10^{-6}$
A

$\beta^{ac} = \Delta Ic / \Delta Ib = 24.1$

10. Under what conditions an amplifier can be converted in to an oscillator? Draw a suitable diagram of an oscillator. (3)

Hint: 1. when feedback is positive. 2. When feedback factor k is equal to l /A_v.



11. Explain through a labeled circuit diagram, working of a transistor, as an amplifier in common emitter configuration. Obtain the expression for current gain, voltage gain and power gain. (3)

12. Draw a circuit diagram to study the input and output characteristic of an NPN transistor in common emitter configuration. Draw the graphs for input and output characteristics. (3)

13. Define trans conductance of a transistor. (2)

Ans: $g_m = \Delta I_C / \Delta V_B$

14. How does the collector current change in junction transistor if the base region has larger width?

Ans: Current decreases. (2)

15. The input of common emitter amplifier is 2KΏ. Current gain is 20. If the load resistances is
5KΏ. Calculate voltage gain trans conductance. (3)

Ans: $g_m = \beta / RI$, $Av = \beta\ RL/RI$

16. Define input, output resistance, current amplification factor, voltage amplification factor, for common emitter configuration of transistor. (3)

17. A change 0.2 mA in base current, causes a change of 5mA in collector current in a common emitter amplifier.

(i) Find A.C current gain of Transistor.

(ii) If input resistance 2KΏ and voltage gain is 75. Calculate load resistance used in circuit.

β AC current gain = β **ΔIc / Δ Ib** **(3)**

19. In a transistor the base current is changed by 20µA. This results in a change of 0.02V in base emitter voltage and a change of 2mA in collector current. (3)

(i) Find input resistance,

(ii) Trans conductance.

20. With the help of circuit diagram explain the action of a transistor. (3)

21. Draw the circuit diagram to study the characteristic of N-P-N transistor in common emitter configuration. Sketch input – output characteristic for the configuration. Explain current gain, voltage gain. (3)

22. Draw the transfer characteristics of a transistor in common emitter configuration. Explain briefly the meaning of the term active region and cut off region in this characteristic. (3)

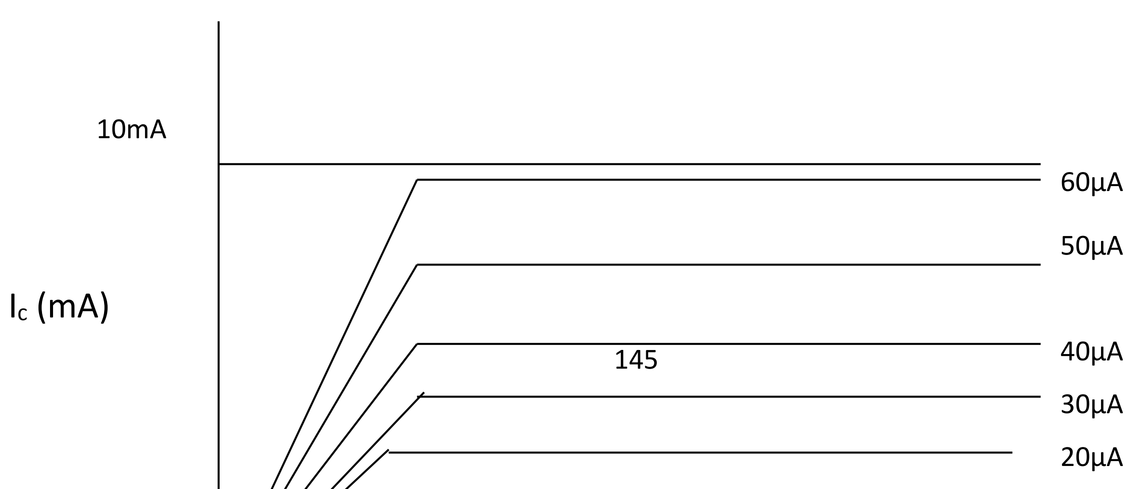
23. Explain with the help of a circuit diagram the working of N-P-N transistor as a common emitter amplifier. Draw input and output wave form. (3)

24. Draw a labeled circuit diagram of common emitter amplifier using P-N-P transistor. Define voltage gain and write expression. Explain how the input and output voltage are out of phase 180^o for common emitter transistor amplifier.(3)

25. The output characteristic of transistor is shown.

(i) Find current amplification

(ii) Output Resistance



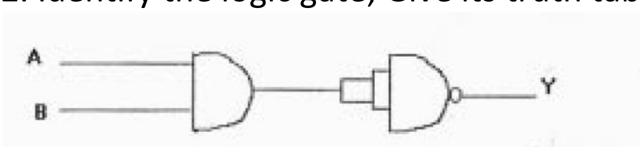
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 V_{CE} (V)

LOGIC GATES

*1. Modern technology use poly silicon instead of metal to form the gate. Why? (1)

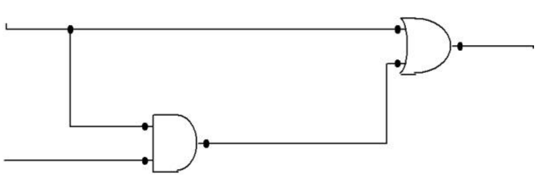
Ans: Poly silicon has high conductivity compared to metal.

2. Identify the logic gate; Give its truth table and output wave form? (1)



Ans: NAND GATE.

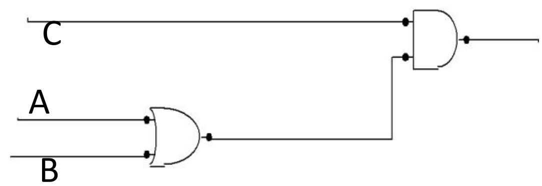
*3. Draw the logic circuit and the output wave form for given output Y=0, 0, 1, 1 (2)



Ans: The output of the AND gate is Y = A.B consequently the input of the OR gate are A and A.B . Then the final Y = A + A.B

Input for AND gate		Output of AND gate	Input of OR gate		output of OR gate
A	B	Y= A.B	A	Y	Y = A + Y
0	0	0	0	0	0
0	1	0	0	0	0
1	0	0	1	0	1
1	1	1	1		1

*4. Construct the truth table for the Boolean equation Y=(A+B).C and represent by logic circuit. (2)



Ans: The output of OR gate is A+B. Consequently, the inputs of AND gate are A+B & C Hence the Boolean equation for the given circuit is Y=(A+B).C

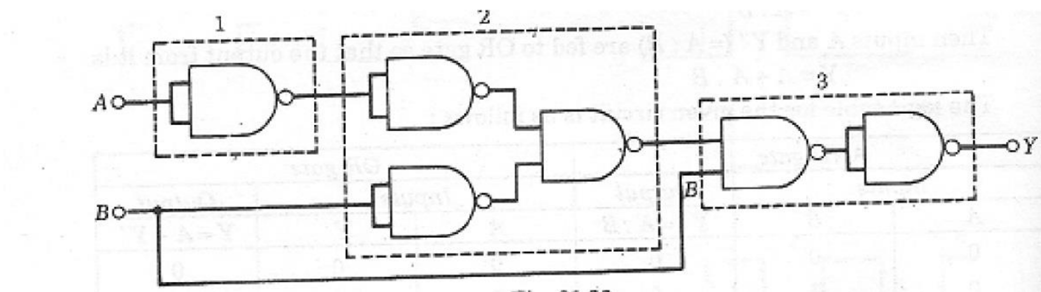
A	B	C	Y'=A+B	Y=(A+B).C=Y'.C
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	1	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	1

*5. Construct AND gate using NAND GATE and give its truth table? (2)

Ans: AND Gate using NAND GATE:-

A	B	Y= A.B
0	0	0
0	1	0
1	0	0
1	1	1

6. Identify which basic gate OR, AND and NOT is represented by the circuits in the dotted lines boxes 1,2 and 3. Give the truth table for the entire circuit for all possible values of A and B? (3)



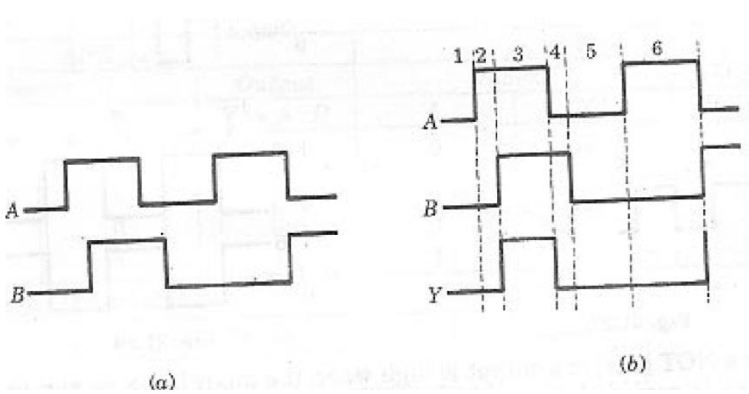
Ans: The dotted line box 1 represents a NOT gate. The dotted line box 2 represents an OR gate. Here we use de Morgan's theorem. The dotted line 3 represents AND gate.

7. Two input waveforms A and B shown in figure (a) and (b) are applied to an AND gate. Write the output

(3)

Time interval	1	2	3	4	5	6
Input A	0	1	1	0	0	1
Input B	0	0	1	1	0	0
Output Y = A.B	0	0	1	0	0	0

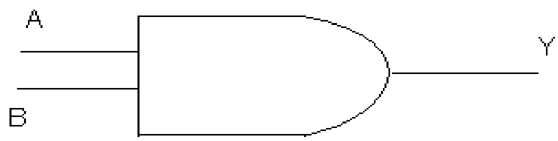
Input waveform

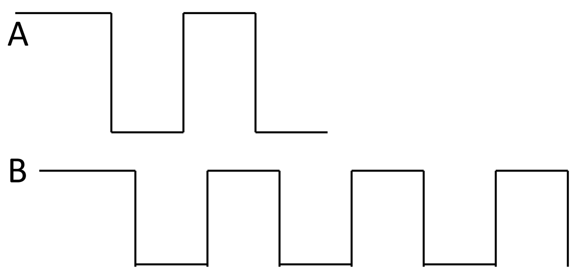


8. A circuit symbol of a logic gate and two input wave forms A and B are shown.

a) Name the logic gate

b) Give the output wave form





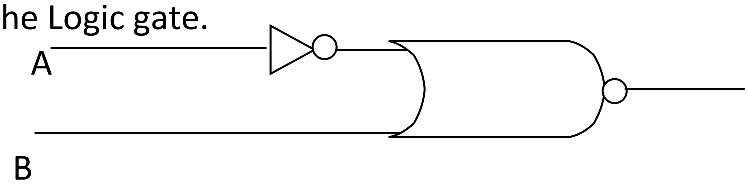
a. Name the logic gate

b. Give the output wave form

(3)

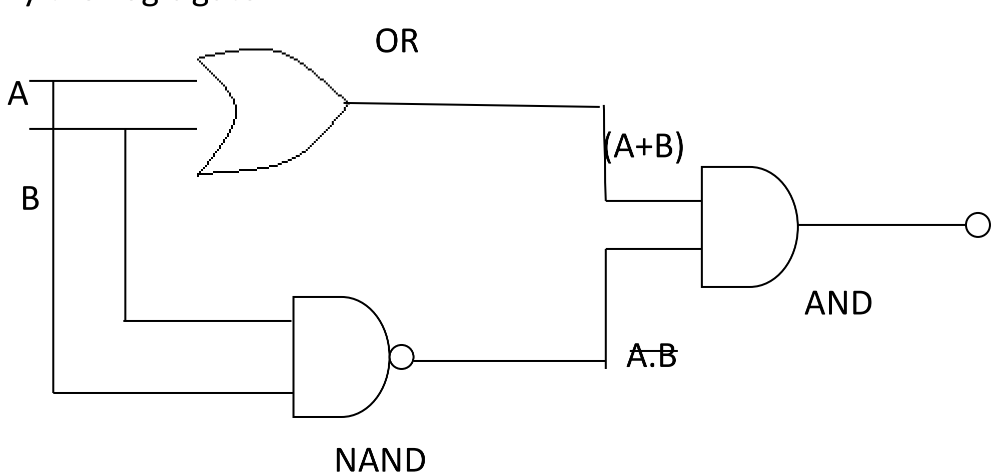
Ans: Current amplifier = **ΔIc / Δ Ib = 9.5 – 2.5 / 50 x 10** $^{-6}$

1. Identify the Logic gate.



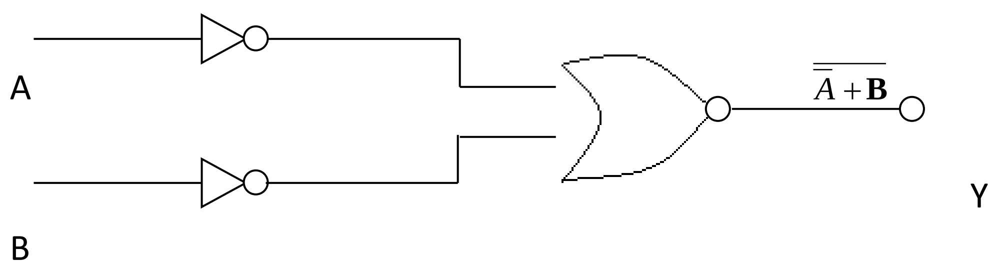
Y = $\overline{\bar{A}+\mathbf{B}}$

2. Identify the Logic gate



Ans: Y = (A+$\overline{B}$) AB

3. Identify the gate:



Ans: AND Gate

VALUE BASED QUESTIONS

1. Ritu's grandparents were planning to go for a long trip to Kashi from their home town Nagpur. Ritu's father asked the grandparents to take one mobile phone with them. But the grandparents denied it telling that they were practiced to live without it. Now Ritu took much effort to convince the grandparents and finally they agreed. What are the values exhibited by ritu?The circuits in mobile phones essentially contain transistors. If two transistor amplifiers of voltage gain 20 and 5 are cascaded in series, find the voltage gain of the combination.

2. Ritu's relatives planned to have DJ programme till midnight for her brother's marriage. Hearing this Ritu opposes the plan and tells that latenight programme will disturb the sleep of neighbouring people. The relatives got convinced. Here what are the social values exhibited by her.
The amplifier systems used in DJ programme uses transistor amplifier in common emitter configuration. Calculate the collector current and emitter current if the base current is 50 μA and current gain is 4.

3. Two students namely Ranjan and Praveen was asked to take up a project on efficient lighting for road ways, cycle paths and bus lanes. They found LED IS THE BEST source for the above said reasons. They collected the information from various sources and submitted the project about its working, advantages and its applications by presenting with a good working model.

a) By seeing these two students, what kind of qualities you want adopt from them.

b) Explain LED with neat diagram and draw its symbol.

(**ANS:** a) Initiative, curiosity, punctuality, obedience & b) Refer NCERT text book)

4. I went out for shopping with my mother; during purchase of vegetables I noticed that the Vendor used a digital weighing machine. On another shop, I noticed the vendor was using an ordinary weighing machine. So I used to go to the shop with digital machine. I remembered having studied about Logic Gates where, digital codes are used.

a) What do you mean by Logic Gate? Mention the basic universal gates.

b) What is the value, in your opinion, that I created by the above incident.

(**ANS:** a) **–**Refer NCERT Text book;

c) concentration and observation in the class room, retaining capacity, co-relating of what was taught with the real life incident)

5. Arun and Naveen studying in KENDRIYA VIDYALAYA watched the film "Swadesh" together getting inspiration from the film,they realized the need of the hour for the conservation of energy. Together they decided to do something for the nation. With the help of their school teachers and principal they arranged an exhibition to depict the various renewable sources of energy and the applications of it.

a) What values must have highlighted so that the youngsters are motivated?

b) Explain the working of a solar cell with a neat diagram.

(ANS: a) Need to conserve energy with the motto of sustainable development in fulfilling the needs of the present generation without compromising the need of the future generation, taking an initiative, bringing awareness among the students and the society. (b) Refer NCERT text book)