QUESTION BANK

(Fully solved)

Class- XII

PHYSICS

Part-1

Based on latest syllabus

2016-17

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PGT Physics

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UNIT-I: Electrostatics:

VERY SHORT ANSWER TYPE QUESTIONS: 1 –MARK

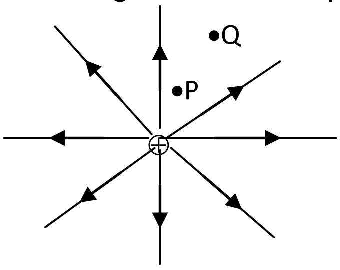
Q1. What is the electric flux through a cube of side 1 cm which encloses an electric dipole?

Q2. Define dielectric constant of a medium. What is its S.I. unit?

Q3. A point charge +Q is placed in the vicinity of a conducting surface. Trace the field lines between the charge and the conducting surface.

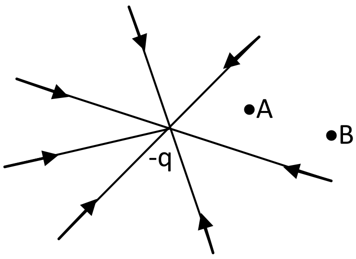
Q4.Write a relation for polarisation $\vec{P}$ of a dielectric material in the presence of an external electric field $\vec{E}$.

Q5.The figure shows the field lines of a positive point charge. What will be the sign of the potential energy difference of a small negative charge between the points Q and P? Justify your answer.

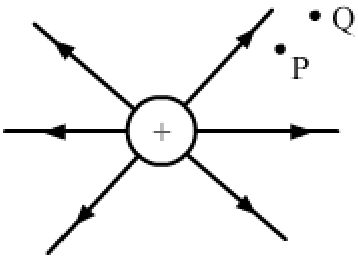


Q6. Depict the electric field lines due to two positive charges kept a certain distance apart.

Q7. The field lines of a negative point charge are as shown in the figure. Does the kinetic energy of a small negative charge increase or decrease in going from B to A?



Q8. The figure shows the field lines on a positive charge. Is the work done by the field in moving a small positive charge from Q to P positive or negative? Give reason.



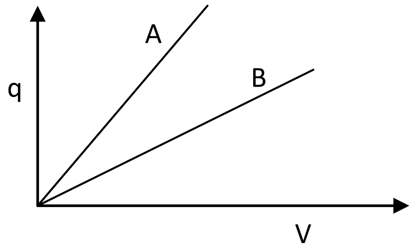
Q9. Why do the electrostatic field lines not form closed loops?

Q10. Define the term 'electric polarisation' of a dielectric medium. Write its S.I. unit.

Q11. Why must electrostatic field lines be normal to the surface at every point of charged conductor?

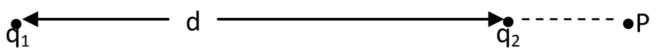
Q12."For any charge configuration, equipotential surface through a point is normal to the electric field." Justify.

Q13. The given graph shows variation of charge ‘q’ versus potential difference ‘V’ for two capacitors C_1 and C_2. Both the capacitors have same plate separation but plate area of C_2 is greater than that of C_1. Which line (A or B) corresponds to C_1 and why?



Ans: because slope (q/V) of B is lesser than the slope is A.

Q14. Two point charges q_1 and q_2 are place d at a distance‘d’ apart as shown in the figure. The electric field intensity is zero at a point ‘p’ on the line joining them as shown. Write two conclusions that you can draw from this.



Q15.A charge ‘q’ is placed at the centre of a cube of side ℓ. What is the electric flux passing through each face of the cube?

Q16. Can electrostatic potential at a point, be zero, while electric field at that point is not zero? Give an example.

Q17. An electron is projected in the direction of uniform electric field with certain velocity. What will be the effect on the kinetic energy of electron? **Ans:** decreases

Q18. How does the energy of dipole change when it in rotated from unstable equilibrium to stable equilibrium in a uniform electric field. **Ans.:** decreases

Q19.Two points A and B are taken on the axial line and equatorial line respectively, of an electric dipole. At which point, the electric field due to dipole is anti-parallel to electric dipole moment?

Q20. A dielectric medium of dielectric strength 9×10^6 V/m is filled between the plates of a parallel plate capacitor having effective capacitance of 1 μF and plate separation 1 cm. Determine the charge on the capacitor.

Q21. Why do two electric field lines not intersect each other?

Q22. “The electric field lines are always continuous” Why?

Q23. What is angle between electric dipole moment and electric field strength to it on its axial line?

Q24. What is angle between electric dipole moment and electric field strength to it on its equatorial line?

Q25.A thin metallic spherical shell of radius (R) carries the charge Q on it. A point charge (q) is placed at its centre and another charge (q_1) is placed outside at distance (r) from its centre. What is force experienced by charge (q)?

Q26.An electron is travelling in a region of electrostatic potential V_1 passes into region V_2 (V_2>V_1)

What change would you observe in its kinetic energy?

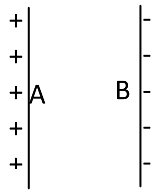
Q27.What is ratio of electric potential due to electric dipole in the end on position to the broad on position for the same distance from its centre?

Q28.The electric field strength at distance (r) from the centre of a charged spherical shell of radius (R) is E. If r>R, how much work would be done in bringing a test charge (q_0) from infinity to that point.

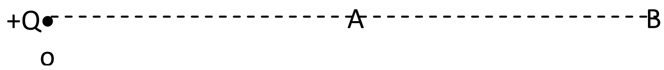
Q30.Two identical rings of radius (r) are placed coaxially. The distance between their centres is (r). What is amount of work done to move a point charge (q) from centre of one ring to centre of another ring?

Q31. Plot a graph to show the variation of electric potential (V) due to charged spherical shell of radius (R) as the function of distance (r) from its centre.

Q32. What change in force would be experienced when a charge (q) is moved from point A to B between a charged parallel plate capacitor?



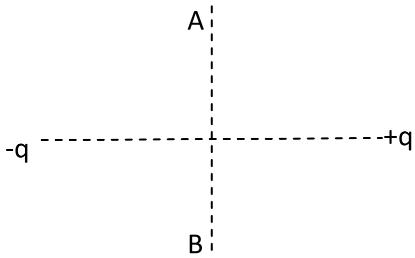
Q33. A point charge +Q is placed at point O as shown in the figure. Is the potential difference VA – VB positive, negative or zero? **CBSE-2016(D)**



Q34. How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased? **CBSE-2016(D)**

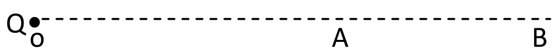
Q35.A charge ‘q’ is moved from point A above a dipole of dipole moment ‘p’to a point B below the dipole in equatorial plane without acceleration. Find the work done in the process.

[CBSE: 2016(C)]

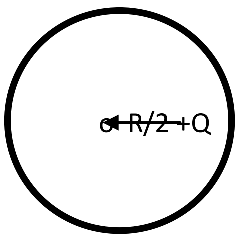


Q36. Define electric flux. Write its SI unit.**CBSE-2016(F)**

Q37. A point charge Q is placed at point o as shown in the figure. The potential difference V_A - V_B is positive. Is charge Q negative or positive? **CBSE-2016(F)**



Q38.Figure shows a point charge +Q, located at a distance R/2 from the centre of a spherical metal shell. Draw the electric field lines for the given system. **CBSE SQP-2016**



SHORT ANSWER TYPE QUESTIONS: 2-MARKS

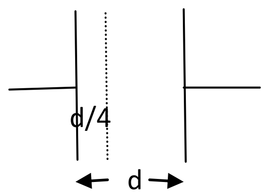
Q1. An electric dipole is placed in a uniform electric field $\vec{E}$ with its dipole moment $\vec{p}$ parallel to the field.

(i) Find the work done in turning the dipole till its dipole moment points in the direction opposite to $\vec{E}$

(ii) the orientation of the dipole for which the torque acting on it becomes maximum.

Q2. In which orientation, a dipole placed in a uniform electric field is in (i) Stable, (ii) Unstable equilibrium?

Q3.A capacitance C has distance between plates (d). A very thin mesh wire is placed as shown. Calculate new capacitance.

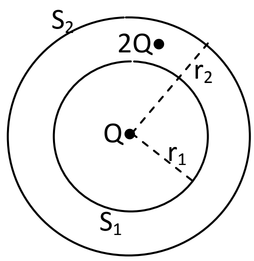


Q4. Two point charges q and – 2q are kept'd' distance apart. Find the location of the point relative to charge 'q' at which potential due to this system of charges is zero.

Ans: At distance d/3 from charge q.

Q5. A sphere S_1 of radius r_1 encloses a net charge Q. If there is another concentric sphere S_2 of radius r_2 ($r_2 > r_1$) enclosing charge 2Q, find the ratio of the electric flux through S_1 and S_2.

How will the electric flux through sphere S_1 change if a medium of dielectric constant K is introduced in the space inside S_2 and S_1 in place of air?



Hint: Ratio of flux = 1:3
No change in flux through S_1 with dielectric medium inside the sphere S_2

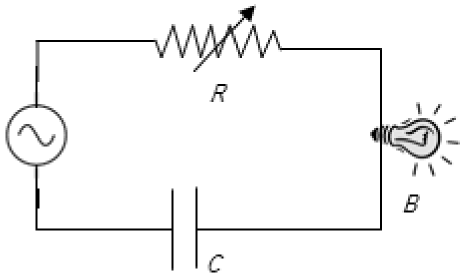
Q6. An electric dipole is held in a uniform electric field,

Show that the net force acting on it is zero.

The dipole is aligned parallel to the field. Find the work done in rotating it through the angle of 180^0.

Q7. A capacitor 'C', a variable resistor 'R' and a bulb 'B' are connected in series to the ac mains in circuit as shown. The bulb glows with some brightness. How will the glow of the bulb change, if

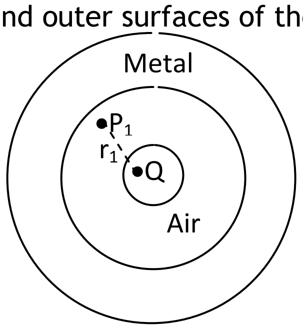
(i) a dielectric slab is introduced between the plates of the capacitor, keeping resistance R to be the same



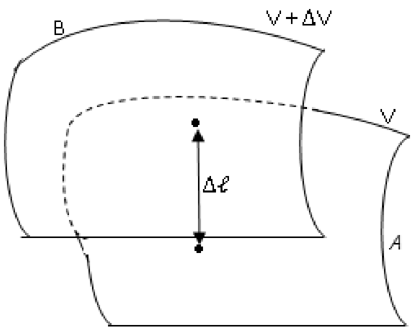
(ii) The resistance R is increased keeping the same capacitance?

Q8. Two point charges q_1 and q_2 are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in an external electric field $\vec{E}$ obtain the expression for the total work done in assembling this configuration.

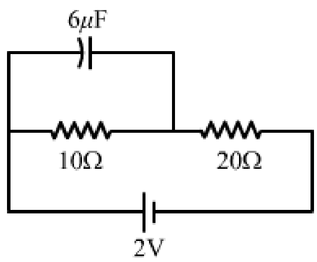
Q9. A small metal sphere carrying charge +Q is located at the centre of a spherical cavity in a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P1.



Q10. Two closely spaced equipotential surfaces A and B with potentials V and V + ΔV, (where ΔV is the change in V), are kept Δ l distance apart as shown in the figure. Deduce the relation between the electric field and the potential gradient between them. Write the two important conclusions concerning the relation between the electric field and electric potentials.



Q11. Find the charge on the capacitor as shown in the circuit.

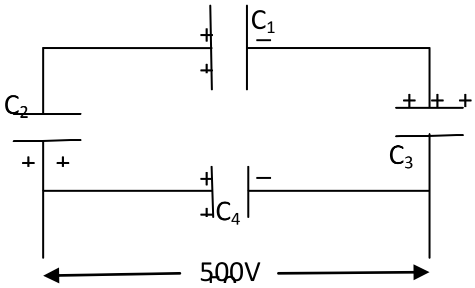


Q12. Given a uniform electric field $\vec{E}$ = 4 x 10^3 $\hat{\imath}$ N/C. Find the flux of this field through a square of 5 cm on a side whose plane is parallel to the Y-Z plane. What would be the flux through the same square if the plane makes a 30^0 angle with the x-axis? **Ans: 10Nm^2/C, 5Nm^2 /C**

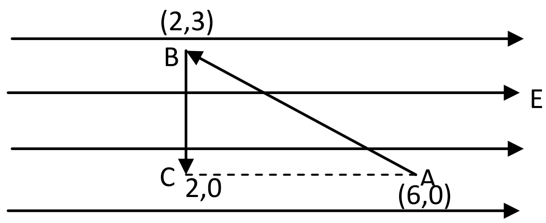
Q13.Two long thin parallel wires having linear charge density 2 x10^{-9} C/m and – 3 x 10^{-9} C/m are kept 20 cm apart in air. Find the magnitude and direction of the electric field at a point 10 cm from each wire.

Q14. An electric dipole of length 1cm with its axis making an angle of 60^o, which placed with uniform electric field, experiences a torque of $6\sqrt{3}$ Nm. Calculate the potential energy of the dipole if it has charge $\pm$ 2 nC. **Ans: -6J**

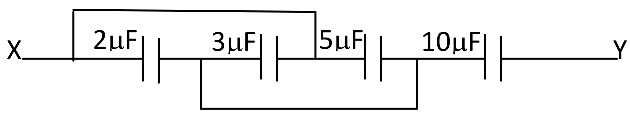
Q15. A network of four 10 μF capacitors is connected to a 500 V supply as shown in the figure. Determine the (a) equivalent capacitance of the network and (b) charge on each capacitor.



Q16. A test charge 'q' is moved without acceleration from A to C along the path from A to B and then from B to C in electric field as shown in figure. (i) Calculate the potential difference between A and C . (ii) At which point (of the two) is the electric potential more and why?



Q17. Calculate Equivalent capacitance between X and Y of the following network. **Ans** 5μF



Q18. Three charges, each equal to (+q) are placed at three corners of a square of side (a). Find the electric field at the forth corner. Ans $(2\sqrt{2} + 1)q/8\pi\varepsilon_0 a^2$

Q19. Two charged particles, having equal charges of $2.0\text{x } 10^{-5}$ C each, are brought from infinity to within a separation of 10cm. Find the increase in the electric potential energy during the process.Ans:36J

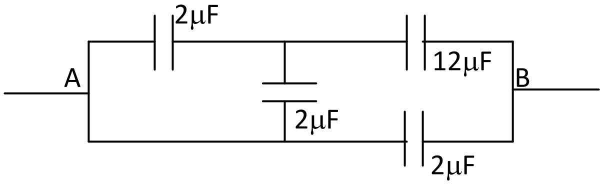
Q20. Two identical metal ball of radius R with charge +2Q and –Q are separated by some distance and exert a force (F) on each other. They are joined by a conducting wire and then removed to same distance. Calculate the new (i) force between them (ii) surface charge density.

Q21.A spherical charged conductor has surface charge density (σ). The electric field intensity on its surface is (E). If radius is doubled keeping the surface charge density unchanged. What is new electric field at its surface? Justify your answer.

Q22.How does the potential energy of two charges change when we increase the separation between them it (i) they have same sign (ii) they have opposite sign?

Q23.The separation between the parallel plate capacitor is (d). A metal plate of thickness y = d/2 is inserted between its plate. What is ratio of capacitance after insertion to the capacitance before insertion of metal plate?

Q24.Calculate the equivalent capacitance of the given network between points A and B; Ans: 5μF



Q25.Derive an expression for the work done in rotating a dipole from the angle θ_0 to θ_1 in a uniform electric field E. CBSE 2016 (E)

SHORT ANSWER TYPE QUESTIONS: 3-MARKS

Q1. Obtain an expression for electric field at any point on the axial line of an electric dipole. How does this electric field differ from the electric field due to a point charge?

Q2. (a) Why does electric field inside a charged parallel plate capacitor decrease when we introduce a dielectric slab between its plates?

(b) A fully charged parallel plate capacitor is connected across an uncharged identical capacitor; Show that the energy stored in the combination is less than that stored initially in the single capacitor.

Q3. Define equipotential surface and write down its two properties. Draw equipotential surfaces due to an electric dipole.

Q4.Write the expression for electric potential energy of system of two charges. Draw a graph showing variation of potential energy with separation between two (i) similar charges and (ii) opposite charges.

Q5.State and explain Gauss's law. Find out the outward flux due to a point charge + q placed at the centre of a cube of side 'a'. Why is it found to be independent of the size and shape of the surface enclosing it? Explain.

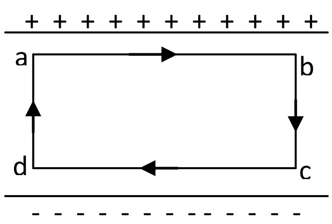
Q6. (a) Derive the expression for the capacitance of a parallel plate area A and plate separation d.

(a) Two charged spherical conductors of radii R_1 and R_2 are connected by a conducting wire acquire charges q_1 and q_2 respectively. What is ratio of surface charge densities in terms of their radii?

Ans: $\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$

Q7. (a) Obtain the expression for the energy stored per unit volume in a charged parallel plate capacitor.

(b) The electric field inside a parallel plate capacitor is E. Find the amount of work done in moving a charge q over a closed rectangular loop a b c d a.



Q8. (a) Define dielectric constant. Write down its unit.

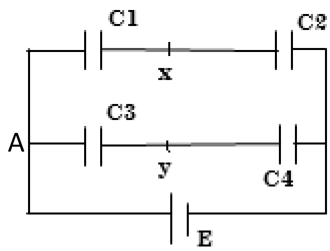
(b) When dielectric slab is introduced between the plates of a capacitor connected to a battery. Which of the following quantities change and why?

(a) Charge (b) potential difference(c) Energy of capacitor (d) Energy density between the plates.

Q9. If the separation between the plated of charged parallel plate capacitor is increased (i) Battery remain connected (ii) battery is disconnected, which of the following quantities will change in both situations and why? (a) Charge (b) potential difference (c) Energy of capacitor.

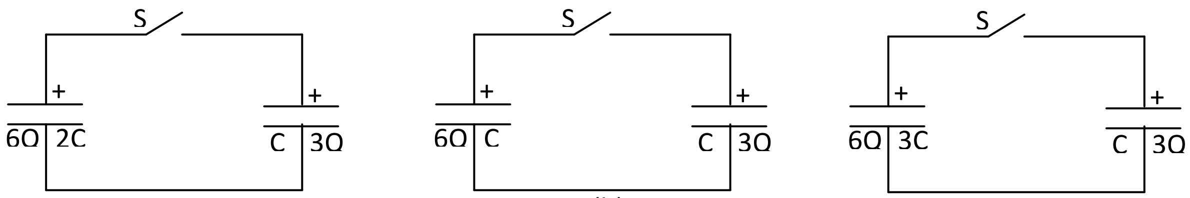
Q10. Obtain expression for electric field intensity at a point on the axis of a uniform charged ring of radius (r) and linear charge densityλ.

Q11. Find the potential difference between points X and Y of the circuit shown in figure. Given that C1= 2μF, C2 = 3μF, C3 = 4μF, C4 = 5μF and E = 5V. **Ans:** 0.22V



Q12.Two long straight parallel wires have charge density $+\lambda_1$ and $+\lambda_2$ per unit length. They are separated by a small distance ‘r’ apart in vacuum. Find the magnitude of force per unit length between them. **Ans:** $\lambda_1 \lambda_2 / 2\pi\varepsilon_0 r$.

Q13. Three circuits, each consisting of a switch ‘S’ and two capacitors, are initially charged, as shown in the figure. After the switch has been closed, in which circuit will the charge on the left-hand capacitor (i) increase, (ii) decrease and (iii) remain same ? Give reasons



(a) (b) (c)

Q14. Explain briefly the process of charging a parallel plate capacitor when it is connected across a d.c. battery. A capacitor of capacitance ‘C’ is charged to ‘V’ volts by a battery. After some time the battery is disconnected and the distance between the plates is doubled. Now a slab of dielectric constant, 1 < k < 2, is introduced to fill the space between the plates. How will the following be affected;

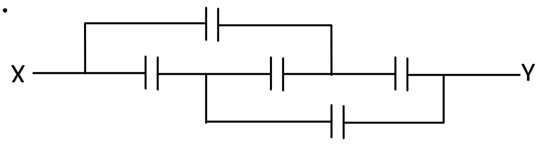
(a) the electric field between the plates of the capacitor?

(b) the energy stored in the capacitor?

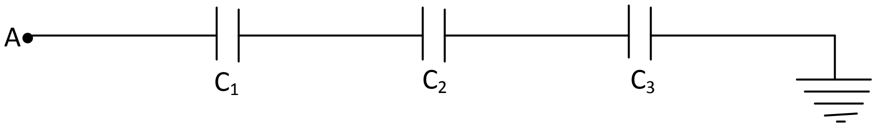
Justify your answer by writing the necessary expressions.

Q15. A 600 pF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to another uncharged 300 pF capacitor. Calculate how much electrostatic energy is lost in the process. What is the source of energy loss?

Q16. Find the equivalent capacitance of the network shown in the figure, when each capacitor is of 1μF. When the ends X and Y are connected to a 6 V battery, find out (i) the charge and (ii) the energy stored in the network.



Q17. Calculate the potential difference and the energy stored in the capacitor C2 in the circuit shown in the figure. Given potential at A is 90 V, C1 = 20 μF, C2 = 30 μF and C3 = 15 μF.



Q18. Two capacitors of unknown capacitances C1 and C2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and 0.25 J respectively, determine the value of C1 and C2. Also calculate the charge on each capacitor in parallel combination. **Ans: C1 = 11.8μF**

Q19.Two capacitors of capacitances C_1 and C_2 such that $C_1 = 2C_2$ are connected in turn (i) in series and (ii) in parallel across the same battery. In which of the two cases will the (a) energy stored and (b) charge acquired be more? Justify your answer.

Q20. Two point charges + 6q and – 8q are placed at the vertices 'B' and 'C' of an equilateral triangle ABC of side 'a' as given in the figure. Obtain the expression for (i) the magnitude and (ii) the direction of the resultant electric field at the vertex A due to these two charges.

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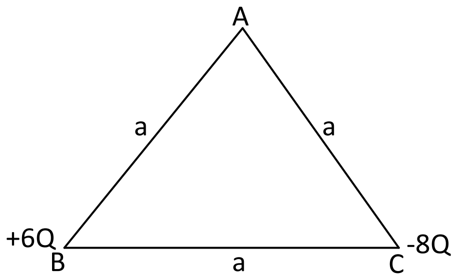
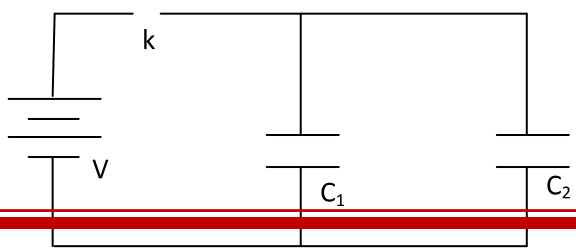


Ans: E = $\frac{1}{4\pi\epsilon_0}\frac{q\sqrt{52}}{a^2}$ Direction: $\alpha = \tan^{-1}\left(\frac{6\sqrt{3}}{(10)}\right)$ with AC

Q21. Two parallel plate capacitors of capacitances C1 and C2 such that C1 = 3C2 are connected across a battery of V volts as shown in the figure. Initially the key (k) is kept closed to fully charge the capacitors. The key is now thrown open and a dielectric slab of dielectric constant (k) is inserted in the two capacitors to completely fill the gap between the plates. Find the ratio of (i) the net capacitance and (ii) the energies stored in the combination, before and after the introduction of the dielectric slab.



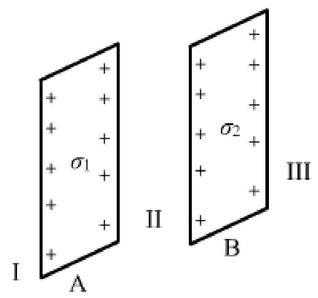
Q22.Two capacitors of capacitance 10 μF and 20 μF are connected in series with a 6 V battery. After the capacitors are fully charged, a slab of dielectric constant (K) is inserted between the plates of the two capacitors. How will the following be affected after the slab is introduced?

(a) The electric energy stored in the capacitors.

(b) The charges on the two capacitors.

(c) The potential difference between the plates of the capacitors. Justify your answer.

Q23.(a) A point charge (+Q) is kept in the vicinity of an uncharged conducting plate. Sketch the electric field lines between the charge and the plate (b) Two infinitely large plane thin parallel sheets having surface charge densities σ_1 and σ_2 ($\sigma_1 > \sigma_2$) are shown in the figure. Write the magnitudes and directions of the net fields in the regions marked II and III



Q24. In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the separation between the plates is 3 mm.

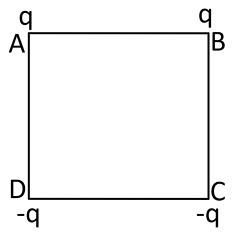
(i) Calculate the capacitance of the capacitor.

(ii) If this capacitor is connected to 100 V supply, what would be the charge on each plate?

(iii) How would charge on the plates be affected, if a 3 mm thick mica sheet of K = 6 is inserted between the plates while the voltage supply remains connected? .

Q25. A charge +Q is distributed uniformly over a thin uniform circular loop of radius R. Deduce an expression for the amount of work done in moving a test charge 'q' from centre to a point on its axis at a distance 'x' from the centre . Ans: $[Qq/4\pi\varepsilon_0]$ $[(r-R)/rR]$ where $r = \sqrt{(R^2+ r^2)}$

Q26. Charges are placed on the vertices of a square of side 'a' as shown above. Calculate electric field and potential at the centre of the square. If charges on A and B are interchanged with those on D and C, then which one Electric field Or electric potential will change?



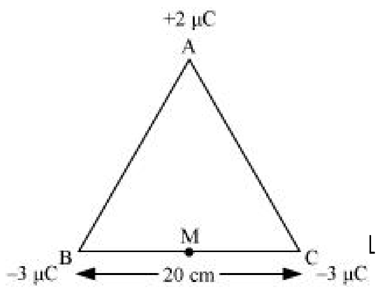
Q27.An alpha particle and a proton are accelerated at same potential difference from the rest. Find the ratio of their final (i) velocity (ii) Kinetic energies (iii) Momentum .**Ans** $1:\sqrt{2}$, 2:1, $2\sqrt{2}:1$

Q28. A proton placed in a uniform electric field of magnitude 2000NC^{-1}.

It moves between two points in the direction of the electric field.

If the distance between the points is 0.2 m, find the value of

(i)Force acting on proto in electric field. **Ans** 3.2×10^{-16}N



(ii) Potential difference between the points. **Ans** 400V

Work done Ans: 6.4×10^{-17}J

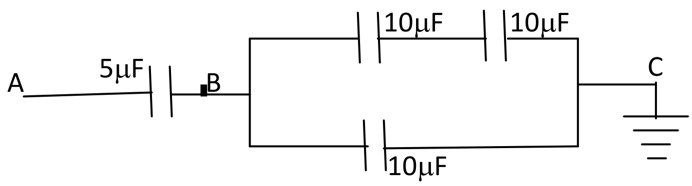
Q29.Three point charges of + 2 μC, − 3μC and − 3μC are kept at the vertices A, B and C respectively of an equilateral triangle of side 20cm as shown in the figure. What should be the sign and magnitude of the charge to be placed at the mid-point (M) of side BC so that the charge at A remains in equilibrium?

Q30.An electric dipole of dipole moment $\vec{p}$ placed perpendicular in uniform electric field of strength $(\vec{E})$. What is its (i) potential energy (ii) force and (iii) torque experienced by the electric dipole in this situation? What will be effect on these quantities if the electric dipole is taken from this situation to unstable equilibrium?

Q31. In a parallel plate capacitor, the region between the plates is completely filled by dielectric slab of dielectric constant K. The capacitor is charged from a battery and then disconnected from it. Now the dielectric slab is now taken out. What will be effect on (i) potential energy stored (ii) electric field between the plates and (iii) potential difference across the plates of capacitor? Justify your answers.

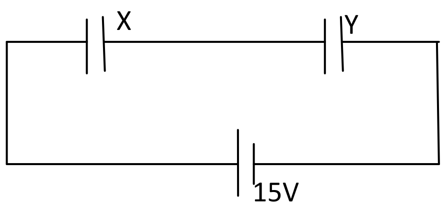
Q32. In a parallel plate capacitor, the region between the plates is completely filled by dielectric slab of dielectric constant K. The capacitor is charged from a battery. Now the dielectric slab is now taken out while the battery remains connected. What will be effect on (i) potential energy stored (ii) charge on the plates and (iii) potential difference across the plates of capacitor? Justify your answers.

Q33.In the given circuit if the point C is connected to earth and a potential of +2000V is given to point A. What is potential at point 'B?'



Q34. A charge is distributed uniformly over a ring of radius 'a'. Obtain an expression for the electric intensity E at a point on the axis of the ring. Hence show that for points at large distances from the ring, it behaves like a point charge.**CBSE-2016-D**

Q35. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric medium of $\varepsilon_r = 4$.



(i) Calculate capacitance of each capacitor if equivalent capacitance of combination is 4μF.

(ii) Calculate the potential difference between the plates of X and Y.

(iii) Estimate the ratio of electrostatic energy stored in X and Y.

CBSE-2016-D

Q36. Define equipotential surface. Draw equipotential surfaces: - **[CBSE:2016(C)]**

(i) in the case of a single point charge and

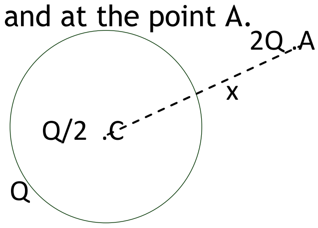
(ii) in a constant electric field in Z-direction.

Why the equipotential surfaces about a single charge are not equidistant?

(iii) Can electric field exist tangential to an equipotential surface? Give reason.

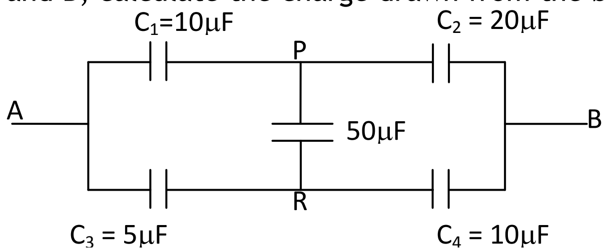
Q37. A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge *Q/2* is placed at its centre C and another charge +2Q is placed outside the shell at a distance *x* from the centre as shown in the figure. Find (i) the electric flux through shell (ii) State the law used (iii) Find the force on the charges at the centre C of the shell and at the point A.

CBSE 2016(E)



Q38.Calculate the equivalent capacitance between points A and B in the circuit below. If the battery of 10V is connected across A and B, calculate the charge drawn from the battery by the circuit.

CBSE-2016(E)

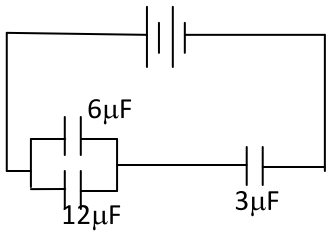


Q39.In the following arrangement of capacitors, the energy stored in the 6μF capacitor is E. Find the value of the following;

(i)Energy stored in 12μF capacitor.

(ii)Energy stored in 3μF capacitor.

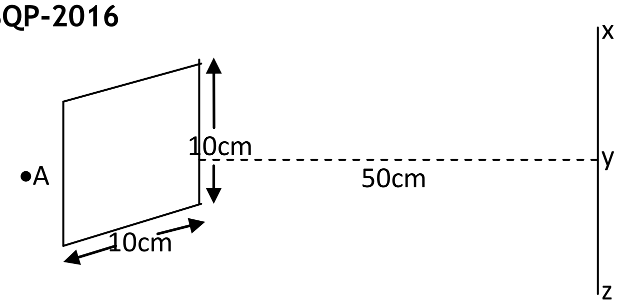
(iii)Total energy drawn from the battery.



Q40.Given a uniformly charged plane/sheet of surface charge density $\sigma = 2x10^{17} C/m^2$.

(i) Find the electric field intensity at a point A, 5mm away from the sheet on the left side.

(ii) Given a straight line with three points X, Y and Z placed 50cm away from the charged sheet on the right side. At which of these points, the field due to the sheet remain the same as that A and why?**SQP-2016**



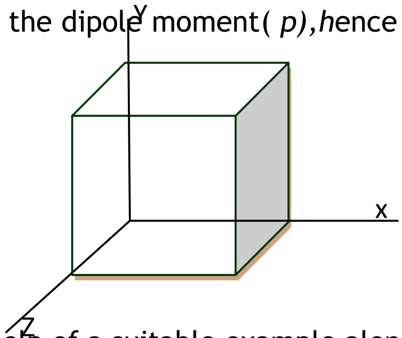
LONG ANSWER TYPE QUESTIONS: 5-MARKS

Q1. (a) "The outward electric flux due to charge +Q is independent of shape and size of the surface which encloses it." Give two reasons to justify this statement.

(b) Two identical circular loops '1' and '2' of radius R each have charge densities $-\lambda$ and $+\lambda$ C/m respectively. The loops are placed coaxially with their centres $R\sqrt{3}$ distance apart. Find the magnitude and direction of net electric field at the centre of loop '1'.

2. (a) An electric dipole of dipole moment $\vec{p}$ consists of point charges $+q$ and $-q$ separated by a distance 2a apart. Deduce the expression for the electric field E due to the dipole at a distance x from the centre of the dipole on its axial line in terms of the dipole moment(p),hence show that in the limit $x >>> a, E \rightarrow 2p / 4\pi\varepsilon_0 x^3$.

(b) Given the electric field in the region $\vec{E} = 2x\hat{i}$, find the net electric flux through the cube and the charge enclosed by it.



Q3. (a) State Gauss's law in electrostatics. Show, with the help of a suitable example along with the figure that the outward flux due to a point charge 'q', in vacuum within a closed surface, is independent of its size or shape and is given by q/ε_0.

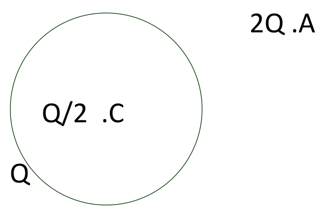
(a) Two parallel uniformly charged infinite plane sheets, '1' and '2', have charge densities $+\sigma$ and -2σ respectively. Give the magnitude and direction of the net electric field at a point

(i) in between the two sheets and

(ii) outside near the sheet '1'.

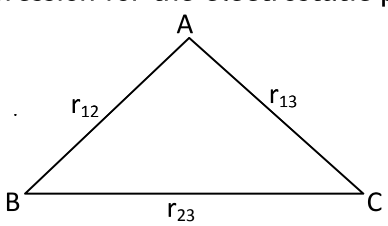
Q4. Explain, using suitable diagrams, the difference in the behaviour of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

(b) A thin metallic spherical shell of radius R carries a charge Q on its surface. A point charge $Q/2$ is placed at its centre C and another charge +2Q is placed outside the shell at a distance x from the centre as shown in the figure. Find (i) the force on the charge at the centre of shell and at the point A, (ii) the electric flux through the shell.



Q5. (a) Define electrostatic potential at a point. Write its S.I. unit.

Three point charges q1, q2 and q3 are kept respectively at points A, B and C as shown in the figure. Derive the expression for the electrostatic potential energy of the system.



(b) Depict the equipotential surfaces due to (i) an electric dipole,(ii) two identical positive charges separated by a distance.

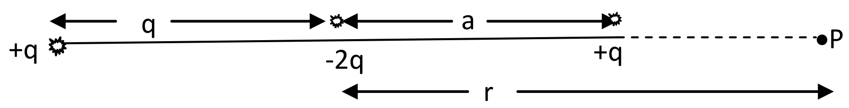
Q6. (a) Derive the expression for the potential energy of an electric dipole of dipole moment $\vec{p}$ placed in a uniform electric field$\vec{E}$. Find out the orientation of the dipole when it is in

(i) stable equilibrium,

(ii) unstable equilibrium.

(b) Figure shows a configuration of the charge array of two dipoles.

Obtain the expression for the dependence of potential on r for r >> a for a point on the axis of this array of charges.



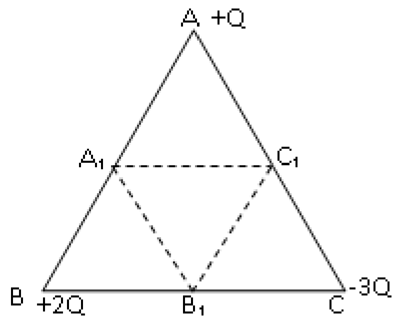
Q7. (a)Define electric flux. Write its S.I. unit.

(b) Using Gauss's law, obtain the electric flux due to a point charge 'q' enclosed in a cube of side 'a'.

(c) Show that the electric field due to a uniformly charged infinite plane sheet at any point at distant x from it, is independent of x.

Q8. (a) Deduce the expression for the potential energy of a system of two charges q_1 and q_2 located at $\vec{r_1}$ and $\vec{r_2}$ respectively in an external electric field.

(a) Three point charges, + Q, + 2Q and – 3Q are placed at the vertices of an equilateral triangle ABC of side l. If these charges are displaced to the mid-points A_1, B_1 and C_1 respectively, find the amount of the work done in shifting the charges to the new locations.



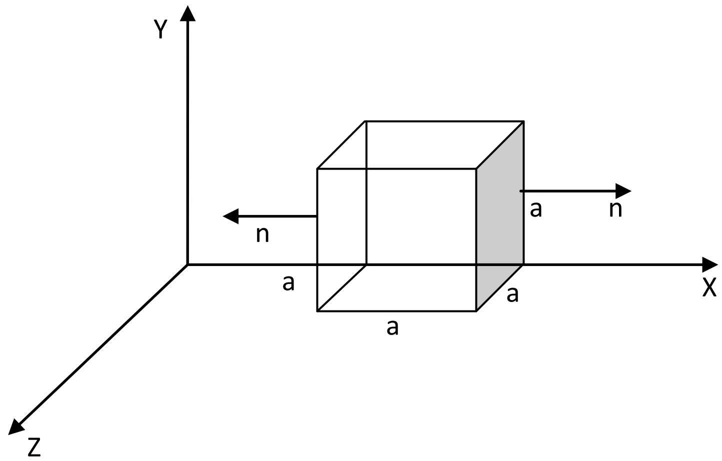
Q9. (a) Define equipotential surface. Why the electric field at any point on the equipotential surface is directed normal to the surface?

(b) Draw the equipotential surfaces for an electric dipole. Why does the separation between successive equipotential surfaces get wider as the distance from the charges increases?

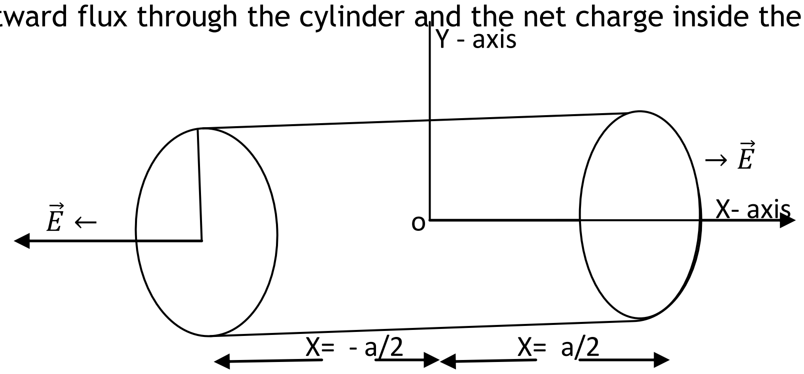
(c)For this dipole, draw a plot showing the variation of potential V versus 'x' where x (x>> 2a), is the distance from the point charge –q along the line joining the two charge.

Q10. (a) Define the term 'electric flux'. Write its S.I. unit.

(b) Given the components of an electric field as Ex = αx, Ey = 0 and Ez = 0, where α is a dimensional constant. Calculate the flux through each face of the cube of side 'a', as shown in the figure, and the effective charge inside the cube.



Q11. A right circular cylinder of length 'a' and radius 'r' has its centre at the origin and its axis along the x-axis so that one face is at x = + a/2 and the other at x = - a/2, as shown in the figure. A uniform electric field is acting parallel to the x-axis such that $\vec{E} = E_0 \vec{\imath}$ for x > 0 and $\vec{E} = - E_0 \vec{\imath}$ for x < 0. Find out the flux (i) through the flat faces, (ii) through the curved surface of the cylinder. What is the net outward flux through the cylinder and the net charge inside the cylinder?



Q12. (a) Show, using Gauss's law, that for a parallel plate capacitor consisting of two large plane parallel conductors having surface charge densities + σ and - σ , separated by a small distance in vacuum, the electric field (i) in the outer regions of both the plates is zero,

(ii) is σ/ε_o in the inner region between the charged plates.

Hence obtain the expression for the capacitance of a parallel plate capacitor.

(b) Explain what is the effect of inserting a dielectric slab of dielectric constant k in the intervening space inside the plates of

(i) the electric field,

(ii) the capacitance of the capacitor.

Q13. a) Define electric flux. Write its S.I. unit.

''Gauss's law in electrostatics is true for any closed surface, no matter what its shape or size is.'' Justify this statement with the help of a suitable example.

(b) Use Gauss's law to prove that the electric field inside a uniformly charged spherical shell is zero. Obtain the expression for the energy density of the electric field.

(c)A fully charged parallel plate capacitor is connected across an uncharged identical capacitor. Show that the energy stored in the combination is less than that stored initially in the single capacitor.

Q14. (i)Use Gauss's law to find the electric field due to a uniformly charged infinite plane sheet. What is the direction of field for positive and negative charge densities?

(ii)Find the ratio of the potential differences that must be applied across the parallel and series combination of two capacitors C_1 and C_2 with their capacitances in the ration 1:2 so that the energy stored in the two cases becomes the same.

Q15. (i) If two similar large plates, each of area A having surface charge densities $+\sigma$ and $-\sigma$ are separated by a distance'd' in air, find the expression for

(a) field at points between the two plates and on outer side of the plates. Specify the direction of the field in each case.

(b) the potential difference between the plates.

(c) capacitance of capacitor so formed.

(ii)Two metallic spheres of radii R and 2R are charged so that both of these have same surface charge densitiesσ. If they are connected to each other with a conducting wire, in which direction will the charge flow and why?

Q16.(i)Use Gauss's law to find the electric field due to uniformly charged infinite plane sheet. What is the direction of field for positive and negative charge densities?

(ii)Find the ratio of potential differences that must be applied across the parallel and series combination of two capacitors C_1 and C_2 with their capacitances in the ratio 1:2 so that the energy stored in the two cases become same. **[All India:2016(C)]**

Q17.(i) If two similar large plates, each area A having surface charge densities $+\sigma$ and $-\sigma$ are separated by distance d in air, find the expressions for

(a)field at the points between the two plates and on outer side of the plates. Specify the direction of the field in each case.

(b) the potential difference between the plates.

(c) the capacitance of the capacitor formed.

(ii)Two metallic spheres of radii R and 2R are charged so that both of these have same surface charge densityσ. If they are connected to each other with a conducting wire, in which direction A will the charge flow and why? **[All India: 2016(C)]**

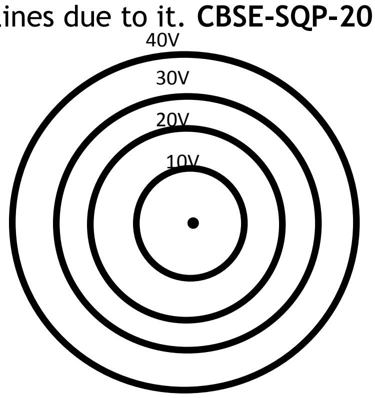
Q18. (a) Deduce the expression for the torque acting on a dipole of dipole moment $\vec{p}$ placed in a uniform electric field$\vec{E}$. Depict the direction of torque. Express it in the vector form.

(a) Show that the potential energy of a dipole making an angle θ with direction of field is given by $U(\theta) = -\vec{p}.\vec{E}$. Hence find out the amount of work done in rotating it from the position of unstable equilibrium to stable equilibrium. **CBSE-2016(E)**

Q19.(a) Two isolated metal spheres A and B have radii R and 2R respectively, and same charge q. Find which of the two spheres have greater: (i)Capacitance and (ii) energy density just outside the surface of the spheres.

(b)(i)Show that the equipotential surfaces are closed together in the regions of strong field and far apart in the regions of weak field. Draw equipotential surfaces for an electric dipole.

(ii)Concentric equipotential surfaces due to a charged body placed at the centre are shown. Identify the polarity of the charge and draw the electric field lines due to it. **CBSE-SQP-2016**



Q20.(a) Compare the individual dipole moment and the specimen dipole for H_2O molecule and O_2 molecule and O_2 molecule when placed in

(i)Absence of external electric field

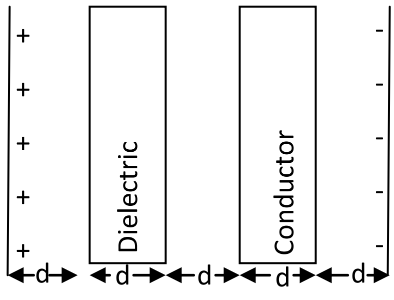
(ii)Presence of external electric field. Justify your answer.

(b)Given two parallel conducting plates of area A and charge densities $+\sigma$ and $-\sigma$. A dielectric slab of constant K and a conducting slab of thickness d each are inserted in between them as shown.

(i)Find the potential difference between the plates.

(ii)Plot E versus 'x' graph, taking x = 0 at positive plate and x =5d at negative plate.

CBSE-SQP-2016



Value Based Questions:4 Marks

It was raining heavily with lightning and thunderstorm. Manoj was on his way home with his father who was driving the car. When he was passing nearby a tree, the lightening took place and a person was standing under the tree struck by lightning. Fortunately, both Manoj and his father were quite safe because they were inside the car. Soon after the lightning, Manoj and his father ran towards that person and took him to a nearby hospital. Due to timely help they were able to save his life. The next day, Manoj discussed this situation with his physics teacher who explained the phenomenon in front of the whole class.

Answer the following questions on the basis of above paragraph;

(a) Why were they not affected by lightning?

(b) Name the phenomenon involved here.

(c) Is the potential in the cavity of a charged conductor zero?

(d)Write one value shown by Manoj and his father each.

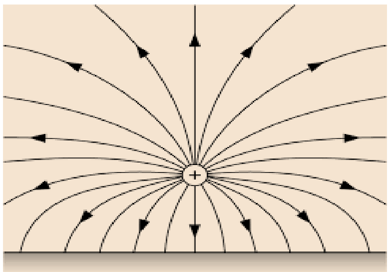
Answer Key:

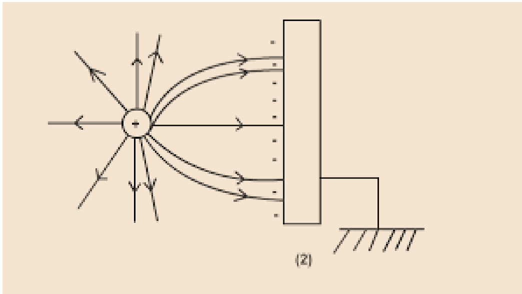
Very Short Answer Type of Questions: 1 Mark

A1.Flux = zero, because net charge enclosed is zero (-q + q = 0)

A2.Dielectric Constant: It is defined as the ratio absolute permittivity of medium to permittivity of free space. No unit.

A3.

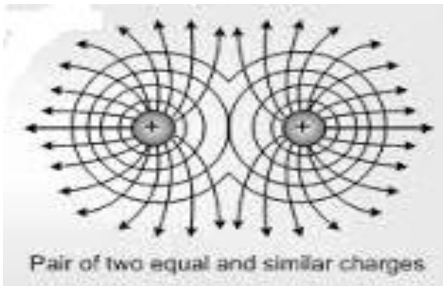




A4.Polarisation is directly proportional to the reduced electric field (E), Polarisation $\vec{P} = \epsilon_0 \chi_e \vec{E}$

A5. Positive: { $(P.E.)_Q > (P.E.)_P$

Reason: Negative charge moves from a point at a higher potential energy to one at a lower Potential energy. $(P.E.)_Q - (P.E.)_P$ = Positive



A6. Figure

A7. Decreases because of repulsive force.

A8. Negative because force and displacement are opposite to each other.

A9. They start from a positive charge and terminate at negative charge.

A10. Electric Polarisation: It is defined as dipole moment developed per unit volume of a dielectric material when placed in an external electric field. Unit: Cm^{-2}

A11.Otherwise the electric field have a component along the surface of charged body. This component makes the charges on the surface to move. Which is not possible in electrostatic situation or violate the law of conservation of energy?

A12. If Electric field is not normal, it will have non-zero component along the surface. In that case, work would be done in moving a charge on an equipotential surface.

A13.For same potential, the charge shown by line A is more than charge by B. Since plate area of C_2 is more than C_1. So C_2 will store more charge. Hence line A represent C_2 and line B represent C_1 **OR**

line B represents C_1

Because C = Q/V (Slope of the line B is less than line A)

A14. (i) The charges q_1 and q_2 have opposite sign.

(ii)The magnitude of q_1 is more than q_2

A15.Flux $\emptyset = \frac{q}{6\epsilon_0}$ since a cube has 6 surfaces.

A16.Yes, midpoint of line joining two charges of an electric dipole.

A17.Decreses because the electron experiences a force opposite to E.

A18. Decreases since -pE -(PE) = -2pE

A19.A point B

A20. $Q = CV = 1x10^{-6} \times \frac{9\times10^6}{100} = 9x10^{-2}C$

A21. If they intersect at a point there will be two directions of electric field at that point which is impossible.

A22.Because the electric field extend from source to infinity.

NOTE: In many questions explanatory answers are given for understanding purpose but the students are required to give the answers as per the demand of particular question.

Short Answer Type of Questions: 2 Marks

A1. Work done $W = pE(\cos\theta_1 - \cos\theta_2) = pE(\cos 0^0 - \cos180^0) = 2pE$

When angle between $\vec{E}$ and $\vec{p}$ is 90^0 since $\tau = pE\ sin\theta$

A2.For stable equilibrium: The angle between $\vec{E}$ and $\vec{p}$ is 0^0

For unstable equilibrium: The angle between $\vec{E}$ and $\vec{p}$ is 180^0; since P.E. = - pE $\cos\theta$.

A3.It is acting as two capacitor in series;

$C_1 = \frac{\epsilon_0 A}{\frac{d}{4}} = 4.\frac{\epsilon_0 A}{d}$ and $C_2 = \frac{4}{3}.\frac{\epsilon_0 A}{d}$ both C_1 and C_2 are in series

Net Capacitance $C = \frac{C_1C_2}{C_1+C_2} = \frac{\epsilon_0 A}{d}$

A4. Let net potential is zero at distance 'x' from the charge 'q'

$k.\frac{q}{x} + k.\frac{(-2q)}{d-x} = 0$ on solving x = d/3

A5.$\emptyset_1 = \frac{Q}{\epsilon_0}$ and $\emptyset_2 = \frac{3Q}{\emptyset_0}$

$\emptyset_1 : \emptyset_2 = \frac{1}{3}$

No change in flux through S_1 with dielectric medium in space between S1 and S_2.

A6. Force on charge (-q) ; $F_1 = -qE$

Force on charge (+q) ; $F_2 = qE$; Net force F = 0

Work done $W = pE(\cos\theta_1 - \cos\theta_2) = pE(\cos 0^0 - \cos180^0) = 2pE$

A7. (i) Brightness will **increase** because the reactance of capacitor $Xc = \frac{1}{\omega C}$ will decrease with increase of capacitance of capacitor on introduction of dielectric slab.

(ii) Brightness will **decrease** due decrease in current.

A8. Work done in bringing charge q_1 from infinity to position $\vec{r_1}$ = $W_1 = 0$

Work done to bring charge q_2 from infinity to position $\vec{r_2}$ = W_2= q_2 x potential due to charge q_1

Network done W = $W_1 + W_2 = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{|\boldsymbol{r_2} - \boldsymbol{r_1}|}$ Here r_1 and r_2 are the position vectors and mode of $\vec{r_2} - \vec{r_1}$ is taken in the denominator.

A9.Charge on inner surface = -Q

Charge on outer surface = +Q

Electric field on point P_1 = E = $\frac{1}{4\pi\epsilon_0}\frac{Q}{{r_1}^2}$

A10. Work done in moving a unit positive charge along distance $\Delta\ell$

$E.\Delta\ell = 1.(V_A - V_{B)} = V - (V + \Delta V) = -\Delta V$

$E = -\frac{\Delta V}{\Delta\ell}$

(i)Electric field is in the direction in which the potential decreases steepest.

(ii) Magnitude of Electric field is given by the change in the magnitude of potential per unit displacement, normal to the equipotential surface at the point.

A11.Current (I) = 2/30 A

Potential difference across 10Ω = Potential across capacitor = I.R = $\frac{2}{30}$ x 10 = 2/3 V

Charge on capacitor = q = CV = 6 x10^{-6} x (2/3) = 4 x 10^{-6} C

A12.(i) Flux $\emptyset = E\Delta S \cos 0^0 = 4\times10^3 \times 5 \times 5\times 10^{-4} = 10Nm^2/C$

(ii) Flux = $E\Delta S \cos(90^0 - 30^0) = 4\times10^3 \times 5 \times 5\times 10^{-4} \times (1/2) = 5Nm^2/C$

A13.$E = E_1 + E_2$

$= \frac{2\lambda_1}{4\pi\epsilon_0 r} + \frac{2\lambda_2}{4\pi\epsilon_0 r} = \frac{9\times10^9 \times 2\times2\times10^{-9}}{10\times10^{-2}} + \frac{9\times10^9 \times 2\times3\times10^{-9}}{10\times10^{-2}}$ = 360 + 540 = 900N/C

A14. Torque (τ) = pE sinθ

$6\sqrt{3} = pE \sin60^0 \Rightarrow pE = 12$

$U = -pE\cos\theta = -12\times\cos60^0 \Rightarrow -6J$

A15. $\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow C' = 10/3\ \mu F$

C= 10 + 10/3 = (40/3)μF

Charge supplied by the source = $\frac{40}{3}\times10^{-6}$ x 500 = $\frac{20}{3}\times10^{-3}$C

Charge on C_4 = q_4 = 10x10^{-6} x 500 = 5x 10^{-3}C and $q_1 = q_2 = q_3 = (\frac{20}{3}\times10^{-3}C - 5\times 10^{-3}C) = (5/3)\times 10^{-3}$ C

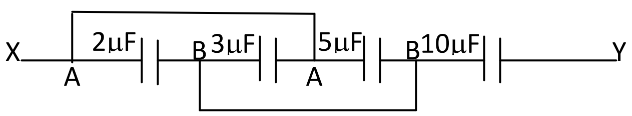
OR: Charge on C_1 = Charge on C_2 = Charge on C_3 = $\frac{10}{3}$ x 10^{-6}x 500 = (5/3) x 10^{-3} C

A16.$E = -\frac{\Delta V}{\Delta\ell}$

ΔV = 4E units

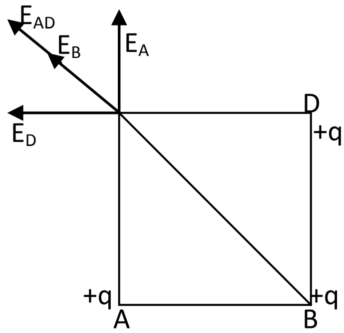
The electric potential is more at point (C) because this point is at less distance from the source of field.

A17.First three capacitors are in parallel because each one is connected between points A and B as shown below and 4th one is connected in series with this group.



$C' = 2 + 3 + 5 = 10\mu F$

$C_{eq} = (10 \times 10)/(10+10) = 5\ \mu F$



A18. $E_A = E_D = k\frac{q}{a^2}$

$E_{AD} = k\frac{q}{a^2}\sqrt{2}$

$E_B = k\frac{q}{2a^2}$

$E_{net} = E_{AD} + E_B = \frac{q}{8\pi\epsilon_0 a^2}(2\sqrt{2}+1)$

A19.Potential energy when they are at infinity = 0

Increase in Potential energy = $k\frac{q_1 q_2}{r} = 9\times10^9 \times \frac{2\times10^{-5}\times2\times10^{-5}}{10\times10^{-2}} = 36J$

A20.New charge on each sphere after connection = $\frac{2Q-Q}{2} = \frac{Q}{2}$

New force F' = F /8

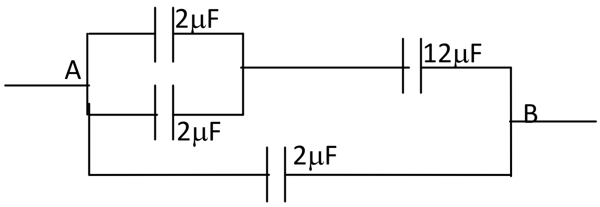
A21.Electric field = $\frac{\sigma}{\epsilon_0}$, there will be no change in electric field as the electric field depends upon surface charge density. The surface charge density is not changing.

A22. (i) potential energy will increase (ii) potential energy will decrease.

A23. Since $C = \frac{\epsilon_0 A}{d}$, when a metal plate of thickness 't' is inserted, the new capacitance $C' = \frac{\epsilon_0 A}{d-t}$

$C' = \frac{\epsilon_0 A}{d-d/2} = 2 \times \frac{\epsilon_0 A}{d} \Rightarrow C' = 2C$

A24.The circuit can be rearranged



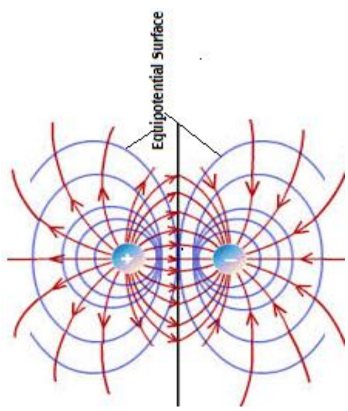
SHORT ANSWER TYPE QUESTIONS: 3-MARKS

A1.Derivation of formula $E = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3} \Rightarrow E \propto \frac{1}{r^3}$

Electric field due to pint charge $E \propto \frac{1}{r^2}$

A2. (a) Polarization of dielectric material under effect of external electric field produces induced charges on the opposite surfaces of dielectric material. The electric field produced by induced charges is opposite to applied electric field , hence the net electric field is reduced.

$\overrightarrow{E_{net}} = \overrightarrow{E_o} - \overrightarrow{E_p} = \frac{\overrightarrow{E_o}}{k}$ where K is dielectric constant of dielectric material.



(a) Energy stored initially $U_i = \frac{q^2}{2C}$

When another similar uncharged capacitor is connected in parallel, common potential

$V = \frac{q+0}{C+C} = q/2C$

Energy stored in the combination U_F = ½ CV^2 = ½ x 2C x $(q/2c)^2$ = $\frac{q^2}{4C}$

Since $U_F < U_i$ hence energy decreases.

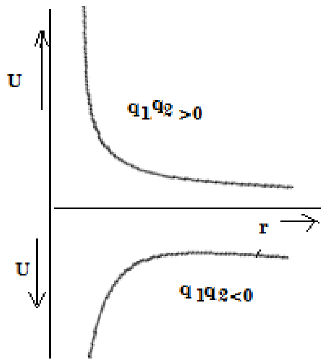
A3.Equipotential Surface: A surface which has same potential at any point on it.

Properties (i) the electric field is perpendicular to equipotential surface.

(ii) No work is done on moving a charge on equipotential surface.

A4.Potential energy of system two point charges is given by

P.E.(U) $= \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r}$



A5.Gauss's Law: The electric flux passing through a closed surface in vacuum is equal to $\frac{1}{\epsilon_0}$ times the charge enclosed by the closed surface.

Electric flux through a cube:$\emptyset = \frac{q}{\epsilon_0}$

The electric field is radial and inversely proportional to square of distance. Therefore the electric flux in independent of shape and size. The number of electric field lines crossing normally through a closed surface depends only on the charge enclosed by it.

A6. (a) Derivation of formula $C_0 = \frac{\epsilon_0 A}{d}$

(b) Derivation of relation $\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$

A7. (a) field between the plates of parallel plate capacitor: $E = \frac{\sigma}{\epsilon_0} \quad \Rightarrow \sigma = \epsilon_0 E$

Charge on either plates of capacitor Q = σA = $\epsilon_0 E A$

Energy stored in capacitor $U = \frac{Q^2}{2C} = \frac{(\epsilon_0 E A)^2}{2\frac{\epsilon_0 A}{d}} = \frac{1}{2}\epsilon_0 E^2 Ad$

$\frac{U}{Ad} = \frac{1}{2}\epsilon_0 E^2$ = Energy density

(b)Work done W = $W_{ab} + W_{bc} + W_{cd} + W_{da}$ = 0 + E×bc + 0 + (-E×da) = 0 (since bc = da, opposite sides of rectangle)

A8. (a) Dielectric Constant (K): It is defined as the ratio of absolute permittivity of medium to permittivity of free space. It has no unit.

(b)When dielectric material is introduced, the capacitance of capacitor become K-times where 'K' is dielectric constant of material.

(i) When battery remains connected:

Charge will increase (K times as q = CV here 'V' remains constant)

Potential Difference: remains constant equal to battery voltage

Energy become K times (as E = ½ CV^2 here 'V' is constant and capacitance become K times.)

(ii) When battery remains disconnected:

Charge: remains constant since battery is disconnected

Potential difference:

A9. When separation between plates is increased the capacitance(C) decreases as C = ε_0 A/d

Physical Quantity	Battery remain connected	Battery is disconnected
Charge	Decreases due decrease in 'C'	Constant since battery is disconnected
Potential	Constant since battery is connected	Increases since V = q/C since 'C' decreases
Energy Stored	Decreases since U = ½ CV^2	Increases since U = ½ (q_2 /C)

A10. linear charge density = λ = q /2πr

In order to find the electric field at any point on its axis , the ring is divided into large number of elements(dℓ)

Charge present on small element (dℓ) = dq = q.dℓ/2πr

Electric field at any point on its axis at distance 'x' from its centre due to charge (dq)

dE = $k\frac{qd\ell}{2\pi r(r^2+x^2)}$

Electric field due to diametrically opposite element (dℓ')

dE' = $k\frac{qd\ell'}{2\pi r(r^2+x^2)}$ since dℓ = dℓ' hence dE = dE'

On resolving dE , the vertical components (dE sinθ)cancel out in pairs and the components along the axis (dEcosθ) add up so net electric field

E = $\int_0^{2\pi r} dE\,cos\theta$ = $\frac{1}{4\pi\epsilon_0}\frac{qx}{(r^2+x^2)^{3/2}}$

When x>>>r then E = $\frac{1}{4\pi\epsilon_0}\frac{q}{x^2}$ same as produced by point charge indicating that for off points the ring behaves as a point charge.

A11. The equivalent capacitance of first arm C' = $\frac{C_1.C_2}{C_1+C_2}$ = $\frac{6}{5}\times 10^{-6}\mu F$

The equivalent capacitance of second arm C'' = $\frac{C_3.C_4}{C_3+C_4}$ = $\frac{20}{9}$ $\times10^{-6}\mu$F

Charge in first arm (i.e. on C_1 and C_2) = q' = C'.V = (6/5) x$10^{-6}\times$5 = 6 $\times10^{-6}$C

Charge in second arm (i.e. on C_3 and C_4) = q'' = C''.V = (20/9) $\times$ 10^{-6} $\times$ 5 = (100/9) $\times10^{-6}$C

Potential across C_1 = V_A - V_X = q'/C_1 = 6$\times10^{-6}$ / 2$\times10^{-6}$ =3Volts

Potential across C_3 = V_A – V_Y = q''/C_3 = (25/9) Volts

V_X - V_Y = 3 – (25/9) = 2/9 = 0.22Volts

A12. Electric field due to wire of charge density λ_1 on second wire

E_1 = $\frac{\lambda_1}{2\pi\epsilon_0 r}$

Charge per unit length of second wire = λ_2

Force per unit length of the wire = $E_1.\lambda_2$

= $\frac{\lambda_1\lambda_2}{2\pi\epsilon_0 r}$

A13. (i) V_L = 6Q/2C = 3Volts

V_R = 3Q/C = 3Volts ⇒ **No change** in charge because potential across both capacitors is same.

(ii) V_L = 6Q/C = 6Vlots

V_R = 3Q/C = 3Volts ⇒ Since $V_L > V_R$ hence the charge will flow from left capacitor to right capacitor hence the **charge on left capacitor will decrease.**

(iii) V_L = 6Q/3C = 2Volts

V_R = 3Q/C = 3Volts ⇒ since $V_R > V_L$ hence the charge will flow from right capacitor to left capacitor **hence the charge on left capacitor will increase.**

A14. To charge a capacitor, work is done by source (Battery) in transferring the charge on to the plates of capacitor. This work done is stored as electrostatic potential energy in the capacitor.

Work done = Energy stored U = $\frac{q^2}{2C_0}$

Initial capacitance of capacitor $C_0 = \frac{\epsilon_0 A}{d}$

New capacitance C' = $K\frac{\epsilon_0 A}{2d}$ = $K\frac{C_0}{2}$ (slightly decreases as 1< K < 2)

(a) Electric field E' = $\frac{\sigma}{\epsilon_0 K}$ hence the electric field become 1/K times.

(b) U' = $\frac{q^2}{2C'}$ = $\frac{2\,q^2}{2KC_0}$ = $\frac{2}{K} \times$ U ⇒ Energy stored increases slightly.

A15. $U_{in} = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}\frac{q^2}{600 \times 10^{-12}}$

Equivalent Capacitance C_{eq} = 600 +300 = 900μF

$U_F = \frac{1}{2}\frac{q^2}{900 \times 10^{-12}}$ (since battery is disconnected the charge will remain same)

Loss of energy = $U_i - U_F = \frac{1}{2} \times \frac{144 \times 10^{-16}}{10^{-12}} \left[\frac{1}{600} - \frac{1}{900}\right] = 4 \times 10^{-6} J$

A16. The combination is equivalent to wheat stone bridge.

C_{eq} = ½ μF + ½ μF = 1μF

Q = C_{eq} V = 1x10^{-12} x6 = 6x10^{-12}C

U = ½ CV^2 = ½ x 1x10^{-12} x 36 = 18x 10^{-12}J

A17. $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ Hence C = 20/3 μF

Q = CV = $\frac{20}{3} \times 10^{-6} \times 90$ = 600 x 10^{-6}

A18. $U_s = \frac{1}{2} \times \frac{C_1 C_2}{C_1 + C_2} \times (100)^2$ = 0.045 ⇒ $\frac{C_1 C_2}{C_1 + C_2}$ = 9.0 x10^{-6}

$U_P = \frac{1}{2} \times (C_1 + C_2) \times (100)^2$ = 0.25 ⇒ $C_1 + C_2$ = 50x 10^{-6}

C_1C_2 = 450 x10^{-12} and $C_1 - C_2$ = 26.46 x 10^{-6}

On solving C_1= 38.23μF and C_2 = 11.77μF

A19. Let $C_2 = x$ so $C_1 = 2x$

$C_s = \frac{x \times 2x}{x + 2x} = \frac{2}{3}x$

U_S = ½ CV^2 = $\frac{1}{2} \times \frac{2}{3}x \times V^2 = \frac{1}{3} x V^2$J and Charge q_s = C_s V = $\frac{2}{3} x V$

$C_p = x + 2x = 3x$

$U_P = \frac{1}{2}CV^2 = \frac{1}{2} \times 3x\,V^2 = \frac{3}{2}x\,V^2$J and charge $q_P = C_PV = 3x\,V$

In parallel combination, both charge and energy stored is more.

A20. Electric field at point A due to charge present at point B = $E_B = k\frac{6Q}{a^2}$

Electric field at point A due to charge present at point C = $E_C = k\frac{8Q}{a^2}$

Resultant of these electric fields = $E_{net} = \frac{kQ\sqrt{52}}{a^2}$

The angle made by this field with side AC = $\tan\alpha = \frac{E_B \sin 120^0}{E_C + E_B \cos 120^0} = \frac{3\sqrt{3}}{5}$ or $\alpha = \tan^{-1}\frac{3\sqrt{3}}{5}$

A21. Net capacitance (C_i) = C1 + C2 = 3C2 + C2 = 4C2

Net capacitance after filling the dielectrics (C_F) = KC1 + KC2 = 3KC2 + KC2 = 4KC2

Ratio: $C_i : C_F$ = 1:K

Energy stored in the combination before the introduction of dielectric;

$U_{initial} = Q^2 / 4C2$

Energy stored in the combination after introduction of dielectric slab;

$U_{final} = Q^2 / 4KC2$

$U_{initial} / U_{final}$ = K:1

A22. The energy stored will be K times to initial value because capacitance increases K times.

New Energies $U_1 = \frac{1}{2}KC_1V_1^2$ and $U_2 = \frac{1}{2}KC_2V_2^2$

Charge also becomes K time due to same reason.

New Charges $q_1 = KC_1V_1$ and KC_2V_2

Potential differences remain same and equal to battery voltage.

V_1 and V_2 (In this question it is assumed that battery is connected)

A23. (a) Same as A.No.3 of VSA.

(b) $E_1 = \frac{\sigma_1}{\epsilon_0}$ and $E_2 = \frac{\sigma_2}{\epsilon_0}$

Electric field in space II; $E_1 - E_2 = \frac{1}{\epsilon_0}(\sigma_1 - \sigma_2)$ towards E_1 (towards B)

Electric field in space III; $E_1 + E_2 = \frac{1}{\epsilon_0}(\sigma_1 + \sigma_2)$ towards right away from sheet B.

A24. (i) $C = \frac{\epsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 6 \times 10^{-3}}{3 \times 10^{-3}} = 17.7 \times 10^{-12}$F

(ii) $q = CV = 17.7 \times 10^{-12} \times 100 = 17.7 \times 10^{-10}$C

(iii) $q' = C'V = 6 \times 17.7 \times 10^{-12} \times 100 = 1.06 \times 10^{-8}$C

A25. Electric potential at the centre of loop due to its own charge

$V_C = k\frac{Q}{R}$

Charge present per unit length = $Q/2\pi R$

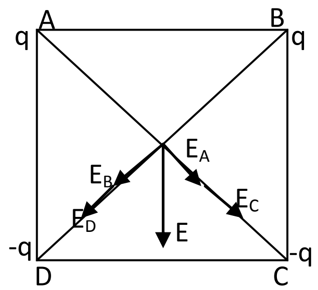
Charge at small element $d\ell = dq = \frac{Q.d\ell}{2\pi R}$

Potential due to this charge dq at distance 'x' from its centre = $dV_p = k\frac{Q.d\ell}{2\pi R(\sqrt{R^2+x^2})}$

Potential due to whole ring = $V_p = \int dV_p = \frac{kQ}{\sqrt{R^2+x^2}}$

Potential difference = Vc - V_p

Work done = (V_c - V_p) x q = $\frac{Qq(\sqrt{R^2+x^2}-R)}{4\pi\epsilon_0 R\sqrt{R^2+x^2}}$



A26. The magnitudes $E_A = E_B = E_C = E_D$

$E_1 = E_A + E_C = 4kq/a^2$

$E_2 = E_B + E_D = 4kq/a^2$

$E_{net} = \sqrt{E_1{}^2 + E_2{}^2} = 4kq\sqrt{2} / a^2$

Electric potential zero

On interchanging the charges, the direction of electric field get reversed but no change in magnitude. Potential will remain zero.

A27. If mass of proton = m, mass of alpha particle = 4m

Charge on proton = q then charge on alpha particle = 2q

Work done = qV = ½ mv^2

(i) $v_\alpha = \sqrt{\frac{2q_\alpha V}{m_\alpha}}$ and $v_P = \sqrt{\frac{2q_p V}{m_p}} \Rightarrow$ $v_\alpha : v_p = 1 : \sqrt{2}$

(ii) $(KE)_\alpha : (KE)_P = q_\alpha V : q_p V = 2:1$

(iii) P_α (momentum) = $\sqrt{2m_\alpha q_\alpha V}$ and P_p (momentum) = $\sqrt{2m_p q_p V}$

Ratio = 2√2: 1

A28. (i) F = qE = 1.6 x 10^{-19} x 2000 = 3.2 x 10^{-16}N

(ii) E = -dV / dx $\Rightarrow$ dV = E .dx = 2000 x 0.2 = 400 Volt

(iii) Work done = W = qV = 1.6 x 10^{-19} x 400 = 6.4 x 10^{-17}J

A29. For equilibrium of charge at point A, the net force acting on it should be zero.

Let charge 'q' is placed at point M

Net for applied by charges at points B and C on charge at point A = Force acting between charge at point A and charge at point M.

$$\frac{9\times10^9\times2\times10^{-6}\times3\times10^{-6}\sqrt{3}}{400\times10^{-4}} = \frac{9\times10^9\times2\times10^{-6}\times q}{(10\sqrt{3})^2\times10^{-4}}$$

q = 3.897 x 10^{-6} and sign should be positive

A30. (i) Potential energy = - pE cosθ = -p.E cos90^0 = 0

(ii)Torque = pE sinθ = p.E sin90^0 = pE

(iii)Net force = zero because electric field is uniform

When dipole is taken to unstable equilibrium;

Potential energy will increase, torque decreases to zero and no effect on net force.

A31. (i) $U_i = \frac{Q^2}{2KC_0}$ and $U_f = \frac{Q^2}{2C_0}$ since $U_f > U_i \Rightarrow$ energy increases

(ii) $E_i = \frac{\sigma}{K\epsilon_0} = \frac{Q}{AK\epsilon_0}$ and $E_f = \frac{Q}{A\epsilon_0}$ since Ei > $E_f \Rightarrow$ Electric field increases

(iii) $V_i = \frac{Q}{KC_0}$ and $V_f = \frac{Q}{C_0}$ since $V_f > V_i \Rightarrow$ P.D. increases

A32. (i) $U_i = \frac{1}{2}KC_0V^2$ and $U_f = \frac{1}{2}C_0V^2$ since $U_f < U_i \Rightarrow$ energy decreases

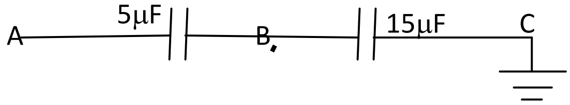
(ii) When battery remains connected, on removing the slab, extra charge goes to battery since the capacitance has been reduced.

(iii) P.D. remains constant and equal to battery voltage.

A33. The charge on 5μF and 15μF capacitors is same

$V_{AB} / V_{BC} = 15/3 = 3$

$V_{AB} = 3V_{BC}$



If V_{BC} = x then V_{AB} = 3x

Now, x + 3x = 2000

$\Rightarrow$ x = 500 hence V_{BC} = 500 Volts and V_{AB} = 1500Volts and point A is at 2000Volts

$\Rightarrow V_B$ = 500Volts

A40. **(i)** at A, $E = \frac{\sigma}{2\epsilon_0}$ = 1.1×10^{28}N/C directed away from the sheet

(ii)Point Y

Because at 50cm, the charge sheet acts as infinite sheet thus the magnitude remains same towards the middle region of the planar sheet.

LONG ANSWER TYPE QUESTIONS: 5-MARKS

A1. (a)(i) Electric field lines emerge radially outward.

(ii)Electric flux depends upon charge enclosed i.e. $\int \vec{E}.\vec{ds} = Q/\varepsilon_0$

(iii) Electric field E α $1/R^2$

(b) Electric field a the centre of loops '1' due to its own charge = 0

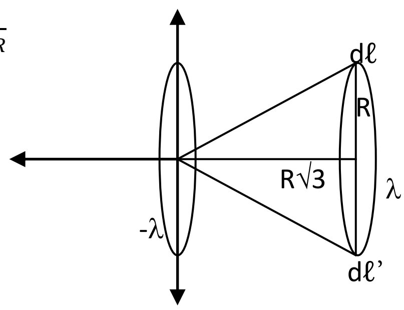
For loop '2' the linear charge density $\lambda = dq/d\ell \Rightarrow dq = \lambda d\ell$

Electric field at the centre of loop '1' due charge (dq) present on small element ($d\ell$)

$dE = \frac{k\lambda\, d\ell}{R^2 + (R\sqrt{3})^2} = \frac{k\lambda\, d\ell}{4R^2}$ ($d\ell$ is taken at the end of one of the diameter)

Same electric filed will also be produced by another element ($d\ell$') taken at another end of the same diameter. When we resolve these electric fields, the vertical components (dE sinθ) cancel in pairs and component along the axis (dEcosθ) add up. The net electric field at the centre of loop '1'

$$E = \int_0^{2\pi R} dE\, cos\theta \;=\; \frac{k\lambda\, cos\theta}{4R^2}\int_0^{2\pi R} d\ell \;=\; \frac{k\lambda\sqrt{3}\pi}{4R} \;=\; \frac{\lambda\sqrt{3}}{16\epsilon_0 R}$$



A2. (a)Derivation of formula $\vec{E} = \frac{2\vec{p}}{4\pi\epsilon_0 x^3}\hat{x}$

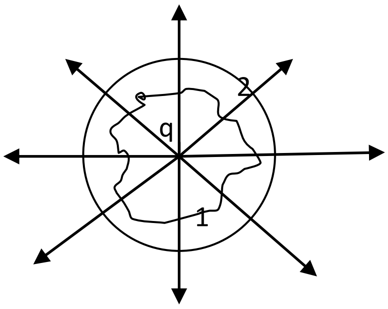
(b) Only the faces which are perpendicular to the direction of x- axis will contribute to the electric flux. Remaining faces of the cube give zero contribution.

Total flux $\emptyset = \emptyset_L + \emptyset_R = 0 + \int_R Eds\ cos0^0 = 2x^3$

Charge enclosed, according to Gauss theorem; $\emptyset = \frac{q}{\epsilon_0}$

$q = \epsilon_0\ \emptyset = 2\ \epsilon_0\ x^3$

A3. (a)Gauss's Theorem: Electric flux through a closed in vacuum is $\frac{1}{\epsilon_0}$ time the total charge enclosed by the closed surface

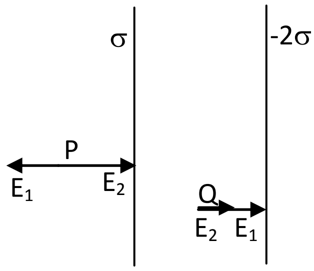


$\oint \vec{E}.\vec{ds} = \frac{q}{\epsilon_0}$

Total number of electric field lines emerging from enclosed charge (q) from surface '1' and '2' is same.

(b)**Electric field at point P outside the plates** due to first sheet of surface charge density (σ)

$E_1 = \frac{\sigma}{2\epsilon_0}$ (towards left)



Due to sheet of surface charge density

$E_2 = \frac{2\sigma}{2\epsilon_0}$ (towards right)

Net electric field at point 'P' = $E_1 - E_2 = \frac{-\sigma}{2\epsilon_0}$ (towards right)

(ii) Between two sheets at point Q

$E = E_1 + E_2 = \frac{3\sigma}{2\epsilon_0}$

A4. Polarization of a dielectric (P) is defined as the dipole moment per unit volume of the polarized dielectric.

$P = \chi_e \varepsilon_0 E$

Since, the electric field inside a spherical shell is zero; the force on the charge placed at the centre of the shell is zero. For the charge at A, the shell will behave as if the entire charge 'Q' is placed at the centre of the shell. Therefore, the total charge is

Q + Q/2 = 3Q/2

Since, its distance from 2Q is 'x', the electric field at A is

$E = \frac{K\frac{3Q}{2}}{x^2}$

So, electric force F = (2Q) × E = $\frac{1}{4\ \pi\epsilon_0} \times \frac{3Q^2}{x^2}$

(ii) Since, the total charge enclosed by the shell is $q_{en} = Q/2$

According to Gauss's law; Flux $\phi = \frac{Q}{2\epsilon_0}$

A5.Electric potential: Electric potential at a point is the work done by external force in bringing a unit positive charge from infinity to that point in the electric field. Its S.I. unit Volt or J/C

Net work done in bringing charges q_1 , q_2 and q_3 from infinity to points A, B and C respectively;

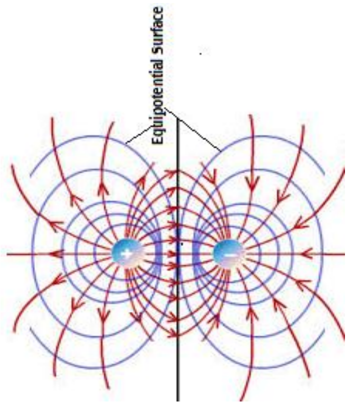
$W = 0 + q_2V_{12} + q_3 (V_{13} + V_{23})$

$= \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}} + \frac{1}{4\pi\epsilon_0}[\frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}]$

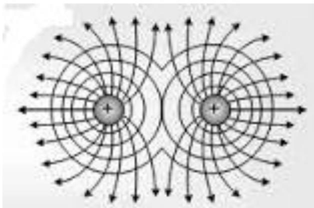
Potential energy of system of three charges;

$U = W = \frac{1}{4\pi\epsilon_0}[\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}]$

b) Equipotential surfaces (i) due to electric dipole;



(ii) Due to two identical charges



Pair of two equal and similar charges

A6. (a) Derivation of formula for potential energy of electric dipole;

Potential energy = - p.E cosθ (where p = dipole moment of electric dipole)

(i) For stable equilibrium: Angle between $\vec{E}$ and $\vec{p}$ is zero. (minimum energy stage)

(ii) For stable equilibrium: Angle between $\vec{E}$ and $\vec{p}$ is 180^0 (maximum energy stage)

(b) $V_p = V_q + V_q + V_{-2q}$

$= \frac{kq}{r-a} + \frac{kq}{r-a} - \frac{2kq}{r}$

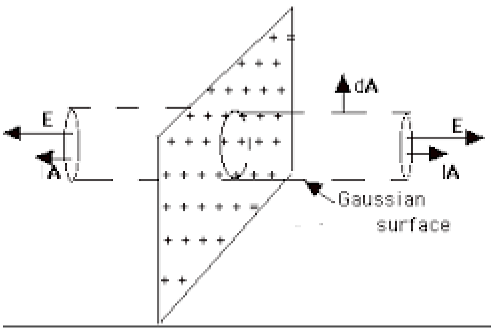
$= 2kq\ [\frac{r}{r^2 - a^2} - \frac{1}{r}] = \frac{2kqa^2}{r(r^2 - a^2)}$

When r>>> a

$V_p = \frac{2kqa^2}{r^3}$

A7. (a) Electric Flux: Electric flux equal to the surface integral of electric field over a given surface.

Or Total number of electric field lines passing perpendicular through a surface is called electric field.



$\phi = \int \vec{E}.\vec{ds}$ unit $Nm^2\ C^{-1}$

(b) By Gauss law $\phi = \oint \vec{E}.\vec{ds} = \frac{q}{\epsilon_0}$

Where 'q' is the charge enclosed by the cube.

(c) Electric Flux $\phi = \oint \vec{E}.\vec{ds}$

$= \int_P \vec{E}.\vec{ds} + \int_P \vec{E}.\vec{ds} + \int_c \vec{E}.\vec{ds}$

$\phi = EA + EA + 0 = 2EA$

According to Gauss law $\phi = q/\varepsilon_0$

$2EA = \frac{q}{\epsilon_0}$

$E = \frac{q}{2A\epsilon_0} = \frac{\sigma}{2\epsilon_0}$ (since σ = q/A)

The expression shows that 'E' is independent of distance(x)

A8. (a) Let charges q_1 and q_2 are placed in the electric field $\vec{E}$ at points P and Q as shown in figure.

Work done in bringing charge q_1 from infinity to point P = $W_1 = q_1\ (V_{r1})$ Where (V_{r1}) is the potential at point P due to external electric field (E)

Work done in bringing charge q_2 from infinity to point Q = $W_2 = q_2\ (V_{r2})$ Where (V_{r2}) is the potential at point Q due to external electric field (E).

Work done on q_2 against the electric field at point Q due to q_1 = $W_3 = \frac{q_1 q_2}{4\pi\epsilon_0 r_{12}}$

Potential energy of two charges U = $W_1 + W_2 + W_3$

$$= q_1\ (V_{r1}) + q_2\ (V_{r2}) + \frac{q_1 q_2}{4\pi\epsilon_0 r_{12}}$$

(b)Initial potential energy of system of charges

$$U_i = \frac{kQ\times 2Q}{\ell} + \frac{kQ\times(-3Q)}{\ell} + \frac{k\times 2Q\times(-3Q)}{\ell} = \frac{-7Q^2}{\ell}$$

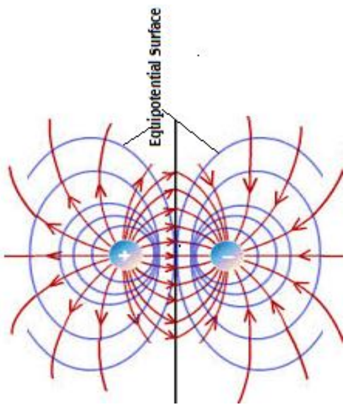
Potential energy in new configuration;

$$U_F = \frac{kQ\times 2Q}{\frac{\ell}{2}} + \frac{kQ\times(-3Q)}{\frac{\ell}{2}} + \frac{k\times 2Q\times(-3Q)}{\frac{\ell}{2}} = \frac{-14Q^2}{\ell}$$

Change in potential energy = $U_i - U_F = \frac{7Q^2}{\ell}$

A9.Equipotential surface (a): It is a surface at which potential is same at every point on it.

If the electric field were not normal to equipotential surface it will have a non-zero component along the surface. Hence work will be done in moving unit charge from one point to another point on it against this component of field which is not true since ΔV =0 therefore work done W = q. ΔV must be zero. **OR**



Component of $\vec{E}$ along the equipotential surface = -(rate of change of potential along the equipotential surface)

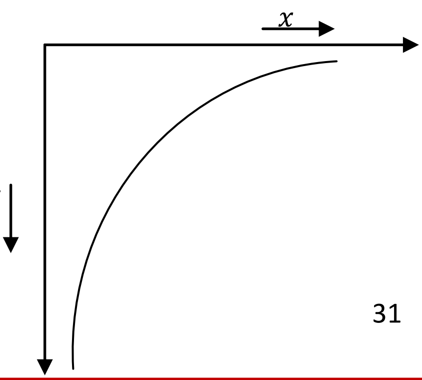
= 0 $\Rightarrow$ hence $\vec{E}$ has no component along the equipotential surface so $\vec{E}$ is perpendicular to equipotential surface.

(b)because the electric field decreases as the distance from the charges increases.

Equipotential surfaces are shown by blue lines in the figure.

A10. (a) Electric Flux: Electric flux equal to the surface integral of electric field over a given surface.

Or Total number of electric field lines passing perpendicular through a surface is called electric field.



$\phi = \int \vec{E}.\vec{ds}$ unit $Nm^2\ C^{-1}$

(b)Net flux through the cube = $\emptyset_x + \emptyset_y + \emptyset_Z$

$$\phi = Eds\cos 180^0 + Eds\cos 0^0 + 0 + 0$$

$$= \alpha(a).a^2\ (-1) + \alpha(2a).a^2\ (1)$$

$$\phi = \alpha a^3$$

Charge enclosed = Q = $\varepsilon_0 \phi$ = $\varepsilon_0 \alpha a^3$

(c) Variation of V with distance from –q charge is shown above.

A11. Flux through plane surfaces:

Flux through left plane surface $\emptyset_L$ = E ds $\cos 0^0$ = $E_0 \pi r^2$ (outwards)

Flux through right plane surface $\emptyset_R$ = E ds $\cos 0^0$ = $E_0 \pi r^2$ (outwards)

Flux through curved surface $\emptyset_C$ = 0

Net outward flux $\emptyset$ = $E_0 \pi r^2 + E_0 \pi r^2$ = $2 E_0 \pi r^2$

Charge enclosed = $\in_0 \emptyset$

= $2\in_0 E_0 \pi r^2$

A12 (a) the electric field outside the plates on both side E = $\frac{\sigma}{2\in_0}$ + $\frac{-\sigma}{2\in_0}$ = 0

(ii) Between the plates: E = $\frac{\sigma}{2\in_0}$ + $\frac{\sigma}{2\in_0}$ = $\frac{\sigma}{\in_0}$ (towards plates having –ve charge density)

Capacitance C = Q/V = $\frac{Q}{Ed}$ = $\frac{\in_0 Q}{\sigma\, d}$ (since E = $\frac{\sigma}{\in_0}$)

$$C = \frac{\in_0 Q}{Q.d/A} = \in_0 A/d$$

(b)Electric field is reduced & become 1/K time's i.e. $\frac{\sigma}{K\in_0}$

Capacitance become K times because electric field decreased by K factor.

A13. (a) Electric flux: Total number of electric lines of force passing perpendicular through a given surface. Unit: Nm^2C^{-1} or V-m

According to Gauss theorem, the electric flux through a closed surface depends only on the net charge enclosed by the surface and not upon the shape or size of the surface.

For any closed arbitrary shape of surface enclosing a charge the outward flux is same as that due to a spherical Gaussian surface enclosing the same charge.

Justification: This is due to the fact

(i) Electric field is radial and

(ii) The electric field E α $\frac{1}{R^2}$

(b) According to Gauss theorem, electric flux $\phi = \oint \vec{E}.\vec{ds}$ = $\frac{q}{\in_0}$ = 0

Since no charge is present inside the charged shell and ds $\neq$ 0

$\Rightarrow$ E = 0

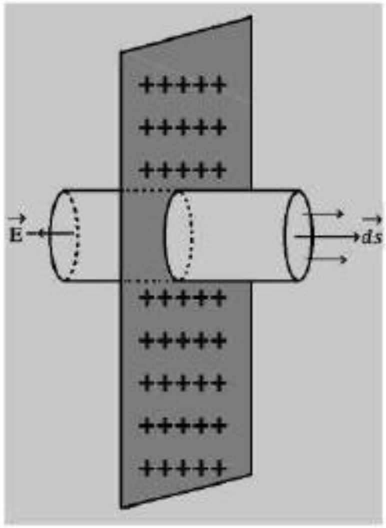
(c) Initial energy = U = $\frac{1}{2}\frac{q^2}{C}$

Common potential V when it is connected with another uncharged identical potential = $\frac{q+0}{2C} = \frac{q}{2C}$

New energy U' = $\frac{1}{2}$ x 2C x $(\frac{q}{2C})^2$ = $\frac{q^2}{4C}$ $\Rightarrow$ U' < U so energy decreases.

A14.(i) Let surface charge density of plane sheet = σ

The electric field is perpendicular to curved surface (area vector) of cylindrical Gaussian surface.



Electric flux passing through curved surface is zero.

Electric flux passing through two plane surface;

$\oint \vec{E}.\vec{ds}$ = $\int Eds\, cos0^0$ + $\int Eds\, cos0^0$

= 2Eds

According to Gauss theorem

2Eds = $\frac{q}{\epsilon_0}$

= $\frac{\sigma.\, ds}{\epsilon_0}$

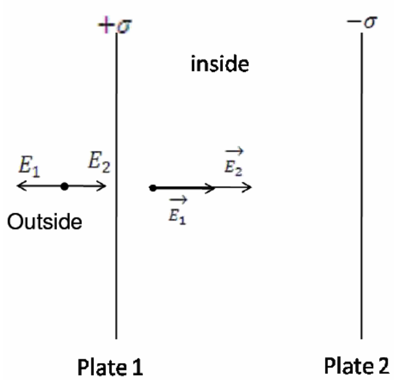
E = $\frac{\sigma}{2\epsilon_0}$

If is σ positive *E* points normally outwards/away from the sheet
If is σ (-)ve *E* points normally inwards/towards the sheet

(ii) $U_s = \frac{1}{2} C_s V_s^2$

$U_P = \frac{1}{2} C_P V_P^2$

Since $U_s = U_P \Rightarrow \frac{V_S}{V_p} = \sqrt{\frac{C_P}{C_S}} = \sqrt{\frac{C_1+C_2}{\frac{C_1C_2}{C_1+C_2}}} = \frac{C_1+C_2}{\sqrt{C_1C_2}} = \frac{3}{\sqrt{2}}$



A15. (i)(a)Inside the plates;

$\vec{E} = \vec{E_1} + \vec{E_2}$

= $\frac{\sigma+\sigma}{2\epsilon_0}$ = $\frac{\sigma}{\epsilon}$

Outside the plates $\vec{E} = \vec{E_1} - \vec{E_2}$ = = $\frac{\sigma-\sigma}{2\epsilon_0}$ = **0**

(b) Potential difference between plates V = Ed = $\frac{1}{\epsilon_0}\frac{Qd}{A}$

(c) Capacitance **C** = $\frac{Q}{V}$ = $\frac{\epsilon_0 A}{d}$

(ii) As the potential on and inside a charged sphere is given

V = $\frac{1}{4\pi\epsilon_0}\frac{q}{r}$ = $\frac{1}{4\pi\epsilon_0}\frac{4\pi r^2\sigma}{r}$

$\Rightarrow$ **V α r**

Hence bigger sphere will be at higher potential, so charge will flow from bigger sphere to smaller sphere.

ANSWER TO VALUE BASED QUESTION:

A1. (i) Electric field inside the conductor is zero

(ii) Electrostatic shielding

(iii) No. it is constant

(iv) Empathy, Curiosity to know (Manoj), helpful, quick decision maker.

UNIT-II: Current Electricity:

VERY SHORT ANSWER TYPE QUESTIONS: 1 –MARK

Q1. Write the expression for the drift velocity of charge carriers in a conductor of length 'l' across which a potential difference 'V' is applied.

Q2. Define the term 'mobility' of charge carriers. Write its S.I. unit.

Q3. Distinguish between emf and terminal voltage of a cell.

Q4. Write any two factors on which drift velocity of charge carriers in a conductor depends.

Q5. Why is conductivity of electrolytes less than that of metals?

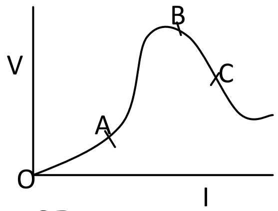
Q6. Define the term 'drift velocity' of charge carriers in a conductor and write its relationship with the current flowing through it.

Q7. State the underlying principle of a potentiometer.

Q8. Graph showing the variation of current versus voltage for a material GaAs is shown in the figure. Identify the region of

(i) negative resistance

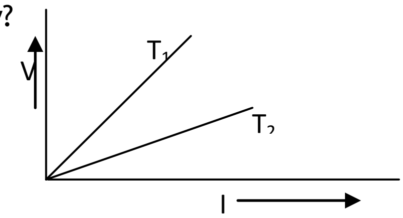
(ii) where Ohm's law is obeyed.



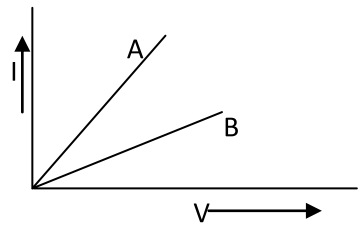
OR

Plot a graph showing variation of current versus voltage for the material GaAs.

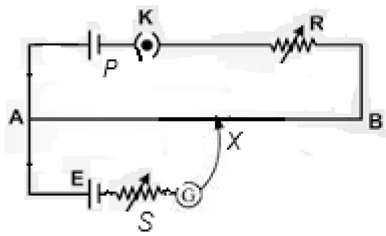
Q9. V – I graph for a metallic wire at two different temperatures T1 and T2 is as shown in the figure. Which of the two temperatures is higher and why?



Q10. Two metallic resistors are connected first in series and then in parallel across a d.c.supply. Plot of I – V graph is shown for the two cases. Which one represents a parallel combination of the resistors and why?

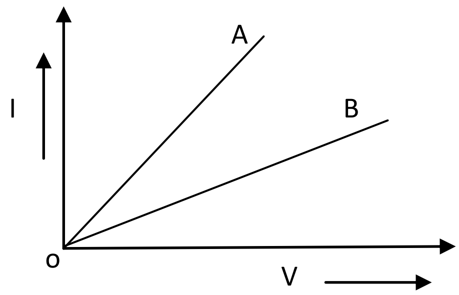


Q11. In the potentiometer circuit shown, the null point is at X. State with reason, where the balance point will be shifted when (a) resistance R is increased, keeping all other parameters unchanged; (b) resistance S is increased, keeping R constant.



Q12. Two wires, one of copper and the other of manganin, have same resistance and equal thickness. Which wire is longer? Justify your answer.

Q13. I – V graph for two identical conductors of different materials A and B is shown in the figure. Which one of the two has higher resistivity?



Q14. What does the no deflection position in the galvanometer of potentiometer experiment tell us about the flow of current?

Q15. Why should the balanced point be obtained in the middle of the meter – bridge wire, while finding the unknown resistance?

Q16. How does one explain increase in resistivity of a metal with increase of temperature?

Q17. How does the random motion of free electrons in a conductor get affected when a potential difference is applied across its ends?

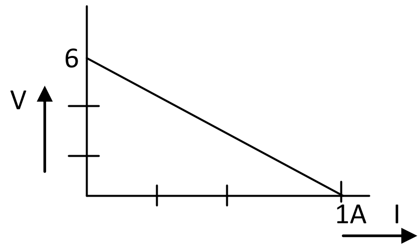
Q18. Two wires of equal length, one of copper and other of maganin have same resistance. Which wire is thicker?

Q19. We prefer potentiometer to compare the e.m.f. s of cells than the voltmeter. Why?

Q20. The current flows in a wire of circular cross section with free electrons travelling with drift velocity (v_d). If an equal current flows in a wire of the same material but twice the radius, what is new drift velocity?

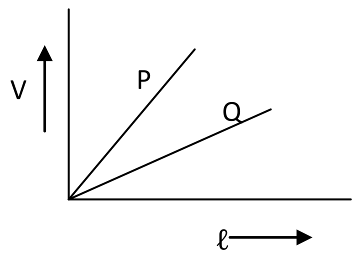
Q21. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is shown below. What is the emf and internal resistance of each cell?

[All India:2016(C)]



Q22. The variation of potential difference (V) with length ℓ in the case of two potentiometer wires P and Q is shown. Which one of these will you prefer for comparing emfs of two primary cells?

CBSE-2016 (E)



Q23. Define conductivity of a conductor. On what factors does it depend? CBSE-2016 (E)

Q24.Write the underlying principle of a moving coil galvanometer.**CBSE-2016-D**

Q25. Give an example of a material each for which temperature coefficient of resistivity is (i) positive, (ii) negative.**SQP-2016**

SHORT ANSWER TYPE QUESTIONS: 2-MARKS

Q1.Use Kirchhoff's rules to obtain conditions for the balance condition in a Wheatstone bridge.

Q2.State the two Kirchhoff's rules used in electric networks. How are these rules justified?

Q3. Define current density and write down its SI unit. What is the direction of current density taken in the circuit?

Q4.Distinguish between emf (E) and terminal voltage (V) of a cell having internal resistance 'r'.

Draw a plot showing the variation of terminal voltage (V) vs the current (I) drawn from the cell.

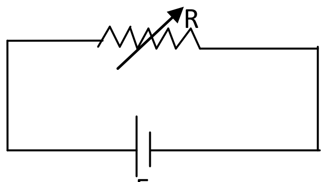
Using this plot, how does one determine the internal resistance of the cell?

Q5. Draw a plot showing the variation of resistivity of a (i) conductor and (ii) semiconductor, with the increase in temperature.

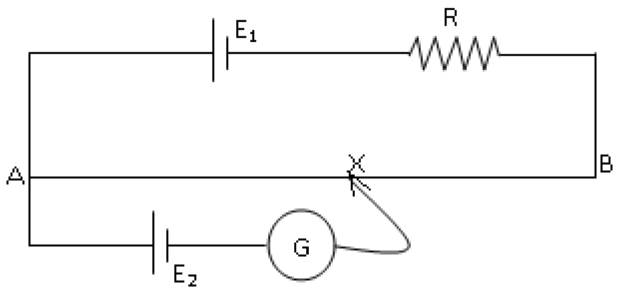
How does one explain this behaviour in terms of number density of charge carriers and the relaxation time?

Q6. A potentiometer wire of length 1 m has a resistance of 10Ω. It is connected to a 6 V battery in series with a resistance of 5 Ω. Determine the emf of the primary cell which gives a balance point at 40 cm. **Ans: 1.6 V**

Q7. A variable resistor R is connected across a cell of emf E and internal resistance(r) as shown in the figure. Draw a plot showing the variation of (i) terminal voltage V and (ii) the current I, as a function of R.

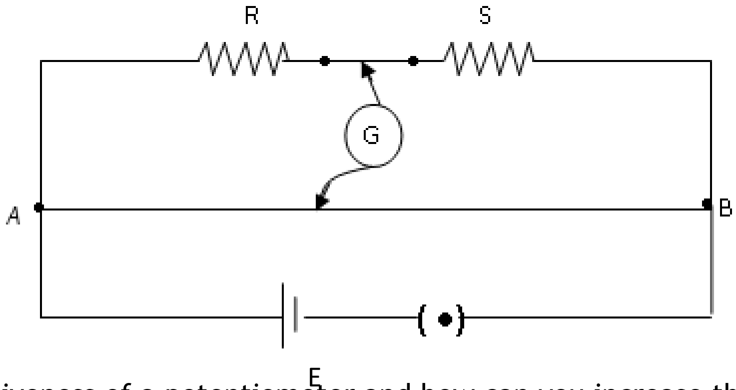


Q8.In the circuit diagram shown, AB is a uniform wire of resistance 15 Ω and length 1 m. It is connected to a cell E_1 of emf 2 V and negligible internal resistance and a resistance R. The balance point with another cell E_2 of emf 75 mV is found at 30 cm from end A. Calculate the value of the resistance R.



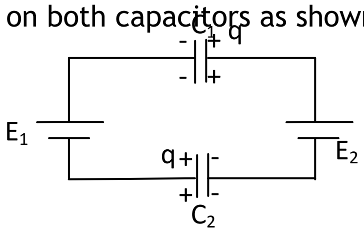
Q9. In a meter bridge shown in the figure, the balance point is found to be 40 cm from end A. If a resistance of 10 Ω is connected in series with R, balance point is obtained 60 cm from A.

Calculate the values of R and S.



Q10. What do you understand by sensitiveness of a potentiometer and how can you increase the sensitiveness of a potentiometer?

Q11. Determine the potential difference across the plates of the capacitor C_1 of the network shown in figure. Assume $E_2 > E_1$ and charge q is present on both capacitors as shown Ans: $E_2 - (E_1 + q / C_2)$



Q12. A heater coil is cut into two equal parts and only one part is used in heater. How much heat will be produced now in comparison to previous one? Ans: Heat produced get doubled.

Q13. A wire of resistance R is cut into 'n' equal parts. These parts are then connected in parallel. What is equivalent resistance of combination? Ans R/n^2

Q14. There are 'n' resistors each of 'r' ohm, when connected in parallel give an equivalent resistance 'R'ohm. If these resistors are connected in series, what would be the equivalent resistance Ans: n^2R

Q15. Two wires of same dimensions but have the resistivities ρ_1 and ρ_2 are connected in series. What is equivalent resistivity of combination? Ans $(\rho_1 + \rho_2)/2$

Q16. In a meter bridge experiment null point is obtained at 20 cm from one end of the wire when 'X' is balanced against another resistance 'Y' (X<Y). Calculate the new position of null point from the same end if one decides to balance a resistance of '4X' and 'Y'. Ans: 50cm

Q17. The specific resistance of the material of potentiometer wire is 10^{-7}ohm-m having uniform cross section area of 10^{-6} m^2 and a constant current 0.1 A is made to pass through it. What is potential gradient along the potentiometer wire? Ans: 10^{-2} V/m

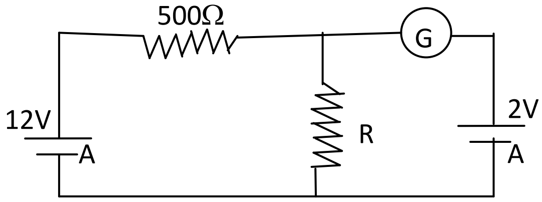
Q18. The length of potentiometer wire is 100cm and the emf of its standard cell is 4 volts. It is employed to measure the emf of a cell whose internal resistance is 0.5Ω. If the balance point is obtained at ℓ = 30cm from the positive end, what is the emf of cell? Ans:1.2V

Q19. In a potentiometer experiment, the balancing length with a cell is 560cm. When an external resistance of 10Ω is connected in parallel to the cell, the balancing length is changes to 412cm.

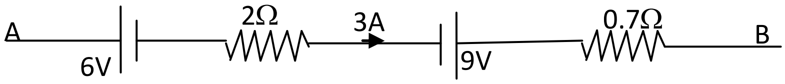
(i)What is internal resistance of the cell? Ans: 3.6Ω

(ii) Why does balancing length decrease?

Q20. In the circuit, the galvanometer shows zero deflection. If the batteries have negligible internal resistance, what is the value of 'R'? Ans: R = 100Ω

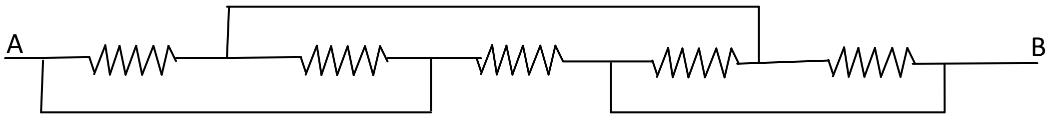


Q21. What is potential difference between points A and B



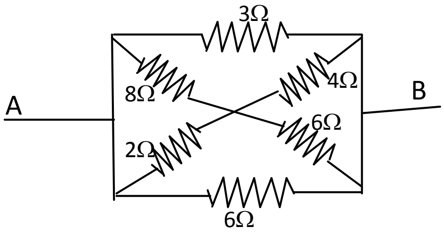
Ans: 5.1Volts

Q22. Resistors each of resistance 1Ω are arranged as shown in figure. Find the equivalent resistance between point A and B. Ans 0.5Ω

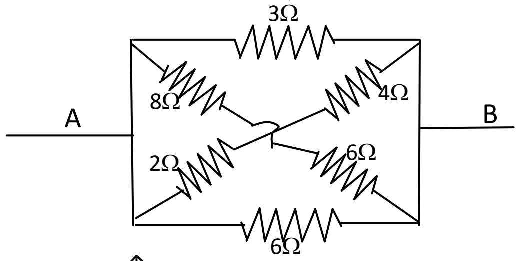


Q23. Find the equivalent resistance of the circuit between point A and B. Ans: 4/3Ω, 42/31Ω

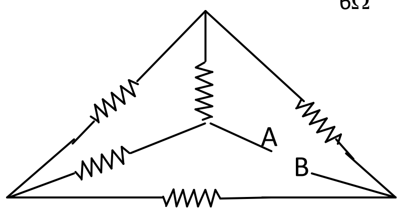
(a)



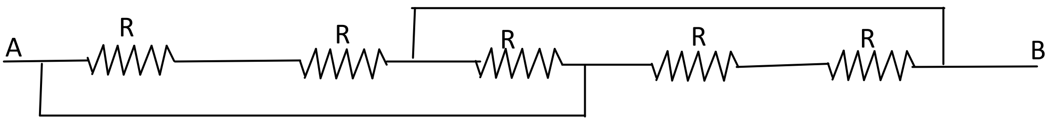
(b)



Q24. Find the equivalent resistance of the circuit between point A and B the value of each resistance is 2Ω. Ans: 2Ω

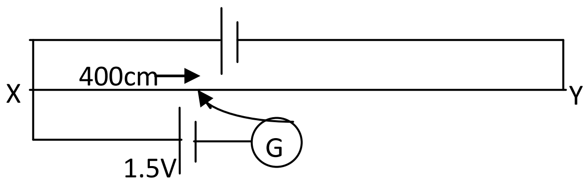


Q25. Calculate equivalent resistance between points A and B if the value of each resistance is RΩ.

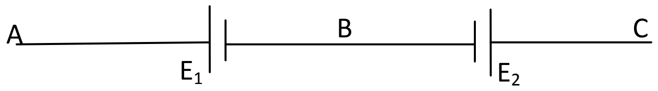


Ans: 0.5Ω

Q26. What is potential difference across X and Y, if a cell of emf 1.5V is balanced at 400cm of the potentiometer wire having length of wire XY = 1000cm. Ans: 3.75V



Q27. Two cells of emf's E_1 and E_2 ($E_1 > E_2$) are connected as shown in figure. When potentiometer is connected between A and B the balancing length of the potentiometer wire is 300cm. On connecting the same galvanometer between A and C, the balancing length is 100cm. What is the ratio of E_1 and E_2. Ans: 3:2



Q28. Two cells of emfs 1.5 V and 2.0 V having internal resistances 0.2 Ω and 0.3 Ω respectively are connected in parallel. Calculate the emf and internal resistance of the equivalent cell.

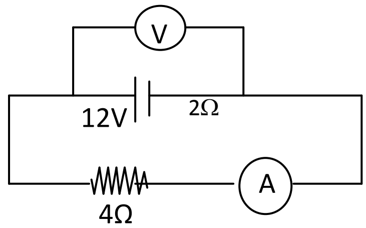
CBSE-2016-D

Q29. A battery of emf 12V and internal resistance 2Ω is connected to a 4 Ω resistor as shown in figure.

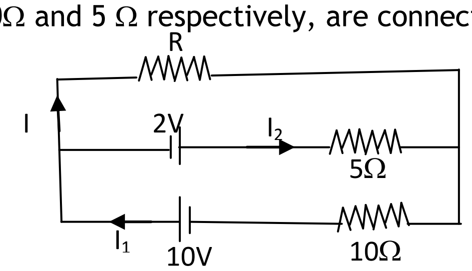
(a) Show that a voltmeter when placed across the cell and across the resistor, in the turn, gives the same reading.

(b) To record the voltage and the current in the circuit, why is voltmeter placed in parallel and ammeter in series in the circuit?

[All India:2016(C)]



Q30.Two cells of E.M.F. 10V and 2V and internal resistances 10Ω and 5 Ω respectively, are connected in parallel as shown. Find the effective voltage across R.



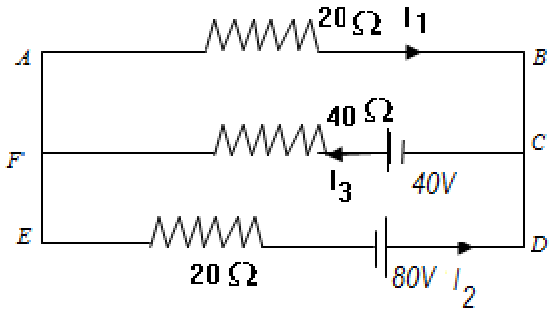
SHORT ANSWER TYPE QUESTIONS: 3-MARKS

Q1.Using a circuit diagram, explain how can a potentiometer be used to compare the emf's of two cells?

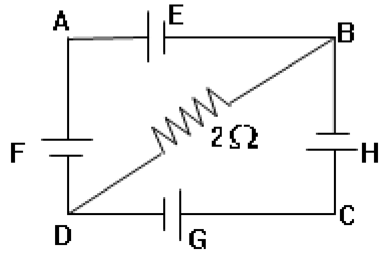
Q2. Using a circuit diagram, explain how a potentiometer can be used in determination of internal resistance of a primary cell?

Q3. Using a concept of drift velocity, derive the Ohm's law.

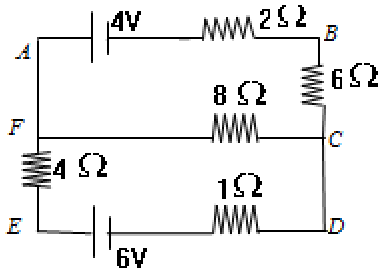
Q4. Use Kirchhoff's rules to find out the values of the currents I_1 and I_2 in the electrical network as shown. **Ans**: I_1 = -6/5 A, I_2 = 14/5 A



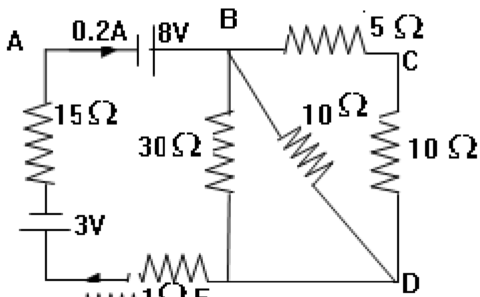
Q5. In the circuit shown below, E, F, G and H are cells of emf 2 V, 1V, 3V and 1V, and their internal resistances are 2Ω, 1Ω, 3Ω and 1Ω, respectively. Calculate (i) the potential difference between B and D and (ii) the potential difference across the terminals of each of cells G and H. Ans: P.D. across B and D = 2/13 V, 1.615V, 1.46V



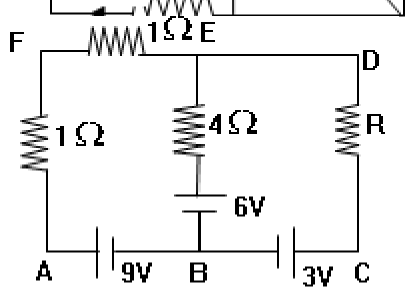
Q6. Using Kirchhoff's Law, calculate the potential difference across the 8 ohms resistor. **Ans:** 3.78V



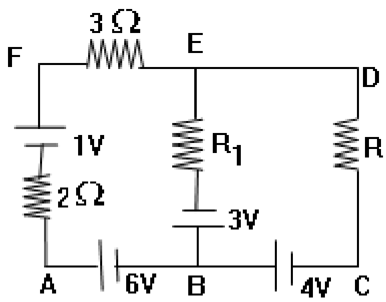
Q7. Calculate the value of the resistance R in the circuit shown in the figure so that the current in the circuit is 0.2 A. What would be the potential difference between points B and E. **Ans:** 1V , R = 5Ω, 1 V



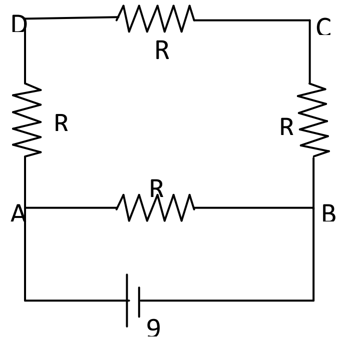
Q8. Using Kirchhoff's rules determine the value of unknown resistance R in the circuit so that no current flows through 4 Ωresistances. Also find the potential difference between A and D. **Ans:** R =2Ω, V_{AD} = 3V



Q9. Using Kirchhoff's rules determine the value of unknown resistance R and potential difference between AD in the circuit so that no current flows through the arm EB. Ans: R=0.5Ω, V=9V



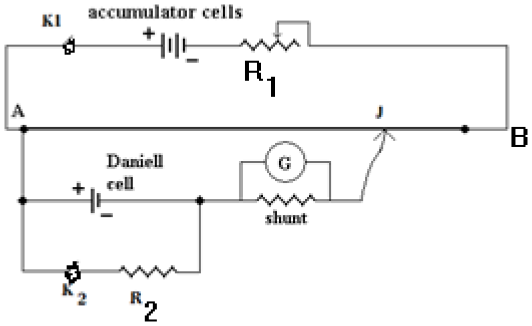
Q10. A 16Ω resistance wire is bent to form a square. A source of emf 9 V is connected across one of its sides as shown. Calculate the current drawn from the source. Find the potential difference between the ends C and D. If now the wire is stretched uniformly to double the length and once again the same cell is connected in the same way, across one side of the square formed, what will now be the potential difference across one of its diagonals? Ans: V_{CD} = 3V, V_{dia} = 6V



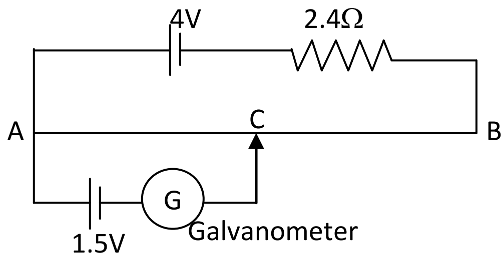
Q11. For the circuit shown below, would the balancing length increase, decrease or remain the same, if

(i) R_1 is decreased

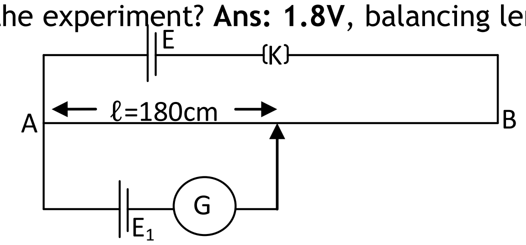
(ii) R_2 is increased.



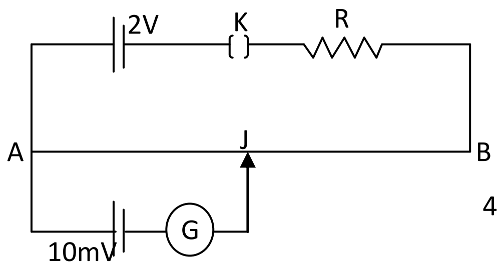
Q12. A potentiometer circuit is shown in figure here. The internal resistance of the 4V battery is negligible. AB is uniform wire of length 100cm and resistance 4Ω. What would be the length AC for zero deflection? **Ans**: 60cm



Q13. In the circuit shown, AB is the wire of uniform cross-section in which potential gradient of 0.01V/cm exists. (i) if the galvanometer G shows no deflection, what is the emf of the cell used? (ii) If the internal resistance of the cell E increases on some account, how will it change the balance point in the experiment? **Ans: 1.8V**, balancing length will increase.



Q14. A potentiometer wire of length 100cm has a resistance of 10Ω. It is connected in series to a resistance and a cell of emf 2V of negligible internal resistance. A source of emf 10mV is balanced by a length of 40cm of the potentiometer wire. What is the value of the external resistance? **Ans R = 790Ω**



Q15.A 10m long wire of uniform area of cross section and of 20 ohms resistance is fitted in a potentiometer. The wire is connected in series with battery of 5V along with an external resistance of 480 ohms. If an unknown emf 'E' is balanced at 600cm of the wire. Calculate the potential gradient of the wire and the value of unknown emf. **Ans: 0.02V/m, 0.12V.**

Q16.The resistance per unit length of 10m long potentiometer wire is 0.01 ohm/cm. It is connected in series with battery and 10 ohms external resistance. If null point for a primary cell of emf 2V occurs at 500cm length of potentiometer wire, find current in the potentiometer wire and the emf of the battery. **Ans: 0.4 A, 8Volts.**

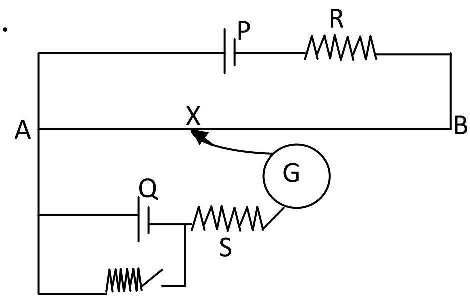
Q17.The resistance of a potentiometer wire of length 10m is 20 ohms. A resistance box and 2V accumulator is connected in series with it. What resistance should be introduced in the box to have a potential drop of 1 micro volt per millimetre of the potentiometer wire? **Ans: 3980 ohms**

Q18.In the potentiometer circuit shown, the balance point is at 'X'. State the reason where the balance point will be shifted when

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

(ii) Resistance 'S' is increased keeping 'R' constant.

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

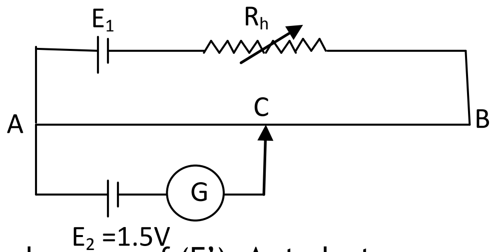


Q19.A battery E_1 of 4V and a variable resistance R_h are connected in series with the wire AB of potentiometer. The length of the wire of potentiometer is 1m. When a cell of emf 1.5 V is connected between the points A and C, no current flows through E_2. Length of AC = 60cm.

(i) Find the potential difference between the ends A and B of the potentiometer.

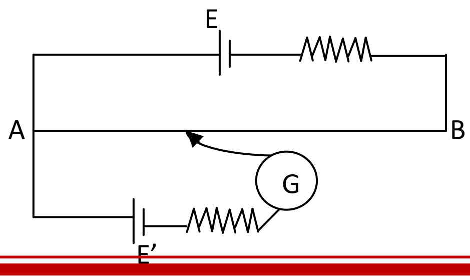
(ii) Would the method work, if the battery E_1 is replaced by a cell of emf of 1V?

Ans: 2.5V, No

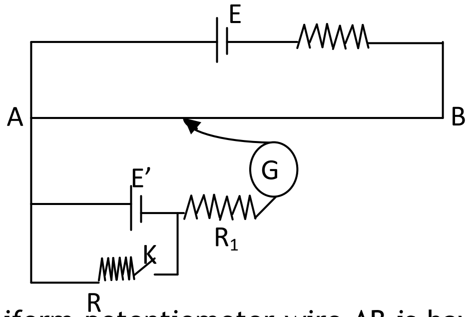


Q20. For the potentiometer circuit shown in figure represents an unknown emf (E'). A student observed that when jockey is moved from the end A to B of the potentiometer wire, the deflection in the galvanometer in same direction. What are two possible faults in the circuit that could recount in this observation?

If the galvanometer deflection at the end B is (i) more (ii) less than that end A, which of the two faults, listed above, would be in the support of your answer.

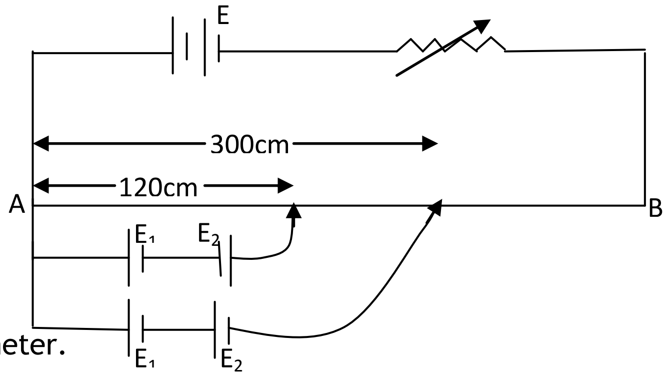


Q21.The circuit shown in fig. shows use of potentiometer to measure the internal resistance of a cell (E'). (i)When key (K) is open, how does the balance point change if the current from the driver cell (E) decreases (ii) when the key (K) is closed, how does balanced point change if R is increased keeping the current from the driver cell constant.



Q22. In figure a long uniform potentiometer wire AB is having a constant potential gradient along its length. The null point is obtained for the two primary cells $E_1$and E_2 connected in the manner shown, are obtained at a distance of 120cm and 300cm from the end A in two different situation as shown.

Find (i) E_1/ E_2 (ii) position of null point for the cell E_1. How is the sensitivity of a potentiometer increased?



Q23. State the principle of working of a galvanometer.

A galvanometer of resistance G is converted into a voltmeter to measure up to V volts b connecting a resistance R_1 in series with the coil. If a resistance R_2 is connected in series with it, then it can measure up to V/2 volts. Find the resistance, in terms of R_1 and R_2, required to be connected to convert it into a voltmeter that can read up to 2V. Also find the resistance G of the galvanometer in terms of R_1 and R_2. **Ans:** $G = R_1 - 2R_2$.

Q24.A potentiometer wire of length 1 m has a resistance of 5Q.It is connected to a 8V battery in series with a resistance of 15Ω. Determine the emf of the primary cell which gives a balance point at 60 cm. **Ans: 1.2V**

Q25. A cell of emf 'E' and internal resistance 'r' is connected across a variable load resistor R. Draw the plots of the terminal voltage V versus (i) R and (ii) the current I. It is found that when R = 4Ω, the current is 1A and when R is increased to 9Ω, the current reduces to 0.5A. Find the values of the emf E and internal resistance r.

Q26.Two capacitors of unknown capacitances C_1 and C_2 are connected first in series and then in parallel across a battery of 100 V. If the energy stored in the two combinations is 0.045 J and

0.25 J respectively, determine the value of C_1 and C_2. Also calculate the charge on each capacitor in parallel combination.

Q27.A potential difference V is applied across a conductor of length L and diameter D. How is the drift velocity, v_d, of charge carriers in the conductor affected when (i) V is halved, (ii) L is doubled and (iii) D is halved? Justify your answer in each case.

Q28.Define the electric resistivity of a conductor.

Plot a graph showing the variation of resistivity with temperature in the case of a (a) conductor, (b) semiconductor.

Briefly explain, how the difference in the behaviour of the two can be explained in terms of number density of charge carriers and relaxation time.

Q29.Plot a graph showing the variation of current density (j) versus the electric field (E) for two conductors of different materials. What information from this plot regarding the properties of the conducting material, can be obtained which can be used to select suitable materials for use in making (i) standard resistance and (ii) connecting wires in electric circuits ? Electron drift speed is estimated to be of the order of mm s^{-1}. Yet large current of the order of few amperes can be set up in the wire. Explain briefly.

Q30.When a metallic conductor is subjected to a certain potential V across its ends, discuss briefly how the phenomenon of drift occurs. Hence define the term 'drift velocity' of charge carriers and show that the current density $\vec{J}$ is related to the applied electric field $\vec{E}$ by the relation

$$\vec{J} = \sigma \vec{E}$$

where σ defines the conductivity of the material.

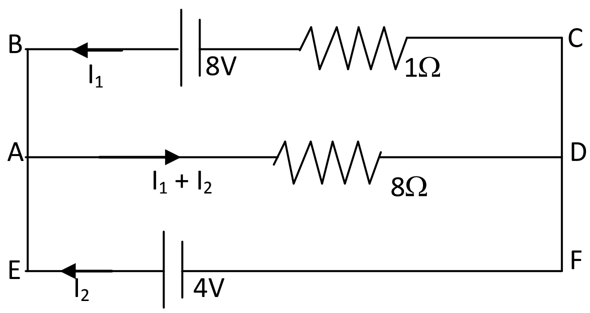
Q31.State the underlying principle of a potentiometer. Write two factors by which current sensitivity of a potentiometer can be increased. Why is a potentiometer preferred over voltmeter for measuring the emf of a cell?

Q32.Find the relation between drift velocity and relaxation time of charge carriers in a conductor

A conductor of length L is connected to a d.c. source of emf 'E'. If the length of the conductor is tripled by stretching it, keeping 'E' constant, explain how its drift velocity would be affected.

Q33.Three cells of emf, E_1 = 1.5 V, E_2 = 2.0 V and E_3= 3 V, having internal resistances r1 = 0.3 Ω, r2 = 0.4 Ωand r3 = 0.6 Ω respectively are connected in parallel. Find out the equivalent emf and the equivalent resistance of a cell which can replace this combination.

Q34.In the electric network shown in the figure, use Kirchhoff's rules to calculate the power consumed by the resistance R = 8 Ω



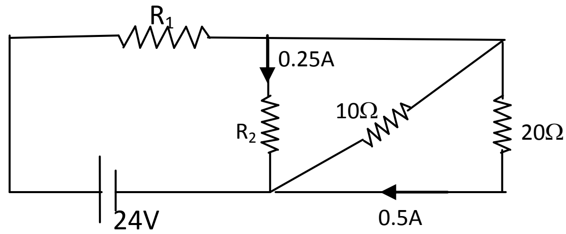
Ans: $I_1 = 4A$, $I_2 = -3.5\ A$, $I_1 + I_2 = 0.5\ A$

Heat produced = $(I_1 + I_2)^2\ R = 2W$

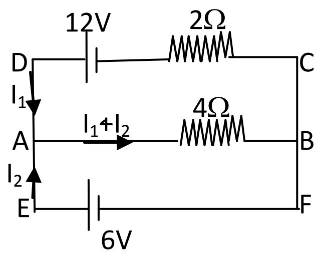
Q35.(a) State the underlying principle of a potentiometer. Why is it necessary to (i) use a long wire, (ii) have uniform area of cross-section of the wire and (iii) use a driving cell whose emf is taken to be greater than the emfs of the primary cells?

(b) In a potentiometer experiment, if the area of the cross-section of the wire increases uniformly from one end to the other, draw a graph showing how potential gradient would vary as the length of the wire increases from one end.

Q36.In the circuit shown in figure, calculate the value of R_1 and R_2. Ans: $R_1 = 8\Omega$, $R_2 = 40\Omega$



Q37. In the electric network shown in the figure, use Kirchhoff's rules to calculate the power consumed by the resistance $R = 4\Omega$.



Q38. (i)Derive an expression for drift velocity of free electrons.

(ii)How does drift velocity of electrons in a metallic conductor vary with increases of temperature? **All India-2016**

Q39. The potential difference across a resistor 'r' carrying current 'I' is Ir.

(i) Now if the potential difference across 'r' is measured using voltmeter of resistance 'R_v', show that the reading of voltmeter is less than the true value.

(ii) Find the percentage error in measuring the potential difference by voltmeter.

(iii) At what difference of R_v does the voltmeter measures the true potential difference? CBSE **SQP-2016**

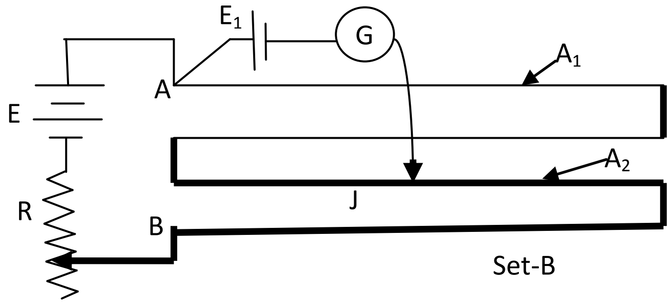
Q40.You are given two sets of potentiometer circuit to measure the emf E_1 of a cell.

Set A: consists of a potentiometer wire of a material of resistivity ρ_1, area of cross section A_1 and length ℓ.

SetB: consists of a potentiometer of two composite wires of equal lengths $\ell/2$ each, of resistivity ρ_1 and ρ_2 and of cross section A_1 and A_2 respectively.

(i) Find the relation between resistivity of two wires with respect to their area of cross section, if the current flowing the two sets is same.

(ii) Compare the balancing length obtained in the two sets. **CBSE SQP-2016**



LONG ANSWER TYPE QUESTIONS: 5-MARKS

Q1.(a) State Kirchhoff's rules and explain on what basis they are justified.

(b) Two cell of emfs E_1 and E_2 and internal resistance r_1 and r_2 are connected in parallel. Derive the expression for the (i) emf and (ii) internal resistance of a single equivalent cell which can replace this combination.

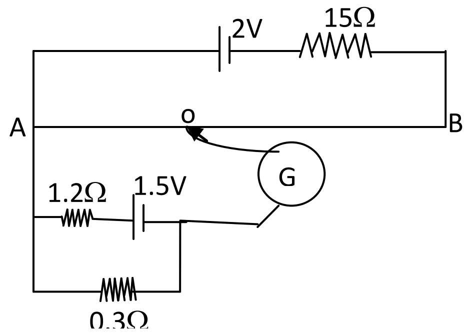
Q2. (i) Define the term drift velocity.

(ii) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistivity of a conductor depend? **CBSE-2016-D**

(iii) Why alloys like constantan and manganin are used for making standard resistors?

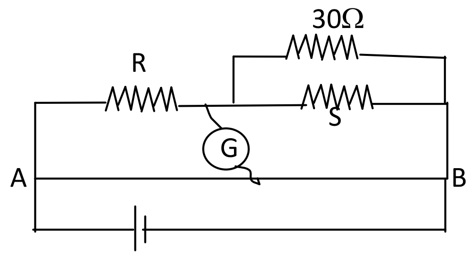
Q3. State the principle of working of a potentiometer.

(ii) In the following potentiometer circuit AB is a uniform wire of length 1 m and resistance 10 Ω. Calculate the potential gradient along the wire and balance length AO (= *l*).**CBSE-2016-D**



Q4.(i) State the principle of a meter bridge. Draw the circuit diagram for finding a unknown resistance using meter bridge. Derive the relevant formula used.

(ii)In a meter bridge with R and S in the gaps, null point is found at 40cm from A. If a resistance of 30Ω is connected in parallel with S the null point occurs at 50cm from A. Determine the values of R and S. CBSE 2016(E)



VALUE BASED QUESTIONS: 4 MARKS

Q1. Deepika and Ruchika were asked by their teacher to perform an experiment using a galvanometer. Before doing the experiment they were very keen to know the different parts of the galvanometer which was given to them in the form of a small box. They approached the teacher and asked for the permission. The teacher thought it would be a good idea if the galvanometer be opened before the whole class and explained its construction and working to all of them.

Based on the above paragraph, answer the following questions:

(a) What, in your opinion, were the qualities displayed by Deepika, Ruchika and the teacher?

(b) State briefly the working principle of the galvanometer.

(c) What is the shape of the magnets used and why is it so designed?

Q2. Ashok and Arun, the students of class-XII, were doing an experiment to determine the internal resistance of a cell using a potentiometer. To perform the experiment, they connected a resistance box (RB_1) and key (K_1) in parallel to the experimental cell after making all other connections.

They were able to find the internal resistance of given cell successfully. But, during the experiment, they once noticed that when they closed the key K_1 in the circuit without inserting any resistance in resistance box (RB_1), the galvanometer started showing one side deflection. They discussed this problem with each other but, being unable to find the correct reason, they requested their physics teacher who explained to them the cause of one side deflection.

(a) Draw the necessary circuit diagram used in determination of internal resistance of a cell.

(b) What is possible cause of showing one side deflection?

(c) What will be the effect on balancing length on decreasing the value of resistance from resistance box (RB_1) while keeping the other parameter same?

(d) Give two values shown by the students.

ANSWER KEY VERY SHORT ANSWER TYPE QUESTIONS: 1-MARK

A1. Drift velocity $V_d = \frac{eV\tau}{m\ell}$

A2. Mobility: It is defined as the electric field applied per unit drift velocity.

SI Unit: Cm/Ns

A3. EMF: It is the potential difference across the terminals of cell/ battery when no current is drawn from the cell/ battery.

Terminal potential: The potential difference across the terminals of cell/ battery when current is drawn from the cell/ battery.

A4. $V_d \propto$ Potential difference and $V_d \propto (1/\ell)$, temperature, electric field (any two)

A5. (i) Electrolytes have less number of charge carriers (ions) per unit volume as compared to free electron concentration in metals.

(ii) Drift velocity of ions is less than drift velocity of free electrons (Any one point)

A6. The velocity with which electrons drift in a conductor under the effect of applied electric field.

Current I = $neAV_d$

A7.When constant current is made to pass through the wire of uniform cross sectional area of potentiometer; the potential drop across any length of wire is directly proportional to that length.

A8.Negative resistance BC part, Ohms law OA part.

A9. T_1 because slope this graph is higher so have higher resistance(R = V/I)

A10.Graph A because in parallel combination the equivalent resistance is lower so the I-V graph should have higher slope.

A11.(a) balance point will shift towards B because potential gradient will decrease.

(b) No effect because no current flows through S at balance point.

A12.copper wire is longer because $\rho_c.\ell_c = \rho_m\ell_m$ (as $\rho\ell$ = constant)

$\therefore\ \ell_c > \ell_m$ because $\rho_m > \rho_c$

A13. Material B

A14.When the balanced point is obtained on the potentiometer wire , no current flows in the galvanometer circuit because the fall of potential across the potentiometer wire between zero end(A) and balance point position become just equal to the emf of the cell, whereas the current in the potentiometer flowing continuously .

A15.(i) because it reduces the end error (ii) a small error in locating the null point does not affect the result appreciably and (iii) all the four resistances P,Q, R and S will be of nearly same magnitude and hence the bridge will be more sensitive.

A16. With increase in temperature, the relaxation time (average time between successive collisions) decreases and hence resistivity increases.

A17.Random motions of free electrons get directed towards the point at a higher potential.

A18. The maganin wire is thicker, given that $\frac{\rho_c}{A_c} = \frac{\rho_m}{A_m} \Rightarrow \frac{\rho_c}{\rho_m} = \frac{A_c}{A_m}$

Since $\rho_m > \rho_c \Rightarrow A_m > A_c$

A19.Because the potentiometer measures the true emf since no current is drawn from the cell by potentiometer at balancing length whereas voltmeter must draw certain current while measuring emf so it measures potential difference across the terminals not the emf.

A20. The drift velocity become 1/4th as radius get twice since $V_d = \frac{I}{neA}$

ANSWER KEY SHORT ANSWER TYPE QUESTIONS: 2-MARKS

A1. At balance condition no current flows through galvanometer.

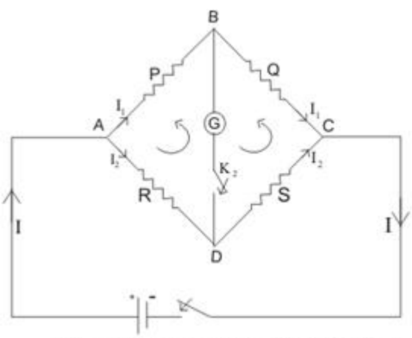
Applying Kirchhoff's loop rule to closed loop ABDA

$I_1P + 0 - I_2R = 0$ ($I_g = 0$)

$I_1P = I_2R$ --------- (1)

For loop BCDB

$I_1Q - I_2S + 0 = 0$



Wheatstone bridge circuit arrangement

$I_1Q = I_2S$ ------------- (2)

From equation (1) and (2)

P/Q = R/S

A2. 1st Law: "Algebraic sum of the currents meeting at a point in an electric circuit is always zero. This law is justified on the basis of law of conservation of charge.

2^{nd} Law: The algebraic sum of changes in potential around any closed loop involving resistors and cells in the loop is zero. This law is justified on the basis of law of conservation of energy.

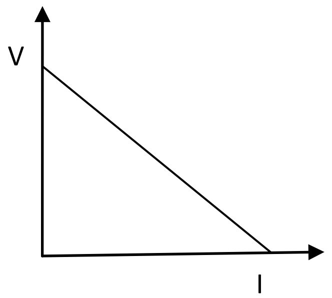
A3. The current density at a point in the conductor is defined as the current per unit cross-section area. The current density **J** at any point on that area is given by;

J=I/A

Direction of current density is same as the direction of conventional current / electric field. Unit of current density is ampere/meter^2 (Am^{-2})

A4.

emf	Terminal voltage
1. It is the potential difference between two terminals of the cell when no current is drawn from it. 2. It is the cause.	1. It is the potential difference between two terminals when current is drawn from it. 2. It is the effect.

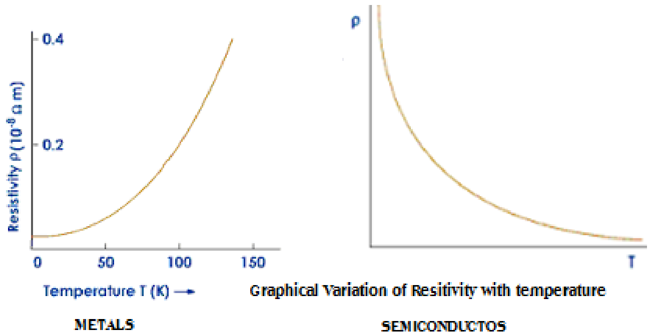


The negative of slope give the internal resistance of cell.

A5.

Resistivity (ρ) = $\frac{m}{ne^2\tau}$

- In conductors average relaxation time decreases with increase in temperature, resulting increase in resistivity.
- In semiconductors, the increase in number density with rise of temperature is more than the decrease in relaxation time. The net result is, therefore decrease in resistivity.



A6.Current in potentiometer wire I = 6/ 15 = 0.4A

Resistance per unit length of wire = 10/100 = 0.1Ω/cm

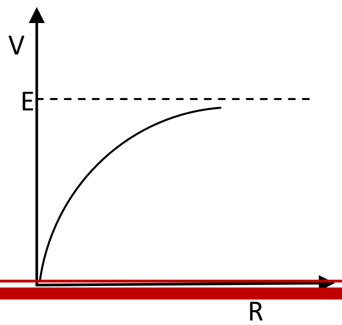
Resistance of 40cm length = 0.1 x 40 = 4Ω

EMF of primary cell which balance at 40cm = 0.4x 4 = 1.6 V

A7.

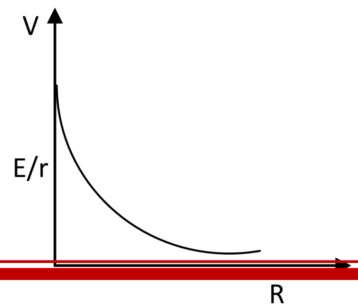
(i) V vs R

V = $\frac{ER}{R+r}$



(ii) I vs R

I = $\frac{E}{R+r}$



A8. Current through wire I = $\frac{E}{R+r}$ = $\frac{2}{R+15}$

Potential gradient = $(\frac{2}{R+15}) \times \frac{15}{100}$

Now E_2 = potential drop across 30cm

= 75×10^{-3} = $(\frac{2}{R+15}) \times 0.15 \times 30$

R = 105Ω

A9. R/S = 40/60 ⇒ 3R = 2S---------------- (i)

$\frac{R+10}{S}$ = 60/40 ⇒ 2R + 20 = 2S ----------- (ii)

On solving equation we get R = 8Ω and S = 12Ω

A10. The sensitiveness of a potentiometer means the smallest potential difference that can be measured with the help of it. The sensitiveness of potentiometer can be increased by decreasing its potential gradient. The same can be achieved (a) by increasing the length of potentiometer wire. (b) If the length of potentiometer wire is fixed, the potential gradient can be decreased by reducing the current in the potentiometer wire.

A11. Moving anticlockwise in the network;

$E_2 - \frac{q}{C_1} - E_1 - \frac{q}{C_2} = 0$

$-\frac{q}{C_1} = -E_2 + E_1 + \frac{q}{C_2}$

$\Rightarrow V_1 = E_2 - (E_1 + \frac{q}{C_2})$

A12. $H = V^2/R$, Now new resistance = R/2

New current = 2V/R

Heat produced $H' = (2V/R)^2 \times R/2 = 2 \times (V^2/R) = 2H$ ⇒ 2-times

A13. Resistance of each part = R/n

1/R' = n/R + n/R + ------------n-times = n ×n/R

$R' = R / n^2$

A14. In parallel :1/R = 1/r + 1/r -------------------n-times

R = r/n ⇒ r = nR

In series $R' = nr = n \times nR = n^2R$

A15. $R = R_1 + R_2 = \rho_1\ell/A + \rho_2\ell/A = (\rho_1 + \rho_2)\,\ell/A$ ------------(1)

Again, $R = \rho 2\ell/A$ ---------------(2)

On comparing equ(1) and equ(2) we have ; $\rho = \frac{1}{2}(\rho_1 + \rho_2)$

A16. X/ Y = 20 / (100-10) = 1/4

Now 4X/Y = ℓ'/ (100-ℓ') ⇒ 4×(1/4) = ℓ'/ (100-ℓ')

ℓ' = 50cm.

A17. Potential gradient K = $I\rho/A = 0.1\times 10^{-7} / 10^{-6} = 10^{-2}$ V/m

A18. V α ℓ Or $\frac{V}{E} = \frac{\ell}{L} \Rightarrow V = \frac{\ell E}{L}$ = 30 E/ 100 = 30 x 4 / 100 = 1,2V

A19. $r = \frac{(\ell_1 - \ell_2)}{\ell_2} R = \frac{(560-412)10}{412} = 3.59 = = 3.6\Omega$

A20. Current through R = I = $\frac{12}{500+R}$

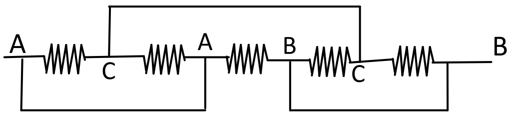
P.D. across R = IR = $\frac{12R}{500+R}$

Since galvanometer shows zero reading

$\therefore \frac{12R}{500+R} = 2 \Rightarrow R = 100\Omega$

A21. $V_A + 6 + 6 - 9 + 2.1 = V_B \Rightarrow V_B - V_A = 5.1V$

A22.



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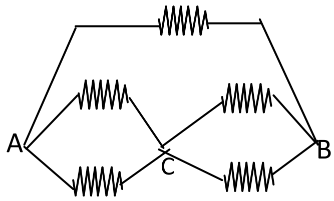


Resistance between AC + Resistance between CB = 0.5 + 0.5 = 1Ω

Net resistance between AB $\frac{1}{R}$ = 1 + 1 ⇒ R = 0.5Ω

A23.(a)Resistance between AB which are in parallel are 3Ω,(8/5Ω +12/5Ω), 6Ω = 3Ω, 4Ω,6Ω

Equivalent resistance = 4/3Ω

(b) Resistance between AB which are parallel 3Ω, (8Ω+6Ω), (2Ω + 4Ω), 6Ω

Equivalent resistance = 42/31Ω

A24.Network of resistance acts as balanced wheat stone bridge arrangement so one of the middle resistance is neglected.

1/R = ¼ + ¼ ⇒ R = 2Ω

A25. Since 2R∥ R ∥2R

1/R' = 1/2R + 1/R + 1/2R ⇒ R' = 0.5R

A26.Since 1.5V is balanced at 400cm ⇒ K = 1.5/400

Hence P.D. across XY = (1.5/400) x 1000 = 3.75V

A27. $E_1 \propto 300$ and $E_1 - E_2 \propto 100$

$\frac{E_1 - E_2}{E_1} = \frac{100}{300}$ on simplifying $E_1 : E_2 = 3:2$

A30. $E_{eq} = \frac{\left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right)}{\left(\frac{1}{r_1} + \frac{1}{r_2}\right)} = 2V$

ANSWER KEY SHORT ANSWER TYPE QUESTIONS: 3-MARKS

A1.See the Study Material

A2 See the Study Material

A3. See the Study Material

A4.Junction rule at point C , $I_1 + I_2 = I_3$

In loop ABCDA: $3I_1 + 2I_2 = 2$ and in loop CDEFC $2I_1 + 3I_2 = 6$

On solving $I_1 = -6/5A$ and $I_2 = 14/5A$

A5.Let current in arm AB(A to B) = I_1 , in arm DC(D to C) = I_2, in arm BD (B to D) = I_3

Junction rule at point: $I_1 + I_2 = I_3$

In the loop ABDA: on applying loop rule: $5I_1 + 2I_2 = -1$

In loop rule BCDB: $I_1 + 3I_2 = 1$

On solving $I_1 = -5/13A$, $I_2 = 6/13A$ and $I_3 = 1/13A$

$V_{BD} = 2/13V$, $V_G = E - I_2r = 3 - \frac{6 \times 3}{13} = 1.615V$

$V_H = E + I_2r = 1 + \frac{6 \times 1}{13} = 1.46V$

A6. Let current in arm AB (B to A) = I_1

Current in arm DE (D to E) = I_2 and arm FC (F to C) = I_3

According to Kirchhoff's Junction rule at point F

$I_1 + I_2 = I_3$

Applying second law to loop AFCBA

$8(I_1 + I_2) + 6I_1 + 2I_1 = 4 \Rightarrow 4I_1 + 2I_2 = 1$

In loop CDEFC, $I_2 + 4I_2 + 8(I_1 + I_2) = 6 \Rightarrow 8I_1 + 13I_2 = 6$

On solving $I_1 = 1/36A$, $I_2 = 4/9A$, $I_3 = 17/36A$, $V_{FC} = 34/9V = 3.78V$

A7.The equivalent resistance across BE: $1/R' = 1/15 + 1/10 + 1/30$

$R' = 5\Omega$

Resistance of whole circuit = $R + R' + 15 = R + 20$

$V_{net} = 8-3 = 5V$

$I = \frac{5}{R+20} \Rightarrow 0.2 = \frac{5}{R+20}$

$R = 5\Omega$

Drop of potential across arm EFAB = $V_E + 1 + 3 + 3 - 8 = V_B$

$V_E - V_B = 1V$

A8.Let current in arm BAFE = I_1, In arm BE (B to E) = I_2 , In arm EDCE = I_3

Using Junction rule at point B $I_3 = I_1 + I_2 \Rightarrow I_3 = I_1$ (since $I_2 = 0$)

Using Kirchhoff's second rule to loop BAFEB;

$2I_1 - 4I_2 = 9-6$

$I_1 = 1.5$ A (since $I_2 = 0$)

For loop EDCBE ; $1.5R + 4I_2 = -3 + 6$

$R = 2\Omega$

A9.Let current in arm EDCB; = I_1, current in arm BAFE = I_3 and current in arm EB = I_2

According to Kirchhoff's loop rule at point B

$I_1 + I_2 = I_3$ as $I_2 = 0$ (given) $\Rightarrow I_3 = I_1$

Applying second law to loop AFEB; $2I_3 + 3I_3 + I_2R = 1 + 3 + 6$

Hence $I_3 = I_1 = 2A$

From A to D along AFD: $V_{AD} = 2I_3 - 1 + 3I_3 = (4 - 1 + 6)\ V = 9V$

A10.Net resistance $R_{eq} = 3\Omega$

Current $I = V / R_{eq} = 9/3 = 3A$

$I_{CD} = 9/12 = 3/4A$

P.D. across CD, $V_{CD} = I_{CD} \times R_{CD} = (3/4)\times4 = 3V$

$R_{new} = n^2R = 4 \times 16 = 64\Omega$

Current in arm ADCB = 9/48 = 3/16A

P.D. across diagonal = (3/16) x 32 = 6V

A11. **(i)** Balancing length increases because of decrease in current, the potential gradient decrease.

ii) Increase because the current drawn from the cell decreases so terminal potential increase.

A12. Current I = 4/(2.4 + 4) = 4/6.4 = (5/8)A

$V_{AB} = 4 - [2.4\text{x}\,(\frac{5}{8})] = 2.5V$

K = 2.5/100 = 0.025V/cm

$V_{AC} = K \times \ell \Rightarrow 1.5 = 0.025\times\ell$

$\ell = 60cm$

A13. (i) emf of cell used $E_1 = K\times\ell$

$= 0.01 \times 180 = 1.8V$

(ii)Balancing length will increase because on increasing internal resistance, the current given by the cell (E) will decrease $\Rightarrow$ k will decrease

A14. According to question $10\times10^{-3}V = k \times 40 \Rightarrow k = 0.25\times10^{-3}$

$V_{AB} = 0.25\times10^{-3}\times100 = 25\times10^{-3}V$

& $V_{AB} = 2 - I \times R$

$25\times10^{-3}V = 2 - (\frac{2}{R+10}) \times R$

$25\times10^{-3} = (\frac{20}{R+10}) \Rightarrow R = 790\Omega$

A15. Current I = 5/ (480 + 20) = 5 / 500 = 0.01A

$V_{AB} = 5 - 80 \times 0.01 = 0.2V$

K = 0.2/10 = 0.02V/m

$E = \frac{0.02}{100} \times 600 = 0.12\ V$

A16. Resistance per cm = 0.01Ω/cm

Resistance of potentiometer wire = 0.01 x 1000 = 10Ω

External resistance = 10Ω

Resistance of 500cm 0f wire = 0.01 x 500 = 5Ω

Since 2 V cell is balance across 500cm of wire

$\Rightarrow 2 = I \times R \Rightarrow I = 2/5 = 0.4A$

Current given by driver cell of emf (E) = $I = \frac{E}{10+10} \Rightarrow E = 0.4 \times 20 = 8\ V$

A17. Given K = 1micro/mm = 1×10^{-3}V/m

Let length of potentiometer wire = AB = 10m

$V_{AB} = 1\times10^{-3} \times 10m = 1\times10^{-2}V$

Also $V_{AB} = 2 - I \times R$

= 1 x 10^{-2} = 2 - $(\frac{2}{R+20} \times R)$

= 0.01 = $\frac{40}{R+20}$

$\Rightarrow$ R = 3980Ω

A18.(i)Balance point increases because current decreases hence the value of potential gradient decreases.

(ii)No change because no current flows through S at balance point.

(iii)Balancing length will not be possible because experimental cell (Q) always dominating to driver cell (P). There will be one side deflection due to experimental cell (Q)

A19. (i) According to question K x 60 = 1.5

K = 1.5 / 60

V_{AB} = K x 100 = (1/5/ 60) x 100 = 2.5 V

(ii) No because no balance point can be obtained in that situation there will be one side deflection

A20.Two possible faults are (i) emf (E) applied across AB is less than unknown emf E'].

(ii) Negative terminal of the source emf is joined with end A of the wire at which positive terminal of the applied emf is connected.

(b) (i)The galvanometer deflection at the end B of the wire is less. It means source of **unknown emf have been joined with its -ve terminal to end A.** The current gets divided at point A and combined at point B (i.e. Two emf support each other)

(ii) The galvanometer deflection at point B is more than that the end A means the **applied emf (of driver cell) is less than the unknown emf (experimental) used.** The P.D across A and C is more results more deflection. As the point C shifts towards the point B, the potential difference between A and C goes decreasing hence the deflection decreases.

A21. (i) Due to decrease of current the potential gradient is decreased. The balance point would now be obtained on the larger length of the wire.

(ii)(a) If the resistance (R) is increased, the amount of current drawn from the cell of emf (E') will decrease. The terminal voltage across the cell shall increase. The balance point will now be obtained on a longer length.

A22.E_1 + E_2 = 300k

E1 - E_2 = 180k

On adding $2E_1$ = 420k $\Rightarrow$ E_1 = 210k ------------ (1)

= E_1/ k = 210 (since E/ k = ℓ)

$\Rightarrow$ ℓ_1 = 210

On subtracting $2E_2$ = 180k $\Rightarrow$ E_2 = 90k --------------- (2)

From equation (1) and (2) E_1 / E_2 = 7/3

The sensitivity can be increased by increasing length of potentiometer wire or decreasing current in the potentiometer wire.

A23. In case (i) $I_g = \frac{V}{R_1 + G}$ ------- (1)

Case (ii) $I_g = \frac{V/2}{R_2 + G}$ ----- (2)

From equation (i) and (ii) we get

$$\frac{V}{R_1+G} = \frac{V}{2(R_2+G)}$$

$R_1 + G = 2R_2 + 2G$

$G = R_1 - 2R_2$ -------------- (iii)

For conversion of galvanometer into a voltmeter of range 2V, we have

$I_g = \frac{2V}{R+G}$ ------------- (iv)

From equation (i) and (iv)

$$\frac{V}{R_1+G} = \frac{2V}{R+G}$$

$R + G = 2R_1 + 2G$

$R = 2R_1 + G$

Putting the value of G from equation (iii) , we get

$R = 2R_1 + (R_1 - 2R_2)$

$R = 3R_1 - 2R_2$.

A24. Current in the wire = I = 8/20 = 0.4A

PD across potentiometer wire = V = IR = 0.4 x 5 = 2V

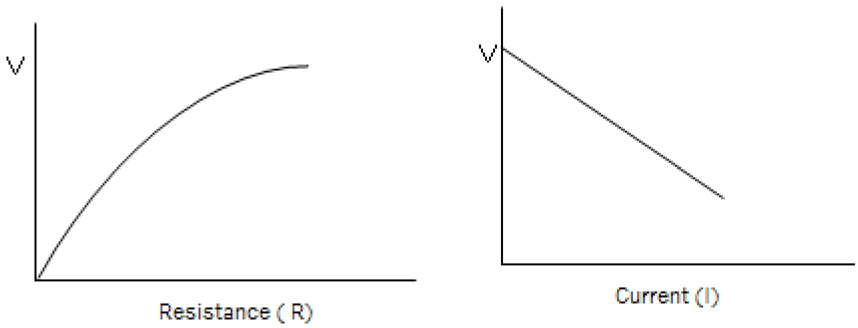
Potential gradient k = 2/100 = 0.02V/cm

Emf of cell = E = $k\ell$ = 0.02 x 60 = 1.2V

A25. Current $I = \frac{E}{(R+r)}$, $I = \frac{E}{4+r} \Rightarrow r + 4 = E$ -------(1)

and $0.5 = \frac{E}{9+r} \Rightarrow 0.5r + 4.5 = E$ -------(2)

$\Rightarrow E = 5V,\ r = 1\Omega$



A26. In series combination $\frac{1}{2}\frac{C_1C_2}{C_1+C_2} \times V^2 = 0.045 \Rightarrow \frac{C_1C_2}{C_1+C_2} = 0.9 \times 10^{-4}$ ---------- (1)

In parallel combination $\frac{1}{2}(C_1 + C_2) \times V^2 = 0.25 \Rightarrow C_1 + C_2 = 0.5 \times 10^{-4}$ ---- (2)

From equation (1) and (2) $C_1 C_2 = 0.045 \times 10^{-8}$

Using $(C_1 - C_2)^2 = (C_1 + C_2)^2 - 4C_1C_2$

$C_1 - C_2 = 0.26 \times 10^{-4}$ ----------------- (3)

On solving eq(2) and eq (3) $C_1 = 0.12 \times 10^{-4}$F and $C_2 = 0.38 \times 10^{-4}$F

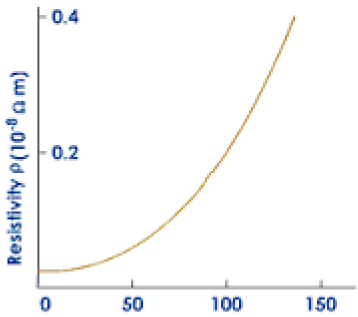
$Q_1 = C_1V = 0.12 \times 10^{-4} \times 100 = 12 \times 10^{-4}$C and $Q_2 = C_2 V = 0.38 \times 10^{-4} \times 100 = 38 \times 10^{-4}$C

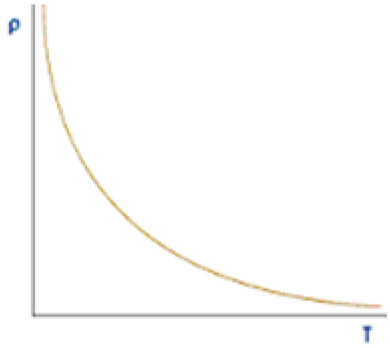
A27. (i) Drift velocity become half as $V_d \propto V$

(ii) Drift velocity become half as $V_d \propto \frac{1}{\ell}$

(iii) Drift velocity will remain same as V_d is independent of diameter (D)

A28. Resistivity of a conductor is defined as the resistance of material of a conductor of unit length and unit area of cross section.





Graphical Variation of Resitivity with temperature

SEMICONDUCTOS

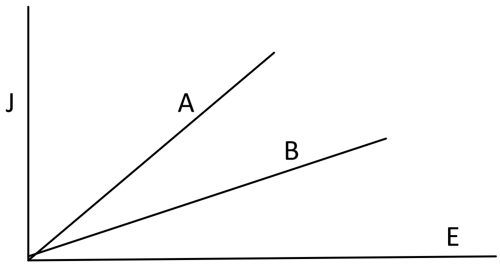
In conductors with rise of temperature relaxation time decreases but number density of charge carriers is not dependent on temperature. Hence ρ increases.

In semiconductors number density of charge carriers increases with temperature. It dominates the decrease in relaxation time hence ρ decreases.

A29. Current density = $J = \sigma E$ = conductivity x electric field.

Slope of graph = conductivity(σ)

Material with less slope(smaller conductivity) is used for making standard resistances and material with greater slope (higher conductivity) for making connecting wires/



We have $I = neAV_d$

Although V_d is small but n (electron number density) is very large. Hence the current will be large.

A30. When metal is subjected to a certain potential the electron get accelerated due to electric field. Each electron experiences acceleration for an average time τ, called relaxation time . It then undergoes a collision and its velocity again becomes random. The average drift velocity of all electrons contributes to the flow of current.

The average velocity of electrons acquired through their acceleration for a time τ is called drift velocity. $V_d = \frac{eE}{m}\tau$

Current density $J = I/A = \frac{neAV_d}{A} = ne\left(\frac{eE}{m}\tau\right) = \left(\frac{ne^2\tau}{m}\right)E = \sigma E$

Q31. **Principle:** When a constant current is made to pass through a resistance wire of uniform cross sectional area, the potential drop across any length of wire is directly proportional to that length.

Two factors: By increasing length of potentiometer wire.

(ii) Connecting a suitable resistance R, in series with potentiometer wire.

Reason: At balance position, there is no net current drawn, from the cell and cell is effectively in an open circuit condition. This is not so for a voltmeter.

A32. There being a random distribution. In the velocities of charge carriers. Their average velocity can be taken zero.

We have F= ma = eE

a = eE/m

If τ is rhe average time between two collisions (called relaxation time)

$v_d = \frac{eE}{m}\tau = \frac{e V \tau}{m\ell}$ ($E = V/\ell$)

When length is made 3 times, the P.D. become one third hence the drift velocity $V_d' = v_d/3$.

A33. $\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} = \frac{1}{0.3} + \frac{1}{0.4} + \frac{1}{0.5}$

$r_{eq} = \frac{2}{15}\Omega$

$\frac{E_{eq}}{r_{eq}} = \frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3} \Rightarrow \frac{E_{eq}}{2/15} = \frac{1.5}{0.3} + \frac{2.0}{0.4} + \frac{3.0}{0.6}$

= 5 + 5 +5

E_{eq} = 15x(2/15) = 2.0V

A34. For ABCDA loop

$8 - I_1 - 8(I_1 + I_2) = 0$

$9I_1 + 8I_2 = 8$................. (1)

For loop ADFEA

$8(I_1 + I_2) - 4 = 0$

$2I_1 + 2I_2 = 1$................. (2)

On solving I_1 = 4A and I_2 = -3.5A

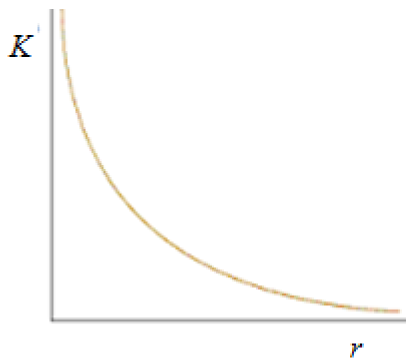
Power consumed by resistor = $I^2R = (4 - 3.5)^2 x8$ = 2W

A35. (a)Principle: The potential drop across the length of a steady current carrying wire of uniform cross sectional is proportional to the length of the wire.

(i) We use long wire to have lower of potential gradient (lower least count) or greater sensitivity of the potentiometer.

(ii) The area of cross section has to be uniform to get constant value of resistance per unit length of wire.

(iii) The emf of the driving cell has to greater than the emf of primary cell as otherwise balance point could not be obtained.



(c) Potential gradient K = $V/\ell = IR/\ell = \frac{I\rho\ell}{\ell A} = \frac{I\rho}{A}$

A36. P.D. across 20Ω resistor = 20 x0.5 = 10V = P.D. across R_2

Current in R_2 = 0.25A

R_2 = 10/0.25 = 40Ω

P.D. across R_1 = 24-10 = 14V

Current passing through R_1 = 0.25 + 10/10 + 0.5 = 1.75A

R_1 = 14/ 1.75 = 8Ω

A37. Similar problem **Ans:** $I_1 = 3A$, $I_2 = -1.5A$, P = 9W

A39.(i) V= Ir (without voltmeter) R_v

$V' = \frac{IrRV}{r+RV} = \frac{Ir}{1+\frac{r}{RV}}$

V' < V

(ii)Percentage error = $\left(\frac{V-V'}{V}\right)$x 100

$= \left(\frac{r}{r+RV}\right)$ x 100

(iii)RV → ∞, V' = Ir = V

A40.(a) $I = \frac{E}{R+\frac{\rho_1\ell}{A_1}}$ for set A

$I = \frac{E}{R+\frac{\rho_1\ell}{2A_1}+\frac{\rho_2\ell}{2A_2}}$ for Set B

Equating above two expressions and simplifying

$\frac{\rho_1}{A_1} = \frac{\rho_2}{A_2}$

(b) Potential gradient of the potentiometer wire for the set A, K = $I\frac{\rho_1}{A_1}$

Potential drop across the potentiometer wire in set B

$V = I\left(\frac{\rho_1\ell}{2A_1} + \frac{\rho_2\ell}{A_2}\right)$

$= \frac{I}{2}\left(\frac{\rho_1}{A_1} + \frac{\rho_2}{A_2}\right)\ell$

$K' = \frac{I}{2}\left(\frac{\rho_1}{A_1} + \frac{\rho_2}{A_2}\right)$, using condition obtained in part (a)

$K' = I\frac{\rho_1}{A_1}$ which is equal to K

Therefore, balancing length obtained in the two sets is same.

ANSWER KEY LONG ANSWER TYPE QUESTIONS: 5-MARKS

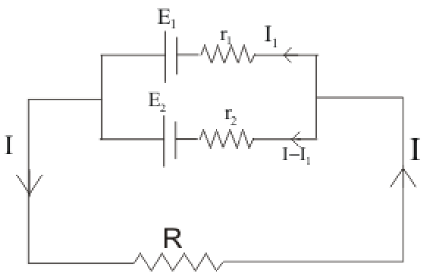
A1. Junction Rule: When currents are steady, the sum of currents entering a junction is equal to the sum of current leaving the junction. This rule is based on conservation of charges.

Loop Rule: The algebraic sum of the changes in potential in any loop is equal to the algebraic sum of emfs.

At junction: $I = I_1 + I_2$.............. (1)

For first cell; $V= E_1 - I_1r_1 \Rightarrow I_1 = \frac{E_1-V}{r_1}$

For second cell; $V = E_2 - I_2r_2 \Rightarrow I_2 = \frac{E_2-V}{r_2}$



Cells grouped in parallel combination

From equation (1)

So, $I = \left(\frac{E_1-V}{r_1}\right) + \left(\frac{E_2-V}{r_2}\right) = \left(\frac{E_1}{r_1}+\frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$

$= \frac{E_1r_2+E_2r_1}{r_1r_2} + V\left(\frac{r_1+r_2}{r_1r_2}\right)$

Or V = $\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} - \frac{I r_1 r_2}{r_1 + r_2}$

If both cells are replaced by single equivalent cell

V = E_{eq} - r_{eq} then on comparing above equation

E_{eq} = $\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$ and r_{eq} = $\frac{r_1\, r_2}{r_1 + r_2}$

UNIT-III: Magnetic Effect of Current and Magnetism:

VERY SHORT ANSWER TYPE QUESTIONS: 1 –MARK

Q1. Write the mathematical expression for the generalized Ampere's circuital law.

Q2. Write the expression, in a vector form, for the Lorentz magnetic force $\vec{F}$ due to a charge moving with velocity $\vec{V}$ in a magnetic field $\vec{B}$. What is the direction of the magnetic force?

Q3. Define one tesla, using the expression for the magnetic force acting on a particle of charge q moving with velocity $\vec{v}$ in a magnetic field $\overrightarrow{B}$.

Q4. Which direction would a compass needle point to if located right on geomagnetic South or North Pole? Give reason. **Ans:** In any direction because $B_H = 0$ at that place.

Q5.Relative permeability (μ_r) of a material has a value lying $1 < \mu_r < 1 + \varepsilon$ (where ε is a small quantity). Identify the nature of the magnetic material.

Q6. Under what conditions does a particle of charge 'q' moving with velocity 'v', experience (i)no force, (ii) maximum force, in an external magnetic field ?

Q7. If horizontal and vertical component of Earth's magnetic field are equal at certain place. What will be angle of dip at that place?

Q8. Why do magnetic lines of force prefer to pass through ferromagnetic substance rather than air?

Q9.Paramagnetic substance shows greater magnetisation when cooled. Why?.

Q10.Diamagnetism is almost independent of temperature. Why?

Q11. How can paramagnetic and diamagnetic rods be distinguished in a uniform magnetic field?

Q12. Give the position of a magnetic dipole in uniform magnetic field so that its potential energy be zero.

Q13. At which place on the earth (i) B_H is zero (ii) B_V is zero? How does compass needle get oriented in these places?

Q14. A bar magnet of dipole moment M is cut into two equal parts along its axis. What is the new pole strength and magnetic dipole moment of each part?

Q15. A proton moving along X-axis enters in a region in which uniform magnetic field acts along Z –axis. In which direction it experience a force?

Q16. Why, work is not done by magnetic force acting on a moving charge particle? OR Energy of a charge particle moving in uniform magnetic field does not change .Why?

Q17.There is two identical galvanometer. One is converted into an ammeter and another into milliammeter . Which of the shunt will be of larger resistance and Why? **Ans:** Milliammeter

Q18.There is two identical galvanometer. One is converted into voltmeter and another into millivoltmeter. Which of the shunt will be of smaller resistance and Why? Ans: Millivoltmeter.

Q19. An electron is not suffering any deflection while passing through a region of uniform magnetic field. What is direction of magnetic field? Ans: parallel or anti parallel.

Q20. Steel wire of length ℓ has magnetic moment M . It is then bent into a semicircular arc. What is the new magnetic moment? Ans $2M/\pi$

Q21.Why do two beams of electrons travelling in same direction repel each other whereas two conductors carrying current in same direction attract each other?

Q22.Why do magnetic fields lines form closed loop?

Q23.Write the condition under which an electron will move undeflected in the presence of crossed electric and magnetic fields.

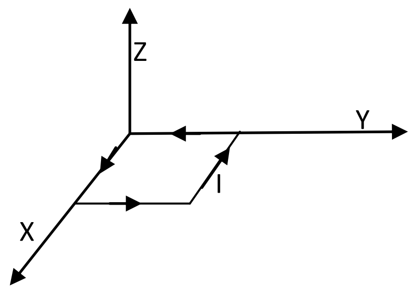
Q24.An electron is moving along positive x-axis subjected to magnetic field so that it traces out anticlockwise circular path in x–y plane. What is direction of magnetic field?

Ans: along +ve z-axis.

Q25.A proton is moving with velocity 'v' in a direction opposite to the direction of magnetic field. What is force experienced by proton? Ans: Zero

Q26.A current carrying loop of radius (r) carries a constant current (I). It is placed in a uniform magnetic field ($\vec{B}$) such that ($\vec{B}$) is perpendicular to the plane of loop. What is magnetic force experienced by loop? Ans Zero

Q27.A rectangular coil of cross sectional area (A) placed in uniform magnetic field ($\vec{B}$) and the direction of magnetic field is along z-axis as shown in figure. What is torque experienced by the coil? Ans Zero



Q28. Why does angle of dip is zero at the magnetic equator?

Ans: because B_v is zero at magnetic equator.

Q29.Write two properties of soft iron due to which it is suitable for making electromagnet.

Q30.The magnetic susceptibility of a material is $7.54\text{x } 10^{-3}$. What is its relative permeability and nature? Ans: Paramagnetic and $\mu_r = 1 + \chi_m = 1.00754$.

Q31.Proton and alpha particle enter perpendicular in a uniform magnetic field with same kinetic energy. Which particle bends in circular path of smaller radius? Ans: proton

Q32.A vertical wire carries current in upward direction. An electron beam sent horizontally towards the wire. In which direction it get deflected? Ans: upward

Q33. Atoms of which magnetic material have no permanent magnetic moment?

Ans: Diamagnetic

Q34. Write the underlying principle of a moving coil galvanometer.

Q35. In what way is the behaviour of diamagnetic material is different from that of a paramagnetic , when kept in an external magnetic field? **All India-2016(C)**

SHORT ANSWER TYPE QUESTIONS: 2-MARKS

Q1. State the underlying principle of a cyclotron. Write briefly how this machine is used to accelerate charged particles to high energies.

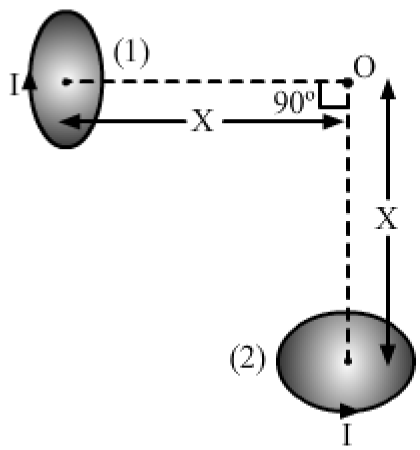
Q2. Draw the magnetic field lines due to a current passing through a long solenoid. Use Ampere's circuital law, to obtain the expression for the magnetic field due to the current I in a long solenoid having n number of turns per unit length.

Q3.How does radial magnetic field produced in galvanometer? What is importance of radial magnetic field?

Q4. Two infinitely long parallel current carrying conductors carrying same current (I) in opposite directions and separated by distance (r) .Find net magnetic field at midpoint between two conductors and direction of net magnetic field.

Q5. Out of the two magnetic materials, 'A' has relative permeability slightly greater than unity while 'B' has less than unity. Identify the nature of the materials 'A' and 'B'. Will their susceptibilities be positive or negative?

Q6. Two very small identical circular loops, (1) and (2), carrying equal currents I are placed vertically (with respect to the plane of the paper) with their geometrical axes perpendicular to each other as shown in the figure. Find the magnitude and direction of the net magnetic field produced at the point 'O'.



Q7. What is difference between force applied and deflection produced by magnetic and electric fields on a proton when it enters (i) at 90^0 (ii) parallel to fields' direction?

Q8.Two parallel coaxial circular coils of equal radius '*R*' and equal number of turns '*N*',carry equal currents '*I*' in the same direction and are separated by a distance '2*R*'.Find the magnitude and direction of the net magnetic field produced at the mid-point of the line joining their centres.

Q9. An electron after being accelerated through a potential difference of 100V enters a uniform magnetic field of 0.004T perpendicular to its direction of motion. Calculate the radius of path described by the electron. **Ans:** 8.4mm

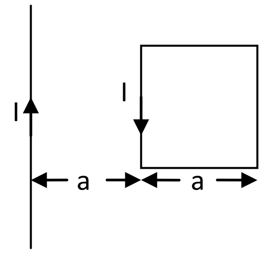
Q10. A particle having charge 100 times that of electron is revolving in a circular path of radius 0.8m with one rotation per second. What is the magnetic field produced at the centre?

Q11. A coil of 100 turns and $5cm^2$ area is placed in a magnetic field equal to 0.2T. The coil makes an angle of 60^0 with the direction of magnetic field. What is magnetic flux linked with coil?
Ans 8.66×10^{-3}Wb.

Q12. A solenoid is 2m long and 3cm in diameter. It has 5 layers of winding of 1000 turns each and carries current of 5A. What is magnetic field at the centre of solenoid? **Ans:** 1.57×10^{-2} T.

Q13. A toroid has core of outer radius 26cm and inner radius 25cm around which 4000 turns of conducting wires are wound. What is magnetic field inside the core of solenoid if it carries current of 10A? **Ans:** 3.14×10^{-2} T.

Q14. Calculate net force acting on a square loop of side (a) carrying current (I) placed at distance (a) near infinitely long current carrying wire as shown in figure. What is direction of net force?



Q15. A wire of length ℓ carrying a current I amperes is bent in the form of circle. What is magnitude of magnetic moment of the circular loop? Ans $I\ell^2/4\pi$

Q16. What will be the difference between force experienced and path followed by an electron and a proton entering in magnetic field with same velocity in similar manner?

Q17. Two circular coils X and Y having radius R and R/2 respectively are placed in horizontal plane with their centres coinciding with each other, The X has current I flowing through it in the clockwise sense. What must be the current in the coil Y to make the total magnetic field zero at their common centre?

Q18. A charged particle moving with uniform velocity v enters a region where uniform electric and magnetic fields **E** and **B** are present. It passes through the region without any change in its velocity. What can we conclude about the

(i) Relative directions of **E**, **v** and **B**?

(ii) Magnitude of **E** and **B?**

Q19. A long straight wire of finite cross –section carrying steady current (I), which is uniformly distributed across its cross section area of radius (a). Show graphically the variation of magnetic field in the region r<a and r>a.

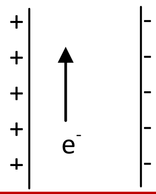
Q20. A charged particle having a charge of 2 nC moving in a magnetic field B with a velocity $\vec{v} = 10^5\ \hat{\imath}$ (m/s) experiences a magnetic force $\vec{F} = 2\times10^{-5}\ (-\hat{\jmath})$ N. Find the direction and magnitude of the magnetic field.

Q21. (i) State Biot – Savart law in vector form expressing the magnetic field due to an element $\overrightarrow{d\ell}$ carrying current I at a distance $\vec{r}$ from the element.

(ii) Write the expression for the magnitude of the magnetic field at the centre of a circular loop of radius r carrying a steady current I. Draw the field lines due to the current loop.

Q22. A proton, a deuteron and alpha particle with same KE enter in a region of uniform magnetic field, moving at right angle to B. What is ratio of radii of their circular paths? **Ans:** 1:√2:1

Q23. A potential difference of 600volts is applied across the plates of a parallel plate capacitor, the plates being separated by 3mm. An electron is projected vertically parallel to the plates with velocity 2×10^6m/s move undeflected



between the plates. What is magnitude and direction of magnetic field applied between the plates?

Ans: B = 0.1T, perpendicular to the plane of paper & inward.

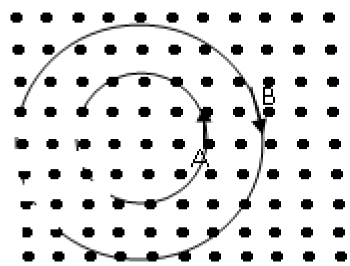
Q24.A proton, a deuteron and an alpha particle accelerated through the same potential difference enter in a region of uniform magnetic field, moving right angle to the magnetic field. What is ratio of their kinetic energy? Ans: 1:1:2

Q25.A galvanometer of resistance 25Ω gives full scale deflection for a current of 10mA. It is to be changed into a voltmeter of range 100V by connected a resistance R in series with galvanometer. What is value of 'R'? Ans: 9975Ω

Q26. A galvanometer of resistance 100Ω gives full scale deflection for a current of 10mA. Calculate the value of shunt required to convert it into an ammeter of range 10A. Ans: 0.1Ω

Q27.Two particles X and Y having equal charges, after being accelerated through same potential differences they enter in a region of uniform magnetic field ($\vec{B}$) describing circular paths of radii R_1 and R_2. What is ratio of their masses? Ans: $(R_1)^2 : (R_2)^2$

Q28. Two particles A and B of mass m_A and m_B respectively have same charge enter perpendicular in a uniform magnetic field ($\vec{B}$) from left and describe the trajectories as shown in figure.



(i) Identify the nature of charge A and B.

(ii) Which particle has greater momentum?

Q29.An electron accelerated through a potential difference (V) through a transverse magnetic field and experiences a magnetic force (F). If the accelerating potential is increased to 2V. How much force will be experienced by the electron in the same magnetic field? Ans √2F

Q30.A bar magnet of length 10cm and having pole strength 10^{-3}wb is kept in a magnetic field of strength $4\pi \times 10^{-3}$T. It makes an angle of 30^0 with direction of magnetic field. Calculate the torque acting on the magnet. Ans: $2\pi \times 10^{-6}$N-m

Q31. A bar magnet of magnetic moment 10^4 JT^{-1} is free to rotate in a horizontal plane. Calculate the work done in rotating the magnet from a direction parallel to horizontal field of 4×10^{-5}T to a direction of 60^0 from the field. Ans: 0.2J

Q32.A magnetic needle lying parallel to magnetic fields requires W units of work to turn it through 60^0. Calculate the torque needed to maintain the needle in this position. Ans: √3W

Q33. At a certain place dip angle is 30^0 and horizontal component of earth's magnetic fields is 0.15T. A beam of proton moving vertically upward with speed of 3×10^5m/s. Calculate the force experienced proton at that place. Ans: 7.2×10^{-15}N

Q34.A magnetic needle of magnetic moment $60Am^2$ is directed towards the geographical north at a place at which value of earth's magnetic field is 0.4G. It experiences a torque of 1.2×10^{-3}Nm. Calculate the angle of declination at that place.

Ans: 30^0

Q35. An electron is accelerated from rest through a potential difference of 3750V. It enters perpendicular to magnetic field of strength of 4×10^{-3}T. Calculate the radius of its path.

Ans: 5.2×10^{-2}m

Q36. (a) How is an electromagnet different from a permanent magnet?

(b) Write two properties of a material which make it suitable for making electromagnets.

SHORT ANSWER TYPE QUESTIONS: 3-MARKS

Q1. How does a paramagnetic material behave in the presence of an external magnetic field? Explain with the help of an appropriate diagram. What happens when the temperature of a paramagnetic sample is lowered? To which of the two –a polar or a non –polar dielectric –does a paramagnetic material correspond? Justify your answer.

Q2. Deduce the expression for the torque $\vec{\tau}$ acting on a planar loop of area $\vec{A}$ and carrying current I placed in a uniform magnetic field $\vec{B}$ If the loop is free to rotate, what would be its orientation in stable equilibrium?

Q3. Draw the magnetic field lines distinguishing between diamagnetic and paramagnetic materials. Give a simple explanation to account for the difference in the magnetic behaviour of these materials.

Q4. State Biot – Savart law. Deduce the expression for the magnetic field at a point on the axis of a current carrying circular loop of radius 'R', distant 'x' from the centre. Hence write the magnetic field at the centre of a loop.

Q5. Draw a schematic sketch of a cyclotron. Explain its working principle. Obtain the necessary mathematical expression to show how this machine is used to accelerate charged particles.

Q6. In what way is Gauss's law in magnetism different from that used in electrostatics? Explain briefly.

The Earth's magnetic field at the Equator is approximately 0.4 G. Estimate the Earth's magnetic dipole moment. Given: Radius of the Earth = 6400 km.

Q7. A uniform magnetic field $\vec{B}$ is set up along the positive x-axis. A particle of charge 'q' and Mass 'm' moving with a velocity enters the field at the origin in X-Y plane such that it has velocity components both along and perpendicular to the magnetic field $\vec{B}$ Trace, giving reason, the trajectory followed by the particle. Find out the expression for the distance moved by the particle along the magnetic field in one rotation.

Q8. State the principle of working of a galvanometer.

A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R1 in series with the coil. If a resistance R2 is connected in series with it, then it can measure up to V/2 volts. Find the resistance, in terms of R1 and R2, required to be connected to convert it into a voltmeter that can read up to 2 V. Also find the resistance G of the galvanometer in terms of R1 and R2.

Q9. Derive an expression for force acting on a current carrying conductor placed in magnetic field. Which law decides the direction of force?

Q10. (a) How is a toroid different from a solenoid ?

(b) Use Ampere's circuital law to obtain the magnetic field inside a toroid.

(c) Show that in an ideal toroid, the magnetic field (i) inside the toroid and (ii) outside the toroid at any point in the open space is zero.

Q11. Derive an expression for the magnetic moment ($\vec{\mu}$) of an electron revolving around the nucleus in terms of its angular momentum ($\vec{L}$)

What is the direction of the magnetic moment of the electron with respect to its angular momentum?

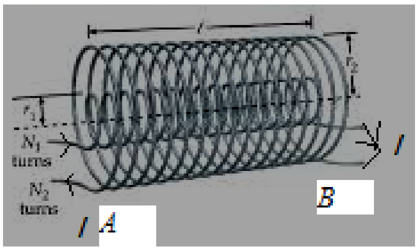
Ans: The direction of ($\vec{\mu}$) is opposite to that of ($\vec{L}$) because of the negative charge of the electron.

Q12. (a) State Ampere's circuital law, expressing it in the integral form.

(b) Two long coaxial insulated solenoids, S_1, and S_2, of equal lengths are wound one over the other as shown in the figure. A steady current "I" flow through the inner solenoid S_1, to the other end B, which is connected to the outer solenoid S_2, through which the same current "I" flows in the opposite direction so as to come out at end A. If N_1 and N_2 are the number of turns per unit length, find the magnitude and direction of the net magnetic field at a point

(i) inside on the axis and

(ii) outside the combined system.



Q13. Consider the motion of a charged particle of mass 'm' and charge 'q' moving with velocity ($\vec{v}$) in a magnetic field $\vec{B}$.

(a) If $\vec{v}$ is perpendicular to $\vec{B}$, show that it describes a circular path having angular frequency $\omega = qB/m$.

(b) If the velocity $\vec{v}$ has a component parallel to the magnetic field $\vec{B}$, trace the path described by the particle. Justify your answer.

Q14. Draw a schematic sketch of a moving coil galvanometer and describe briefly its working.

"Increasing the current sensitivity of a galvanometer does not necessarily increase the voltage sensitivity." Justify this statement.

Q15. A particle mass (m) charge (q) moves at right angle to uniform magnetic field. Show graphically the variation of radius (r) of circular path described by with increase in

(i) Its Velocity

(ii) Its charge

(iii) Kinetic energy.

Q16. A charge q of mass m moving in a straight line is accelerated by a potential difference V .It inters a in a uniform magnetic field perpendicular to its path. Deduce an expression in terms of V for the radius of the circular path in which it travels. **Ans:** $\sqrt{(2Vm/qB^2)}$

A17. A wire of length ℓ carries a current I . Show that if the wire is formed into a circular coil, the maximum torque in a given magnetic field B is developed when the coil has only one turn and the maximum torque has the value. **Ans:** $\tau = \ell^2 I B/4\pi$.

Q18. (a) A charged particle enters an environment of strong and uniform magnetic field at any angle θ ($<90^0$) with Velocity (V) and comes out of it. If there is no collisions with the environment. (i) What is the nature of path of particle? (ii) change (if any) in final speed when it comes out of magnetic field.

(b) An electron travelling from west to east enters a chamber having a uniform electrostatic field in north to south direction. Specify the direction in which a uniform magnetic field should be setup to prevent the electron from deflecting from its straight line path.

Q19. A straight horizontal conducting rod of length 0.45m and mass 60g is suspended by two vertical wires at its ends. A current of 5 A is set up in the rod through the wires.

(a) What magnetic field should be set up normal to the conductor in order that the tension in the wire is zero?

(b) What will be the total tension in the wires if the direction of current is reversed keeping the magnetic field same as before? (Neglect mass of wires , g = 9.8m/s^2)**Ans** : 0.26T , 1.176N

Q20.A long straight wire A B carries a current of 4A . A proton travels at 4x 10^6 m/s , parallel to the wire at 0.2m from it and in a direction opposite to flow of current. Calculate the force which the magnetic field of current exerts on the proton. Also, specify the direction of force.

Ans : 2.56x 10^{-18} N

Q21. A cyclotron's oscillator frequency is 10 MHz. What should be the operating magnetic field for accelerating protons? If the radius of its 'dees' is 60 cm, calculate the kinetic energy (in MeV) of the proton beam produced by the accelerator.

Q22. A circular coil of 200 turns and radius 10 cm is placed in a uniform magnetic field of 0.5 T, normal to the plane of the coil. If the current in the coil is 3.0 A, calculate the

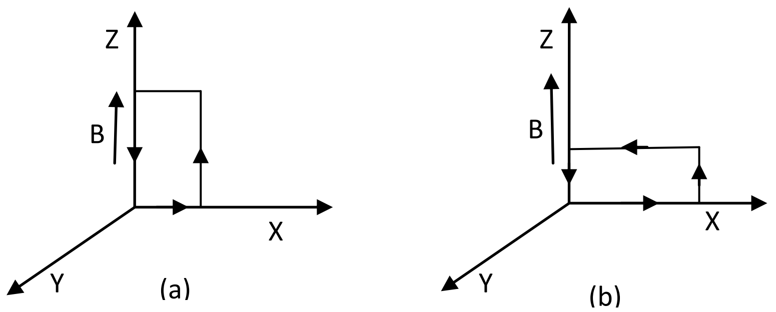
(a) Total torque on the coil (b) Total force on the coil

(c) Average force on each electron in the coil due to the magnetic field

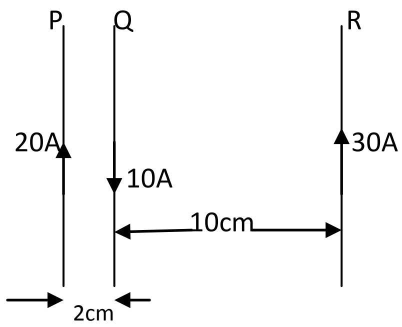
Assume the area of cross-section of the wire to be 10^{-5}m^{2}and the free electron density is 10^{29}/m^3.

Q23.A uniform magnetic field of 6·5 x 10^{-4} T is maintained in a chamber. An electron enters into the field with a speed of 4·8 x10^6 m/s normal to the field. Explain why the path of the electron is a circle. Determine its frequency of revolution in the circular orbit. Does the frequency depend on the speed of the electron? Explain.

Q24.A uniform magnetic field of 3000G is established along the positive z-direction. A rectangular loop of sides 10cm and 5cm carries a current of 12 A. What is the torque on the loop in the different cases shown? Mention direction of torque in each case. Which case corresponds to stable equilibrium?

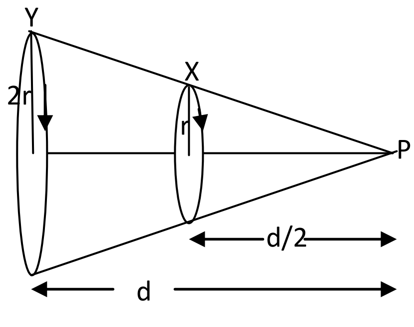


Q25. Three long straight and parallel wires P, Q and R carrying currents are arranged as shown in figure. What is magnetic force experienced by 10cm length of wire Q. Also state the direction of force.
Ans: 1.4×10^{-4}N towards right

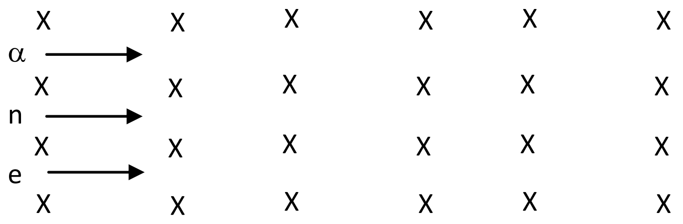


Q26. A current of 3A is flowing in a plane coil of radius 4cm having 20turns. The coil is placed in uniform magnetic field of 0.5Wb/m^2. Calculate the (i) magnetic dipole moment (ii) P.E. of dipole in stable equilibrium (iii) Torque in stable equilibrium. Ans: M = 0.3Am^2, (ii) U = -0.15J
(iii) $\tau = 0$

Q27.Two circular coils X and Y having equal number of turns and carrying equal currents in the same sense. They are placed coaxially and subtending same solid angle at any point (P) on the axis. The smaller coil X is placed midway between P and Y. Find the ratio of magnetic induction due to coil Y and coil X at point (P).Ans: 1:2



Q28. (a) Write the expression for the magnetic force acting on a charged particle moving with velocity
(v) in the presence of magnetic field B.
(b) A neutron, an electron and an alpha particle moving with equal velocities, enter a uniform magnetic field going into the plane of the paper as shown. Trace their paths in the field and justify your answer.**CBSE-2016-D**



Q29. Two long straight parallel conductors carry steady current I_1 and I_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set up in one produces an attractive force on the other. Obtain the expression for this force. Hence define one ampere.**CBSE-2016-D**

Q30. How is a galvanometer converted into a voltmeter and an ammeter? Draw the relevant diagrams and find the resistance of the arrangement in each case. Take resistance of galvanometer as G.

CBSE-2016(E)

Q31.Use Biot-Savart law to derive the expression for the magnetic field on the axis of a current carrying circular loop of radius R.

Draw the magnetic field lines due to a circular wire carrying current I. **All India-2016(C)**

Q32. (i) Name the machine which uses crossed electric field and magnetic fields to accelerate the ions to high energies. With the help of diagram, explain the resonance condition.

(ii)What will happen to the motion of charged particle if frequency of alternating voltage is doubled? **CBSE SQP: 2016**

Q33.Derive the expression for magnetic field at the site of a point nucleus in Hydrogen atom due to the circular motion of the electron. Assume that the atom is in its ground state and give the answer in terms of fundamental constant. **CBSE SQP-2016**

LONG ANSWER TYPE QUESTIONS: 5-MARKS

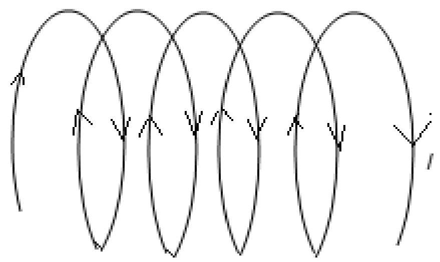
Q1. Give a brief description using necessary diagrams, of the three elements (quantities) required to specify the magnetic field of the Earth at a point on its surface. Also write the necessary formulae used. (b) Specimens of a paramagnetic material and a diamagnetic material are placed in a uniform magnetic field. Draw the behaviour of magnetic field lines near these specimens. Justify your answer.

Q2. (a) Derive, with the help of a suitable diagram, the expression (in vector form) for the torque acting on a rectangular loop of area A carrying current I, placed in a uniform magnetic field.

(b) Mention the conditions under which (i) the above expression for the torque is applied in moving coil galvanometer; (ii) the sensitivity of the moving coil galvanometer is increased.

Q3. (a)State Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside an air cored toroid of average radius '*r*' having '*n*' turns per unit length and carrying a steady current I.

(c) An observer to the left of a solenoid of N turns each of cross section area 'A' observes that a steady current I in it flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that its acts as a bar magnet of magnetic moment m = NIA.



Q4. Explain, using a labelled diagram, the principle and working of a moving coil galvanometer. What is the function of (i) uniform radial magnetic field, (ii) soft iron core?

Define the terms (i) current sensitivity and (ii) voltage sensitivity of a galvanometer. Why does increasing the current sensitivity not necessarily increase voltage sensitivity?

Q5. (a) Draw a labelled diagram of a moving coil galvanometer. State its working principle. What is the function of a cylindrical soft iron core used in it?

(b) Define the terms (i) current sensitivity and (ii) voltage sensitivity.

(c) Explain the underlying principle used in converting a galvanometer into a (i) voltmeter and (ii) ammeter.

Q6. (a) Write, using Biot – Savart law, the expression for the magnetic field $\vec{B}$ due to an element $d\vec{\ell}$ carrying current I at a distance $\vec{r}$ from it in a vector form.

Hence derive the expression for the magnetic field due to a current carrying loop of radius R at a point P distant x from its centre along the axis of the loop.

(b) Explain how Biot – Savart law enables one to express the Ampere's circuital law in the integral form, viz;

$$\oint \vec{B} . d\vec{\ell} = \mu_0 I$$

where I is the total current passing through the surface.

Q7. (a) Draw the magnetic field lines due to a circular loop of area $\vec{A}$ carrying current I. Show that it acts as a bar magnet of magnetic moment $\vec{M} = I\vec{A}$.

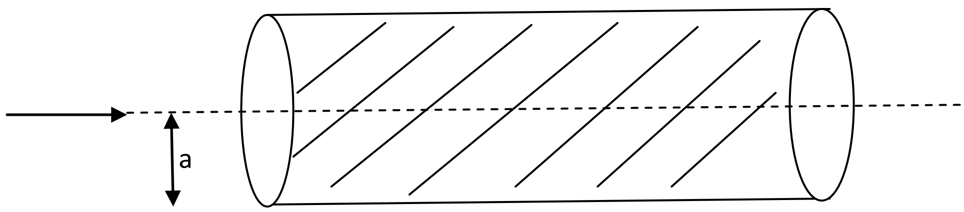
(b) Derive the expression for the magnetic field due to a solenoid of length '2 l', radius 'a 'having 'n' number of turns per unit length and carrying a steady current 'I' at a point on the axial line, distant 'r' from the centre of the solenoid. How does this expression compare with the axial magnetic field due to a bar magnet of magnetic moment 'm'?

Q8. (a)Two infinitely long straight parallel wires, '1' and '2', carrying steady currents I_1 and I_2 in the same direction are separated by a distance d.Obtain the expression for the magnetic field $\vec{B}$ due to the wire '1' acting on wire '2'. Hence find out, with the help of a suitable diagram, the magnitude and direction of this force per unit length on wire '2' due to wire '1'. How does the nature of this force change if the currents are in opposite direction? Use this expression to define the S.I. unit of current.

(b)Two long straight wires X and Y separated by a distance of 5cm in air carry current of 10A and 5A respectively in opposite direction. Calculate magnitude and direction of on a 20cm length of wire Y.

Q9. (a) State Ampere's circuital law. Show that the magnetic field B at a distance r outside the straight infinite wire carrying current I is given by $B = \mu_0 I / (2\pi r)$.

(d) Consider a long straight cylindrical wire of circular cross-section of radius a, as shown in the figure. The current I is uniformly distributed across this cross-section. Calculate the magnetic field B in the region r < a and r > a. Plot a graph of B versus r from the centre of the wire.



Q10. (i) Draw a neat labelled diagram of a cyclotron.

(ii) Show that time period of ions in cyclotron is independent of both the speed of ion and radius of circular path. What is the significance of this property?

(iii)An electron after being accelerated through a potential difference of 100V enters a uniform magnetic field of 0.004 T perpendicular to its direction of motion. Calculate the radius of path described by the electron. CBSE-2016(E)

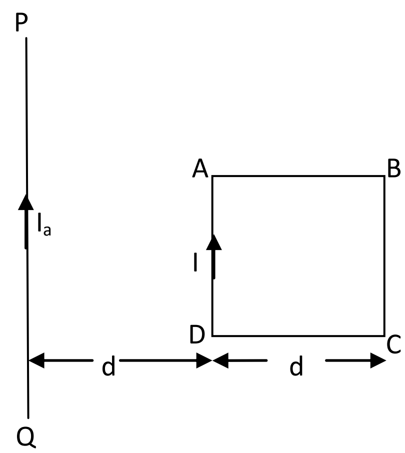
Q11. (i)Depict magnetic field lines due to two straight, long parallel conductors carrying steady currents I_1 and I_2 in the same direction.

(ii)Write the expression for the magnetic field produced by one of conductor over other. Deduce an expression for the force per unit length.

(iii)Determine the direction of this force.

(iv) In figure given below, wire PQ is fixed while the square loop ABCD is free to move under the influence of currents flowing in them. State with reason, in which direction does the loop begin to move or rotate?

CBSE-2016(E)



VALUE BASED QUESTIONS: 4 MARKS

Q1.Asha's uncle was advised by his doctor to have an MRI (magnetic resonance imaging) scan of his brain. Her uncle felt that it was too expensive and wanted to postpone it. When Asha learnt about this, she took the help of her family and when she approached the doctor, he also offered a substantial discount. She thus convinced her uncle to undergo the test to enable the doctor to know the condition of his brain. The resulting information greatly helped his doctor to treat him properly.

Based on the above paragraph, answer the following questions:

(a) What according to you are the values displayed by Asha, her family and the doctor?

(b) What in your view could be the reason for MRI test to be so expensive?

(c) Assuming that MRI test was performed using a magnetic field of 0·1 T, find the maximum and minimum values of the force that the magnetic field could exert on a proton (charge = $1{\cdot}6\times 10^{-19}$ C) that was moving with a speed of 10^4 m/s.

Q2. Deepika and Ruchika were asked by their teacher to perform an experiment using a galvanometer. Before doing the experiment they were very keen to know the different parts of the galvanometer which was given to them in the form of a small box. They approached the teacher and asked for the permission. The teacher thought it would be a good idea if the galvanometer be opened before the whole class and explained its construction and working to all of them.

Based on the above paragraph, answer the following questions:

(a) What, in your opinion, were the qualities displayed by Deepika, Ruchika and the teacher?

(b) State briefly the working principle of the galvanometer.

(c) What is the shape of the magnets used and why is it so designed?

Q3. Ria recently read about earth's magnetic field and its causes. She became so much fascinated by the topic that she further studied it in detail. She collected information as follows:

- The magnitude of magnetic field at the Earth's surface ranges from 0.25 to 0.65gauss.
- The Earth's magnetic field varies with time. There are short term and long term variations.
- One the scale of million years, the Earth's magnetic field reverses its direction, and much more

She made a power point presentation on the same and shared all this information with her classmates.

(i) Suggest another activity related to the same topic, which will help a student to internalize the same value gained by Ria.

(ii) Draw a labelled diagram showing the three magnetic elements of earth.

Answer Key

Short Answer Type Questions: 1 Mark

A1. $\oint \vec{B}.\overrightarrow{d\ell} = \mu_0 (I_C + I_D) = \mu_0(I_C + \epsilon_0 \frac{d\phi_E}{dt})$

A2. $F = q (\vec{E} + \vec{v} \times \vec{B})$

A3. Since $F = qvB$ (When $\theta = 90^0$)$\Rightarrow B = F/qv$

The strength of magnetic field is said to one Tesla when unit coulomb charge moving with unit velocity perpendicular to magnetic field experiences a force of one Newton.

A4. In any direction

A5.Pramagnetic material

A6.(i) When it moves parallel to magnetic field (ii) when it move perpendicular to magnetic field

A7. Angle of dip = 45^0 since $\tan\delta = \frac{B_V}{B_H}$

A8.Due to very high magnetic permeability

A9. Because the random thermal motion of atomic dipoles decreases with fall of temperature.

A10.Because atoms / molecules are not magnetic dipoles in themselves .Their random motion, therefore not affect their magnetism.

A11.A freely suspended paramagnetic rod align itself along the direction of magnetic field whereas diamagnetic rod align itself perpendicular to magnetic field.

A12.When magnetic dipole placed along external magnetic field (B) i.e. angle between $\vec{M}$ and $\vec{B}$ is zero.

A13.(i) $B_H = 0$ at magnetic poles and magnetic needle align itself in any direction.

(ii) $B_V = 0$ at magnetic equator and magnetic needle align itself in N-S direction.

A14.Magnetic dipole moment of original magnet $M = m \times 2\ell$

New pole strength = m/2

New magnetic moment of each part = $\frac{m}{2} \times 2\ell = \frac{M}{2}$

A15. Downward

A16.Magnetic force always acts on perpendicular to direction of motion.

A17.Milliameter, it has a shunt of higher resistance as compared to the shunt of ammeter.

A18.Millivoltmeter

A19.Parallel or anti-parallel to magnetic field.

A20. $2M/\pi$ since $M = m \times \ell$

$\pi r = \ell \Rightarrow r = \ell/\pi$ Or $2r = 2\ell/\pi$

New magnetic moment $M' = m \times 2r = m \times (2\ell/\pi) = 2M/\pi$

A21.They repel due to electrostatic force of repulsion is much more than the magnetic interaction (attractive) and current carrying wire attract each other due to magnetic interaction. Net charge on the current carrying wires is zero and there is no electrostatic interaction between wires.

A22.Due to non-existence of free poles.

A23. Since $qvB = qE \Rightarrow v = E/B$

A24. Along + z axis, **A25.Zero**, **A26.**Zero, **A27.Zero** because $\vec{M}$ is parallel to $\vec{B}$,**A28.**Because Bv is zero at magnetic equator, **A29.High** permeability and low coericivity

A30. Paramagnetic material & $\mu_r = 1.00754$

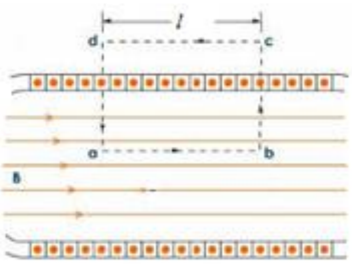
A31. Proton,**A32.**Upward, **A33.**diamagnetic

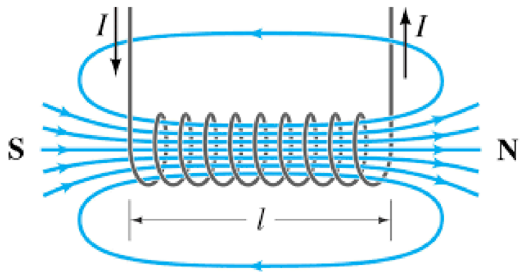
Answer Type Questions: 2 Marks

A1.It makes use of the principle that the energy of the charged particles/ions can be made to increase in the presence of crossed electric and magnetic fields.

A normal magnetic field act on the charged particle and makes them to move in a circular path. While moving from one dee to another, particle is acted upon by the alternating electric field, and is accelerated by this field, which increases the energy of the particle.

A2. Applying Ampere circuital law for rectangular loop abcd



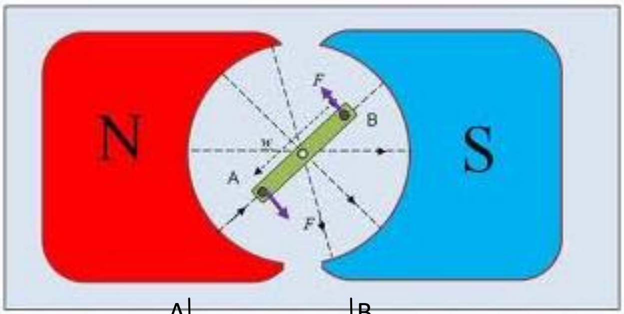


$\oint \vec{B}.\vec{d\ell} = \mu_0 I$

$B.\ell = \mu_0 I(n\ell)$

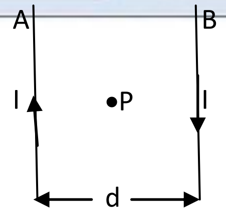
$B = \mu_0 n I$

A3.Radial magnetic field is produced by taking curved cylindrical poles and placing soft iron core.



In such magnetic field, the plane of coil of galvanometer remains along the field line so it experience maximum torque in any position.

A4. Magnetic field at point P due to conductor A carrying current (I); $B_1 = \frac{\mu_0 I}{2\pi.\frac{d}{2}} = \frac{\mu_0 I}{\pi d}$ (vertically downward)



Magnetic field at point P due to conductor B carrying current (I); $B_2 = \frac{\mu_0 I}{2\pi.\frac{d}{2}} = \frac{\mu_0 I}{\pi d}$ (vertically downward)

Net magnetic field at point P = $B = B_1 + B_2 = \frac{2\mu_0 I}{\pi d}$ (vertically downward)

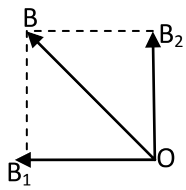
A5. A- Paramagnetic material

B- Diamagnetic material

A- has susceptibility positive slightly greater than one.

B- has susceptibility small negative value.

A6. Magnetic field due to 1^{st} coil at point 'o'



$B_1 = \frac{\mu_0 M}{2\pi x^3}$ and $B_2 = \frac{\mu_0 M}{2\pi x^3}$

$B = \sqrt{B_1{}^2 + B_2{}^2} = \frac{\mu_0 M}{2\pi x^3}\sqrt{2}$

$\tan\theta = B_1/B_2 = 1$

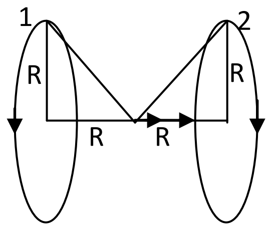
$\theta = 45^0$

A7.

		Electric field	Magnetic field
90^0	Force	F = qE	F = qVB
	Deflection	Parabolic path	Circular path
Parallel	Force	F = qE	F = 0

	Deflection	Accelerated	No deflection

A8. $B_1 = B_2 = \frac{\mu_0 INR^2}{2(R^2 + R^2)^{3/2}}$



Net magnetic field $B = B_1 + B_2 \ = \frac{\mu_0 IN}{2\sqrt{2}R}$

A9. $qV = \frac{1}{2} mv^2 \Rightarrow v = \sqrt{\frac{2qV}{m}}$

$r = \frac{mv}{qB} = \sqrt{\frac{2mV}{qB^2}} = \sqrt{\frac{2 \times 9.1\times10^{-31}\times100}{1.6\times10^{-19}\times16\times10^{-6}}}$ = 8.4mm

A10. $q = 100\text{x}1.6\text{x}10^{-19} = 1.6\ \text{x}10^{-17}\text{C}$

$\omega = 2\pi f = 2\pi \Rightarrow T = 2\pi/\omega = 2\pi/2\pi = 1\text{s}$

$I = q/T = 1.6 \times 10^{-17}$

$B = \frac{\mu_0 I}{2r} \ = \frac{4\pi\times 10^{-7}\times1.6\times10^{-17}}{2\times0.8} = 4\pi\ \text{x}10^{-24} = 1.256 \times 10^{-23}\text{T}$

A11.Flux $\phi = NBA\cos(90^0 - 60^0)$

$= 100\text{x}0.2\ \text{x}5\text{x}10^{-4}\ \text{x}\frac{\sqrt{3}}{2} = 8.66\ \text{x}10^{-3}$ wb

A12. N = 5 x 1000= 5000

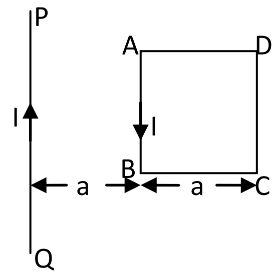
Number of turn per unit length (n) = 5000/2 = 2500

$B = \mu_0 nI = 4\pi\ \text{x}10^{-7}\ \text{x}2500 \times 5 = 1.57\ \text{x}10^{-2}\text{T}$

A13. Mean radius $r = (25+ 26)/2 = 25.5\text{cm} = 25.5\ \text{x}10^{-2}\text{m}$

$n = 4000/2\pi r$

$B = \mu_0\ nI = \frac{4\pi\times10^{-7}\times4000\times10}{2\pi\times25.5\times10^{-2}} = 3.14 \times 10^{-2}\text{T}$



A14. Repulsive force between PQ and side AB of square

$F_1 \ = \frac{\mu_0 I^2}{2\pi a}\times a \ = \frac{\mu_0 I^2}{2\pi}$

Attractive force between PQ and side CD of square

$F_2 = \frac{\mu_0 I^2}{2\pi\times2a}\times a \ = \frac{\mu_0 I^2}{4\pi}$

Net force = $F_1 - F_2 = \frac{\mu_0 I^2}{2\pi} - \frac{\mu_0 I^2}{4\pi} = \frac{\mu_0 I^2}{4\pi}$ (Away from the wire PQ, Repulsive)

A15. Since $2\pi r = \ell \Rightarrow r = \frac{\ell}{2\pi}$

Magnetic moment = $IA = I\times\pi r^2 \ = I\times\pi\times(\frac{\ell}{2\pi})^2 = \frac{I\ell^2}{4\pi}$

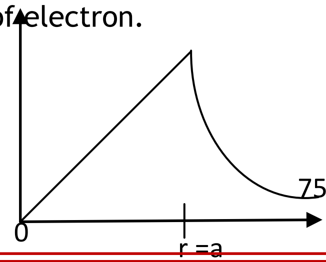
A16.Direction of force will be opposite to each other. If proton is tracing out circular path in clockwise direction then the electron will trace out circular path in anticlockwise direction in the given magnetic field.

Radius of path $r = \frac{mv}{qB} \ \Rightarrow r \propto m$

Hence the radius of path of proton will be larger than the radius of path of electron.

A17. $B_X \ = B_Y$

$\frac{\mu_0 I}{2R} \ = \frac{\mu_0 I_1}{2\times R/2} \Rightarrow I_1 = I/2$



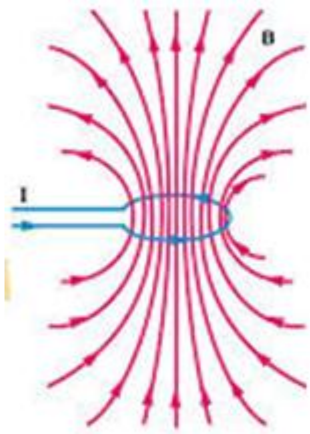
A18.(i) **E** $\perp$**v, E** $\perp$ **B** (ii) $|\boldsymbol{E}|$ = v B

A19. Current passing through area πa^2 = I

Current per unit area = $I/\pi a^2$

Current enclosed in area π r^2 = I' = $\frac{I}{\pi\, a^2} \times \pi r^2 = \frac{Ir^2}{a^2}$

Magnetic field due to current enclosed in area (πr^2) = B_1 = $\frac{\mu_0 I'}{2r}$ = $\frac{\mu_0 \times Ir^2}{2r \times a^2}$ = $\frac{\mu_0 I\, r}{2a^2}$



Magnetic field out of wire = B_2 = $\frac{\mu_0 I}{2a}$

A20. Direction of B along +Z axis because

F = q (**v x B**) $\Rightarrow$ -$\hat{j}$ = $\hat{\imath}$ $\times k$

B = $\frac{F}{qv}$ = $\frac{2 \times 10^{-5}}{2\times 10^{-9}\times 10^{5}}$ = 0.1 T

A21. $\vec{B} = \frac{\mu_0}{4\pi} \cdot \frac{I\, \overrightarrow{.d\ell} \times \vec{r}}{r^3}$

Magnetic field at the centre of current carrying loop B = $\frac{\mu_0 I}{2r}$

A22.Mass of proton, deuteron and α-particle: m, 2m and 4m respectively

Charge on proton, deuteron and α-particle: q, q and 2q respectively

Energy of proton = energy of deuteron

$v_p : v_d = \sqrt{2}:1$

r = $\frac{mv}{qB}$

$\frac{r_p}{r_d} = (\frac{m_p}{m_d})(\frac{q_d}{q_p})(\frac{v_p}{v_d})$ = 1:$\sqrt{2}$

Similarly

Energy of proton = energy of α-particle

$v_p : v_\alpha$ = 2:1

Similarly for proton and alpha particle $\frac{r_p}{r_\alpha}$ = 1:1

$r_p : r_d : r_\alpha$ = 1:$\sqrt{2}$:1

A23. qE = qvB

B = E/v = $\frac{V}{\ell \times v}$ = $\frac{600}{3 \times 10^{-3} \times 2\times 10^{6}}$ = 0.1V

A24.$\frac{(KE)_p}{(KE)_d} = \frac{q_p V}{q_d V}$ = 1:2

A25.R_g = 25Ω, I = 10 x 10^{-3}A , Range = 1-100V

R = $\frac{V}{I_g} - R_g$ = $\frac{100}{1\times 10^{-2}} - 25$ = 9975Ω

A26. S = $\frac{I_g R_g}{I - I_g}$ = $\frac{10 \times 10^{-3} \times 100}{10 - 10^{-2}}$ = 0.1Ω

A27. $\frac{R_1}{R_2} = \left(\frac{m_1}{m_2}\right)\left(\frac{q_2}{q_1}\right)\left(\frac{v_1}{v_2}\right)$ .... (1)

Since qV = ½ mv^2

$\Rightarrow v_1 = \sqrt{\frac{2q_1V}{m_1}}$

$\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$........... (2)

Using equation (1) and 2) and according to question

$\frac{R_1}{R_2} = \left(\frac{m_1}{m_2}\right)\left(\frac{q}{q}\right)(\sqrt{\frac{m_2}{m_1}}) \Rightarrow \frac{R_1{}^2}{R_2{}^2} = \frac{m_1}{m_2}$

A28. $qBv = mv^2/r$

$\Rightarrow qB = mv/r$

But $qV = \frac{1}{2} mv^2 \Rightarrow v = \sqrt{\frac{2qV}{m}}$

Now $Bq = \frac{m}{r}\sqrt{\frac{2qV}{m}}$

Here B, V and q are constant $\Rightarrow \frac{m_X}{m_Y} = \frac{R_1{}^2}{R_2{}^2}$

A29. $F = eBv$

$\frac{1}{2} mv^2 = eV$

$v = \sqrt{\frac{2eV}{m}}$

Hence $F = eB\sqrt{\frac{2eV}{m}}$

New Force F' when V' = 2V

$F' = \sqrt{2}\, eB\sqrt{\frac{2eV}{m}} = \sqrt{2}\, F$

A30. $\tau = MB \sin\theta = 10^{-3} \times 4\pi \times 10^{-3}$

A31. $M = 10^4$, $B = 4 \times 10^{-5}$T

$W = MB(\cos\theta_1 - \cos\theta_2)$

$= 10^4 \times 4 \times 10^{-5}(1 - \frac{1}{2})$

$= 0.2$J

A32. $W = MB(1 - \cos\theta)$

$= MB(1 - \frac{1}{2})$

$MB = 2W$

$\tau = MB \sin 60^0$

$MB \times \sqrt{3}/2 \Rightarrow 2W \times \frac{\sqrt{3}}{2}$

$\tau = \sqrt{3}W$

A33. $F = q\, v\, B_H$

$= 1.6 \times 10^{-19} \times 3\times10^5 \times 0.15$

$= 7.2 \times 10^{-15}$N

A34. $\tau = MB \sin\theta$

$1.2 \times 10^{-3} = 60 \times 0.4 \times 10^{-4} \times \sin\theta$

$\theta = 30^0$

A35. r = $\frac{mv}{eB}$ and we know that

$\frac{1}{2} mv^2 = eV$

$v = \sqrt{\frac{2eV}{m}}$

$\therefore r = \sqrt{\frac{2mV}{eB^2}} = \sqrt{\frac{2 \times 9.1 \times 10^{-31} \times 3750}{1.6 \times 10^{-19} \times (4 \times 10^{-3})^2}} = 5.2 \times 10^{-2}$m

A36.(a)An electromagnet consists of a core made of a ferromagnetic material placed inside a solenoid. It behaves like a strong magnet when current flows through the solenoid and effectively loses its magnetism when the current is switched off.

(i) A permanent magnet is also made up of a ferromagnetic material but it retains its magnetism at room temperature for a long time after being magnetized once.

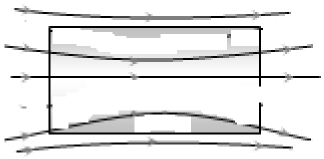
b)(i) High permeability

(ii) Low retentivity

(iii)Low coericivity

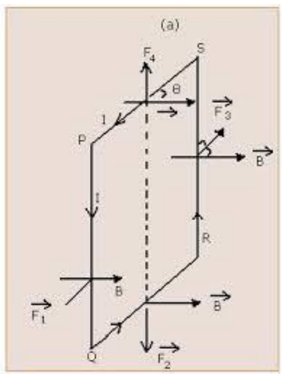
Short Answer Type Questions: 3 Marks

A1.A paramagnetic material get magnetised weakly in the direction of applied magnetic field because their permeability is slightly greater than one.



When temperature is decreases its intensity of magnetisation increases because thermal energy of atomic magnetic magnet is lowered and the alignment increases.

Paramagnetic materials are corresponding to polar dielectric because individual atoms are acting as magnet.



A2. Force on arms PQ and RS $F_1 = F_3 = IaB$ (PQ = RS = a)

Moment of couple (τ) = IaBb sinθ (PS =QR = b)

τ = I ab B sinθ

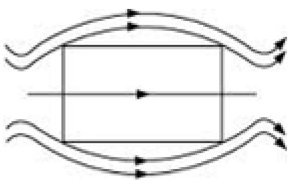
τ = IAB sinθ (Area A = ab)

When the plane of the loop is perpendicular to the magnetic field, the loop will in stable equilibrium ($\theta = 0^0$)

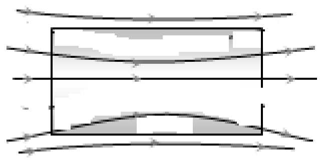
$\vec{M}$ = equivalent magnetic moment of planer loop = I$\vec{A}$

$\vec{\tau} = \vec{M} \times \vec{B}$

A3. Explanation: For diamagnetic material resultant magnetic moment in an atom is zero. In presence of external magnetic , they acquire a net magnetic moment in a direction opposite to applied field.



Diamagnetic



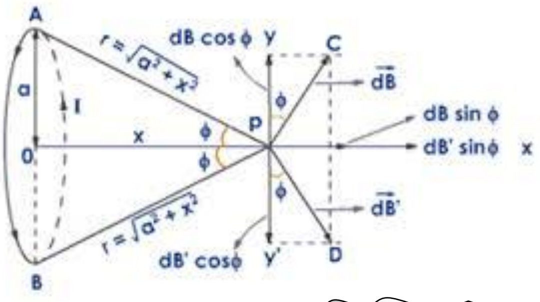
Paramagnetic

In paramagnetic material there is a permanent magnetic dipole moment of atoms. The external magnetic field tends to align these along its own direction.

A4. Biot-Savart law states that magnetic field due to current element

$$dB \propto \frac{I\, dl\, Sin\theta}{r^2}$$

The resultant magnetic field will be along the axis as the perpendicular components cancel out in pairs.



$$B = \int_0^{2\pi R} dB\, sin\phi$$

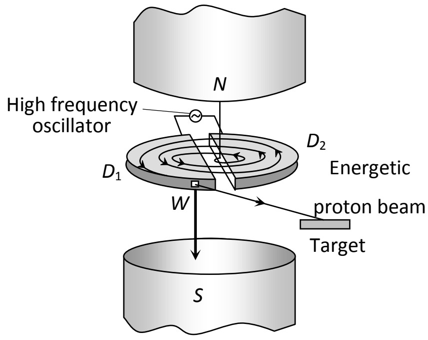
$$= \int_0^{2\pi R} \frac{\mu_0}{4\pi}\frac{Id\ell}{(a^2+x^2)}\frac{a}{(a^2+x^2)^{1/2}}$$

$$= \frac{\mu_0 I}{4\pi}\frac{2\pi\, a^2}{(a^2+x^2)^{3/2}}$$

$$= \frac{\mu_0 I a^2}{2(a^2+x^2)^{3/2}}$$

At centre x = 0

$$B = \frac{\mu_0 I}{2a}$$



Q5. A charged particle can be accelerated to very high energy by subjecting it to an oscillating electric field applied between the dees. When the charged particle is subjected to a uniform magnetic field, it moves in a circular path. Both the fields are perpendicular to each other. The time for one revolution of the charged particle is independent of its speed or radius of its orbit.

Magnetic force on charge particle = centripetal force

$$qv\,B = \frac{mv^2}{r}$$

$$v = \frac{Bqr}{m}$$

Time period $T = \frac{2\pi r}{v}$

$$T = \frac{2\pi m}{Bq}$$

A6. In magnetism, Gauss's law states that $\oint \vec{B}.\overrightarrow{ds} = 0$

In electrostatics Gauss's law states that $\oint \vec{E}.\overrightarrow{ds} = \frac{q}{\epsilon_0}$

Reason: Isolated poles do not exist.

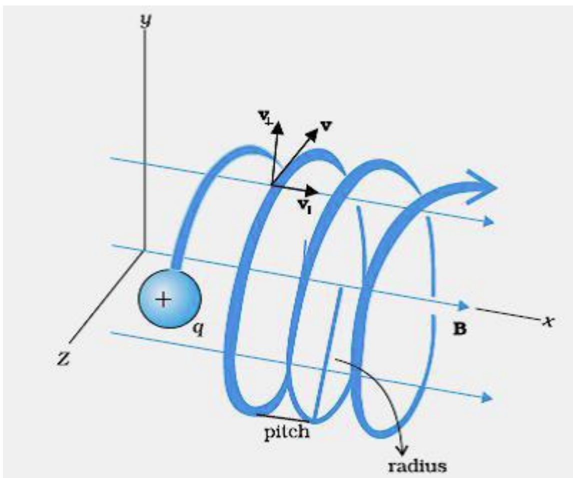
$$B = \frac{\mu_0}{4\pi}\left(\frac{M}{R^3}\right) = 10^{-7}\left(\frac{M}{R^3}\right)$$

$$M = \frac{0.4\times10^{-4}\times(6400\times10^3)^3}{10^{-7}} = 1.1 \times 10^{23}\,Am^2$$

A7. Trajectory will be helix

Explanation:

The particle will describe a circle in y-z plane due to the velocity component v_y of its velocity. It also moves along the x-axis (parallel to field), due to



component v_x of its velocity hence the trajectory would be helical.

Distance moved along the magnetic field in one rotation

$X = v_x \times T$

Since $T = \frac{2\pi m}{Bq}$

Therefore $x = \frac{2\pi m v_x}{Bq}$

A8. In case (i) $I_g = \frac{V}{R_1 + G}$ ------- (1)

Case (ii) $I_g = \frac{V/2}{R_2 + G}$ ----- (2)

From equation (i) and (ii) we get

$\frac{V}{R_1+G} = \frac{V}{2(R_2+G)}$

$R_1 + G = 2R_2 + 2G$

$G = R_1 - 2R_2$ -------------- (iii)

For conversion of galvanometer into a voltmeter of range 2V, we have

$I_g = \frac{2V}{R+G}$ ------------- (iv)

From equation (i) and (iv)

$\frac{V}{R_1+G} = \frac{2V}{R+G}$

$R + G = 2R_1 + 2G$

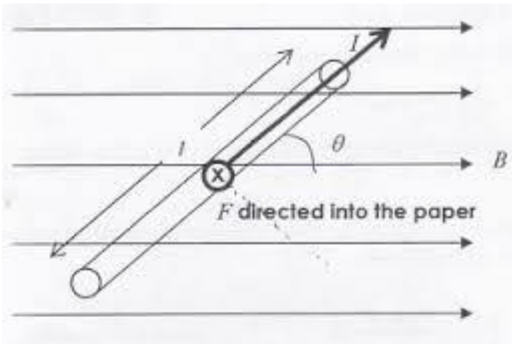
$R = 2R_1 + G$

Putting the value of G from equation (iii) , we get

$R = 2R_1 + (R_1 - 2R_2)$

$R = 3R_1 - 2R_2$.

A9.Magnetic force acting on an electron



$\vec{f} = - e (\vec{v_d} \times \vec{B})$

If n is the number of free electrons per unit volume, then total number of electrons in the conductor of length ℓ, area of cross section A is

$N = nA\ell$

Total force on the conductor $\vec{F} = N\vec{f} = nA\ell [- e (\vec{v_d} \times \vec{B})] = neA [-\ell\vec{v_d} \times \vec{B}]$

If $I\vec{\ell}$ represent a current element vector in the direction of current, then vectors $\vec{\ell}$ *and* $\vec{v_d}$ Will have opposite directions and we can take;

$-\ell \vec{v_d} = v_d \vec{\ell}$

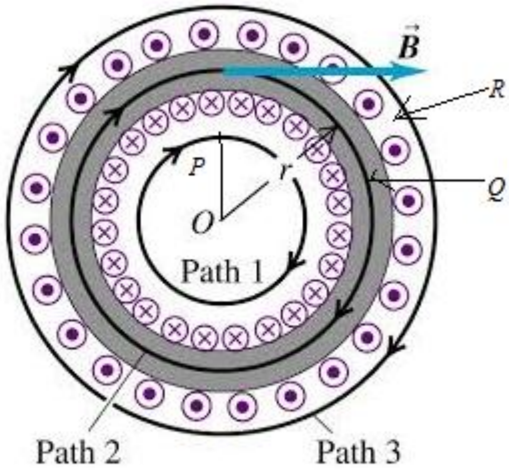
$\vec{F} = enA\, v_d (\vec{\ell} \times \vec{B})$

$\boldsymbol{\vec{F} = I (\vec{\ell} \times \vec{B})}$

Fleming's left hand rule **decides the direction of force.**

A10. (a) Toroid is a endless solenoid. It can be viewed as a solenoid which has been bent into a circular shape to close on itself.

(b)Magnetic field inside the toroid (taking the path of radius r)



Let the total number of turns in the toroid is N

Magnetic field at point Q

B($2\pi r$) = μ_0 NI

B = $\mu_0 \frac{N}{2\pi r} I$

= μ_0 n I (where n is the number of turns per unit length)

(c)For path-1 of radius r_1 at point P, Ampere's circuital law gives

$B_1.2\pi r_1 = \mu_0(0)$ i.e. $B_1 = 0$

For the paths-3 considered outside of the toroid, magnetic field at point R

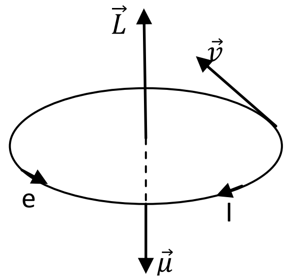
We have $B_2 (2\pi r_2) = \mu_0 (I_{enclosed})$

But from the solenoid , we know that current coming out of the plane of paper, is cancelled exactly by the current going into it hence current enclosed in path-3 = zero

$B_2 = 0$

A11. Let an electron revolving anticlockwise around a nucleus in an orbit of radius (r) with speed v

Equivalent current I = $\frac{Charge}{time} = \frac{e}{T} = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$



Area of loop A = πr^2

Orbital magnetic moment μ = IA = $\frac{ev}{2\pi r} .\pi r^2 = \frac{evr}{2}$ .... (1)

Also angular momentum L = mvr $\Rightarrow$ v r = $\frac{L}{m}$.................... (2)

From equation (1) and (2)

$$\Rightarrow \mu = \frac{e}{2m} L$$

In vector form $\vec{\mu} = -\frac{e}{2m}\vec{L}$

The direction of magnetic dipole moment ($\vec{\mu}$) is opposite to that of $\vec{L}$ because of negative charge on the electron.

A12. (a) Ampere's Circuital law: The line integral of magnetic field around the closed path enclosing current is equal to μ_o times the current enclosed by the closed path in vacuum.

$$\oint \vec{B}.\vec{d\ell} = \mu_0 I$$

(b) B = μ_0 n I

Magnitude of net magnetic field inside the combined system on the axis;

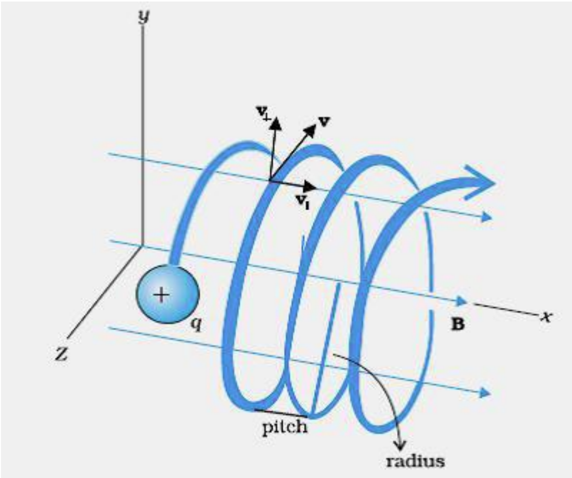
$B = B_1 - B_2$

$\Rightarrow B = \mu_0 (n_1 - n_2)I$

(c)Outside the combined system the net magnetic field is zero.

A13.(a) Force acting on the charge particle, moving with velocity $\vec{v}$, in a magnetic field $\vec{B}$

$\vec{F}$ = q ($\vec{v} \times \vec{B}$)



As, $\vec{v} \perp \vec{B}$, magnitude of force F = qvB

Since $\vec{F} \perp \vec{v}$ it acts as centripetal force and makes the particle move in a circular path in the plane, perpendicular to the magnetic field.

$qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$

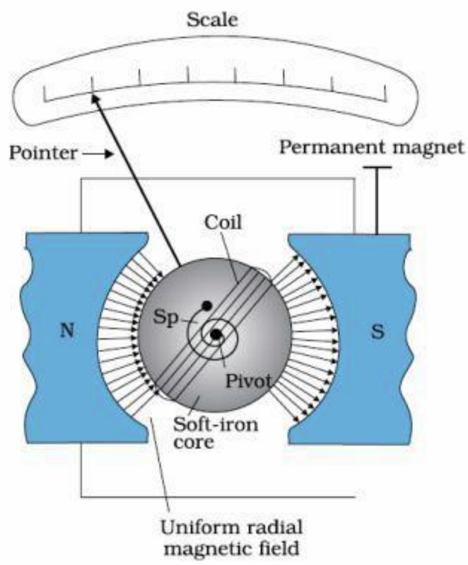
Now $\omega = \frac{v}{r}$ $\quad \therefore \omega = \frac{qB}{m}$

b) Component of velocity $\vec{v}$ parallel to magnetic field will make the particle move along the field.

Perpendicular component of velocity will cause the particle to move along a circular path in the plane perpendicular to the magnetic field.

Hence, the particle will follow a helical path, as shown.

A14. When a current, I, flows through the coil, a torque τ = NIAB acts on it.



A spring provides a counter torque (k θ) which balances the deflecting torque;

$k\theta = NIAB$

$\theta = \left(\frac{NAB}{k}\right) I$

$\theta \propto I$

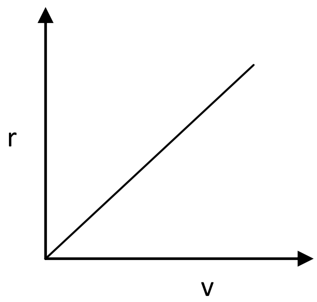
Current sensitivity $\frac{\theta}{I} = \frac{NAB}{k}$

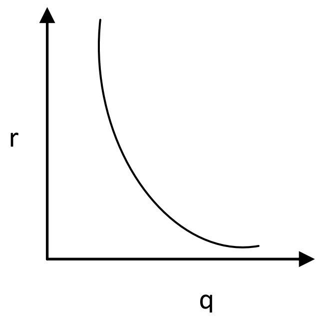
Voltage sensitivity = $\frac{NAB}{kR}$

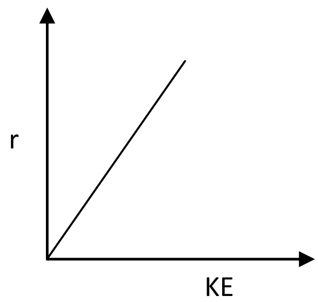
On increasing number of turns, the resistance of the coil increases proportionally.

Increase in current sensitivity does not necessarily increase voltage sensitivity.

A15. Radius of path (r) = $\frac{mv}{qB}$







A16. When charge particle is passed through potential V: then qV = $\frac{1}{2}\, m\, v^2$

$$v = \sqrt{\frac{2qV}{m}}$$

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB} = \frac{m}{qB} \times \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2mV}{qB^2}}$$

A17. When wire is turn into circular loop $2\pi r = \ell$

$$r = \frac{\ell}{2\pi}$$

$$M = IA = I \times \pi r^2$$

$$= I \times \pi \frac{\ell^2}{4\pi^2} = \frac{I\ell^2}{4\pi}$$

$$\tau = MB$$

$$= \frac{I\ell^2}{4\pi} \times B$$

A18.(a) Path: Helical

(b)No change in speed of particle.

(c) upward.

A19. Force F = $I\ell B \sin\theta$

$Mg = I\ell B \sin\theta$

0.06 x 10 = 5 x 0.45 x B

B = $\frac{0.588}{5 \times 0.45}$ = 0.26T (Horizontally, perpendicular to length)

When direction of current is reversed

T = mg + $I\ell B$ = 0.588 + 0.588 = 1.17N

A20. B = $\frac{\mu_0 I}{2r}$ = $10^{-7} \times \frac{2 \times 4}{0.2}$ = 4×10^{-6}T

F = qvB

= $1.6 \times 10^{-19} \times 4 \times 10^{6} \times 4 \times 10^{-6}$

= 2.56×10^{-18}N (Repulsive)

A21. Magnetic field B = $\frac{2\pi m}{qT} = \frac{2\pi m \nu}{q}$

$$= \frac{2 \times 3.14 \times 1.67 \times 10^{-27} \times 10 \times 10^6}{1.6 \times 10^{-19}}$$

$$= \frac{104.88}{1.6} \times 10^{-2} = 0.66\text{T}$$

Final velocity = $2\pi\nu \times R$

= 2 x 3.14 x 10 $\times 10^6$ x 0.6

= 3.8×10^7m/s

Energy = ½ mv^2 = ½ x $(1.67 \times 10^{-27} \times (3.8 \times 10^7)^2$

= 12.06×10^{-13}J = 7.5MeV

A22.(a) Torque τ = MB sinθ

= 0 because $\theta = 0^0$

(b) Total force = 0 because forces on the opposite arms of coil are equal and opposite and act in the same plane hence cancel out.

(c)Force on each electron F = e v_dB = BI/nA (since I = neAv_d = $\Rightarrow v_{d=} \frac{I}{neA}$)

= $\frac{0.5 \times 3}{10^{29} \times 10^{-5}}$ = 1.5x 10^{-24}N

A23. Path is circular because force is acting perpendicular to direction of motion.

Frequency $\nu = \frac{qB}{2\pi m}$

$= \frac{1.6 \times 10^{-19} \times 6.5 \times 10^{-4}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$

= 1.8 x 10^7Hz.

The frequency does not depend upon speed of electron because as speed increases the radius of paths also increases.

A24. (a) M = IA = 12 x 50 x x10^{-4} = 0.06Am^2

$\vec{\tau} = \vec{M} \times \vec{B}$

= 0.06 $\hat{j} \times$ 0.3 $\hat{k}$ = 1.8 x 10^{-2} $\hat{\imath}$ Nm, along +ve x- axis.

(b) $\vec{\tau}$ = 1.8 x 10^{-2} $\hat{\imath}$ Nm, along +ve x- axis.

(c) $\vec{\tau}$ = 0.06$\hat{k} \times$ 0.3$\hat{k}$ = 0 (stable equilibrium)

A25.Force between conductors P and Q

$F_{PQ} = \frac{\mu_0 \times 2 \times I_1 \times I_2 \times \ell}{4\pi a} = \frac{10^{-7} \times 2 \times 20 \times 10 \times 0.1}{2 \times 10^{-2}}$ = 2 x10^{-4}N (repulsive towards R)

$F_{QR} = \frac{10^{-7} \times 2 \times 10 \times 30 \times 0.1}{10 \times 10^{-2}}$ = 0.6 x10^{-4}

Net force F = F_{PQ} - F_{QR} = 1.4 x10^{-4}N (towards conductor R)

A26.(a) M = NIA = 20x3 x 3.14 x (4x $10^{-2})^2$ = 0.3Am^2

(b) PE = -MB cosθ = -0.3 x 0.5 x 1 = -0.15J

(c)Torque τ = MB sinθ = MBsin0^0 = 0

A27. B = $\frac{\mu_0 N I a^2}{2(x^2 + a^2)^{3/2}}$

$B_Y = \frac{\mu_0 NI \times 4r^2}{2(d^2 + 4r^2)^{3/2}} = \frac{\mu_0 NI \times 2r^2}{(d^2 + 4r^2)^{3/2}}$

$B_X = \frac{4 \times \mu_0 NI \times r^2}{(d^2 + 4r^2)^{3/2}}$

B_Y: B_X = 1: 2

A32.Machine: Cyclotron

Resonance Condition: When the frequency of rotation of particle is matching the frequency of alternating voltage. OR

Polarity of Dees should change at the same moment as the accelerating ions reach to gap of two Dees so the ions get accelerated while crossing the gap.

(iii) Particle will accelerate and decelerate alternately. However, the radius of path will remain unchanged.

A33.We know that Electrostatic force provides necessary centripetal force for the revolution of electron around the nucleus; $\frac{m\,v^2}{r} = \frac{e^2}{4\pi\,\epsilon_0\,r^2}$

$v^2 = \frac{e^2}{4\pi\epsilon_0 mr}$

Bohr's quantization condition

Mvr = $\frac{nh}{2\pi}$

On solving, v = $\frac{e^2}{2\epsilon_0 h}$, r = $\frac{\epsilon_0\,h^2}{2me^2}$

Magnetic field at centre B = $\frac{\mu_0\,I}{2\,r} \Rightarrow$ I = $\frac{e\,v}{2\,\pi\,r}$

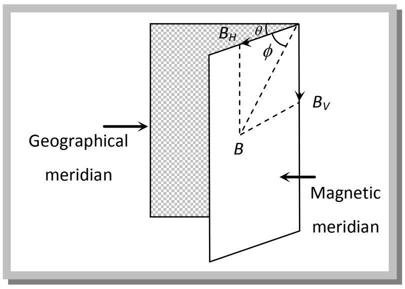
B = $\frac{\mu_o\,e^7\,\pi\,m^2}{8\,\epsilon_0{}^3 h^5}$

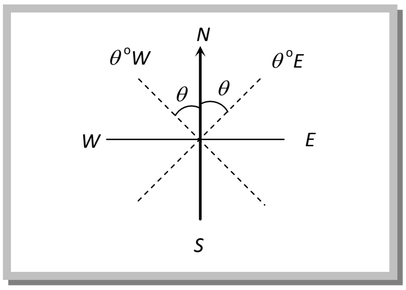
ANSWER KEY LONG ANSWER TYPE QUESTIONS: 5-MARKS

Q1. Angle of declination (θ): The angle between the true geographical north and north shown by compass needle is called magnetic declination.

Angle of Dip (ϕ): It is the angle that the total magnetic field of earth makes with surface of earth.

Horizontal component Earth's magnetic field: The component of total magnetic field of earth along the surface of earth.





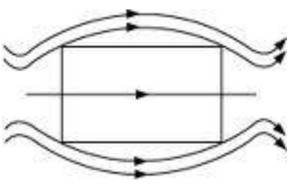
Horizontal component B_H= $B\cos\phi$ ...... (i)

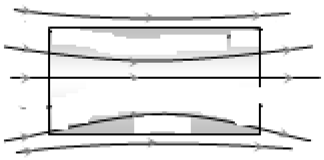
Vertical component $B_V = B\sin\phi$ .... (ii)

By squaring and adding equation (i) and (ii) $B = \sqrt{B_{H^2} + B_{V^2}}$

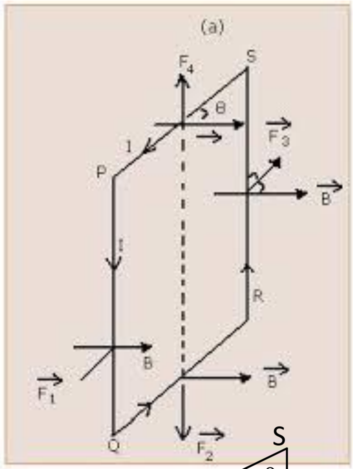
Dividing equation (ii) by equation (i) $\tan\phi = \frac{B_V}{B_H}$

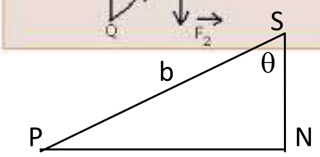
(b)





Q2. Let a loop PQRS is carrying current I and its sides PQ = ‘a’ and PS = ‘b’ placed in magnetic field **‘B’**





Force on the arms PS and QR are equal, opposite and act along the axis of coil, being collinear along the axis, they cancel each other. Forces on arms PQ and SR are F_1 and F_3 which are equal and opposite but not collinear.

$F_1 = F_3 = IaB \sin 90^0 = IaB$

Torque acting on the loop τ = Force x perpendicular distance between two forces F_1 and F_3

$\tau = IaB \times PS \sin\theta = I(ab)B\sin\theta$

$= IAB\sin\theta$ (Area A = ab)

$\tau = MB\sin\theta$ (magnetic moment M = IA)

$\vec{\tau} = \vec{M} \times \vec{B}$

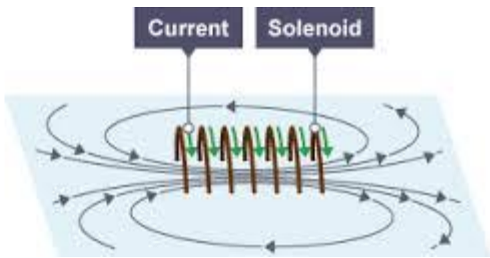
(*b*) (i)In moving coil galvanometer, this expression is applied at $\theta = 90^0$ i.e. $\tau = NIAB$

(ii) Sensitivity of a galvanometer is increased by increasing number of turns / increasing area of coil/ increasing magnetic field/by decreasing torsion constant.

A3. (a)**Ampere’s Circuital Law:** Line integral of magnetic over a closed loop is equal to μ_0 times the total current enclosed by closed surface.

$$\oint \vec{B}.\vec{d\ell} = \mu_0 I$$

Let the current flowing through each turn of the toroid be I. The total number of turns $n.2\pi r$ where n is the number of turns per unit length. Applying Ampere’s circuital law, for the Amperian loop, for the interior points.



$$\oint \vec{B}.\vec{d\ell} = \mu_0 (n.\ 2\pi r I)$$

$$\oint B d\ell \cos 0^0 = \mu_0 (n.\ 2\pi r I)$$

$$\Rightarrow B \times 2\pi r = \mu_0 (n.\ 2\pi r I)$$

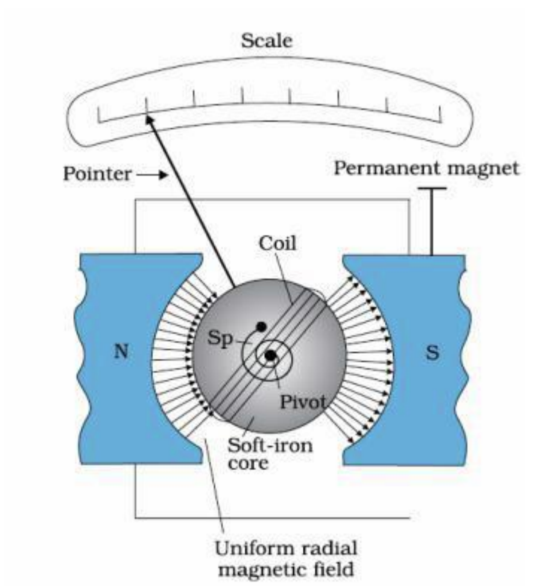
$$\Rightarrow B = \mu_0 n I$$

(b)The solenoid contains N loops, each carrying a current I

Therefore each loop acts as a magnetic dipole. The magnetic moment for a current I, following in loop of area (Vector) A is given by **M = IA**

The magnetic moment of all loops are aligned in the same direction and acting as a small magnet. Hence, net magnetic moment equals to **NIA.**

Whole solenoid is acting as bar magnet.



A4. Principle: "whenever a current carrying coil is placed in magnetic field, it experiences a deflecting torque"

Working: When current is passed through a coil, free to rotate in a magnetic field, deflecting torque acting on the coil, τ = NIABsinθ.= NIAB (since $\theta = 90^0$)

The coil starts to rotate. The rotation of coil is opposed by spring (S_p) by providing a restoring torque (Kϕ). When two torques become equal, the coil comes to rest.

$\therefore$ NIAB = Kϕ

$$I = \frac{K\phi}{NAB}$$

$\Rightarrow I \alpha \phi$

Function of (i)Radial Magnetic field: It keeps magnetic field lines normal to area vector of the coil.

(ii)Soft Iron Core: It increases the strength of magnetic field.

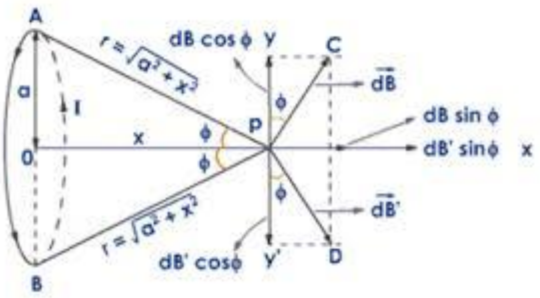
Current sensitivity: Deflection per unit current $\frac{\phi}{I} = \frac{NAB}{k}$

Voltage sensitivity: Deflection per unit voltage = $\frac{NAB}{kR}$

If number of turns is increased, then current sensitivity increases but voltage sensitivity remains same because resistance increases proportionally.

A6.(a)Biot-Savart law in vector form

$$d\vec{B} = \frac{\mu_0}{4\pi}.\frac{I\,.\vec{d\ell}\times\vec{r}}{r^3}$$



Magnetic field on the axis of a circular loop:

The net magnetic field along the x-axis only

Net contribution along X-axis

B = $\int_0^{2\pi a} dB\ sin\phi$

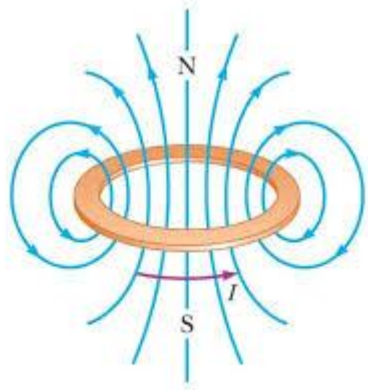
since dB = $\frac{\mu_0 I d\ell\ sin90^0}{4\pi r^2} = \frac{\mu_0 I d\ell}{4\pi r^2}$

and r^2 = $a^2 + x^2$, sinϕ = $\frac{a}{(x^2+a^2)^{1/2}}$

$$\therefore B = \int_0^{2\pi a}\frac{\mu_0 I d\ell}{4\pi(x^2+a^2)}\frac{a}{(x^2+a^2)^{1/2}} = \frac{\mu_0 I a}{4\pi(x^2+a^2)^{3/2}}\int_0^{2\pi a} d\ell = \frac{\mu_0 I a}{4\pi(x^2+a^2)^{3/2}}\times 2\pi a$$

$$B = \frac{\mu_0 I\, a^2}{2\,(x^2+a^2)^{3/2}}$$

(b)Biot-Savart law can be expressed as Ampere's circuital law by considering the surface to be made up a large number of loops. The sum of the tangential components of magnetic field multiplied by the length of all such elements, gives the result.



A7.(a) Magnetic field due to circular loop on its axis for far off points

$$\mathbf{B} = \frac{\mu_0\, 2IA}{4\pi\, x^3}$$

Magnetic field due to bar magnet at an axial point;

$$B = \frac{\mu_0\, 2M}{4\pi\, x^3}$$

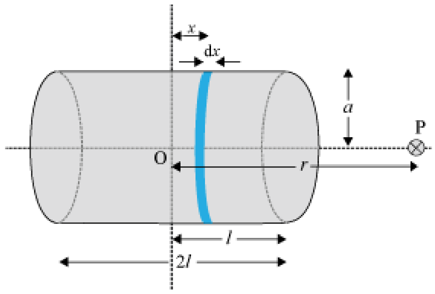
Om comparing above two results; $\vec{M} = I\vec{A}$

(b)Let number of turns per unit length of solenoid = n

A current element dx at distance x is taken from point 'o'

If I is the current through solenoid, then magnetic field at point P due to circular current element;

$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{2\pi(ndx)Ia^2}{[(a^2+(r-x)^2]^{3/2}}$$



Let P be far off from point 'o', then r>>> a and r>>> x

so$(a^2 + (r-x)^2]^{3/2} = r^3$

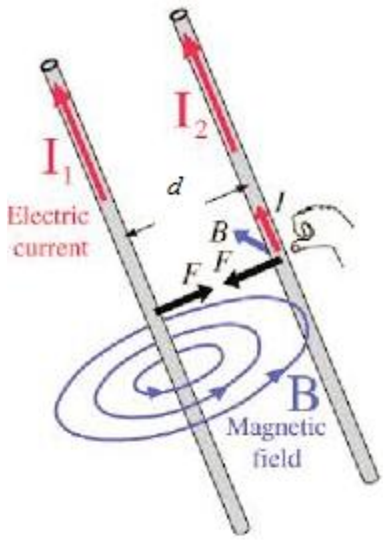
$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{2\pi(ndx)I\,a^2}{r^3}$$

Net magnetic field at point P due to whole solenoid can be obtained by integrating the above equation between the limit -ℓ to ℓ.

$$B = \left(\frac{\mu_0}{4\pi}\right)\frac{2\pi\,n\,I\,a^2}{r^3}\int_{-\ell}^{\ell}dx = \left(\frac{\mu_0}{4\pi}\right)\frac{2\pi\,nI\,a^2}{r^3}(2\ell)$$

$$B = \left(\frac{\mu_0}{4\pi}\right)\frac{2[n\times 2\ell\times I\times\pi a^2]}{r^3} = \left(\frac{\mu_0}{4\pi}\right)\frac{2m}{r^3}$$

This expression is same as in the case of a bar magnet.



A8.(a)Magnetic field of wire 1 on the wire two

$$B = \frac{\mu_0 I_1}{2\pi d}$$

Force acting per unit length of wire 2

$F = I_2B$

$= \frac{\mu_0 I_1 I_2}{2\pi d}$ **(Attractive)**

The force will be repulsive if current is flowing in opposite direction.

Definition of 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, interact each other with a force of 2×10^{-7} N/m of their length.

(b)Force F = $\frac{\mu_0}{4\pi}\times\frac{2I_1I_2}{d}\times\ell = 10^{-7}\frac{2\times10\times5\times0.2}{5\times10^{-2}} = 4\times10^{-5}$N, Repulsive towards right.

A9. 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.

$$\oint \vec{B}.\vec{d\ell} = \mu_0 I$$

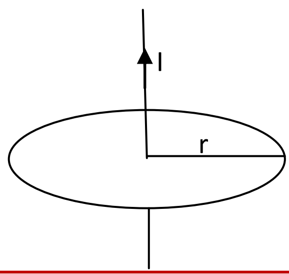
Let an infinite straight wire carry a current I. We consider a circle of radius r, centred on the wire, and having its plane perpendicular to the wire.

By right hand thumb rule, the magnetic field is tangential at every point of this circular loop

By Ampere's circuital law

$$\oint \vec{B}.\vec{d\ell} = \mu_0 I$$

$$B\oint d\ell. = \mu_0 I$$



B. $2\pi r = \mu_0 I$

$$B = \frac{\mu_0 I}{2\pi r}$$

(b)For r < a, we have

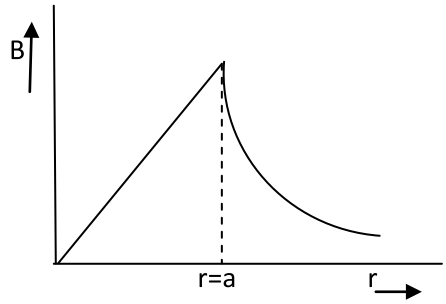
B.$2\pi r = \mu_0 \times$ current enclosed

$$= \mu_0\left(\frac{\pi r^2}{\pi a^2}\right) I = \mu_0\left(\frac{r^2}{a^2}\right) I$$

$$B = \frac{\mu_0 I r}{2\pi a^2}$$

For r> a, B. $2\pi r = \mu_0 I$

$$B = \frac{\mu_0 I}{2\pi r}$$



ANSWER TO VALUE BASED QUESTIONS:

A1. (a) Asha and her family helpful, concern for others , caring nature (any two)

Doctor was generous, helping nature, caring (any two)

b) High magnetic field required. / (Expensive set up needed) Any other correct answer.

A2. (a)The values displayed by Deepika and Ruchika are their inquisitiveness for practical knowledge.

The teacher displayed concern for the students.

b) Principle: When a current passes through a coil, placed in a uniform magnetic field, it experiences a torque.

c) The pole pieces of the magnet are given a concave shape. This is done to produce a radial magnetic field.

UNIT –IV: Electromagnetic Induction and Alternating Current:

VERY SHORT ANSWER TYPE QUESTIONS: 1 –MARK

Q1. Define capacitor reactance. Write its S.I. units.

Q2. Define the term ‘quality factor’ of resonance in series LCR circuit. What is its S.I. unit? **CBSE-2016-D**

Q3. Define the term ‘wattless current’.

Q4. Define the term ‘self-inductance’ of a coil. Write its S.I. unit.

Q5. A planar loop of rectangular shape is moved with uniform speed within the region of uniform magnetic field acting perpendicular to its plane. What is the direction and magnitude of the current induced in it ? Ans: No induced current hence no direction

Q6.In a series LCR circuit, $V_L = V_C \neq V_R$. What is the value of power factor? Ans: 1

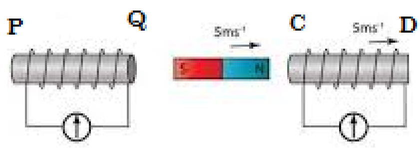
Q7. In an a.c. circuit, the instantaneous voltage and current are V = 200 sin 300 t volt and I = 8 cos 300 t ampere respectively. Is the nature of the circuit capacitive or inductive? Give reason.

Ans: Capacitive because current lead the voltage

Q8. Draw a graph to show variation of capacitive-reactance with frequency in an a.c. circuit.

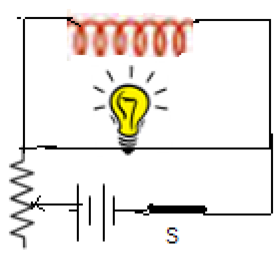
Q9. Draw a graph to show variation of inductive-reactance with frequency in an a.c. circuit.

Q10.A bar magnet is moved in the direction indicated by the arrow between two coils PQ and CD. Predict the direction of current in each coil.



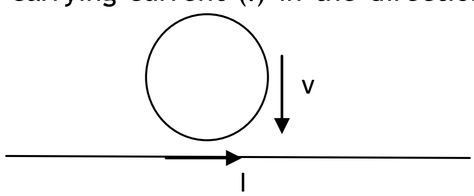
Q11. Why is choke coil needed in the use of fluorescent tubes with ac mains?

Q12. For a circuit arrangement shown in figure. The circuit is switched on and variable resistance is adjusted such that the bulb just glows. What would you observe if the circuit is switched off?

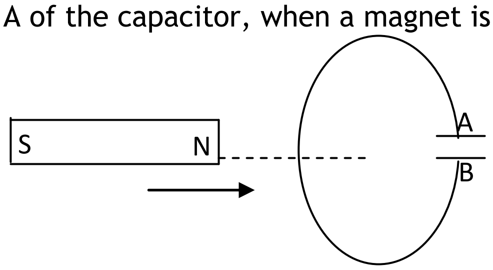


Q13. In series LCR circuit the voltage across an inductor, a capacitor and resistor are 30V, 30V and 60V respectively. What is the phase difference between applied voltage and current?

Q14. Predict the direction of induced current in a metal ring when ring is moved towards a straight conductor with speed (v).The conductor is carrying current (I) in the direction shown in figure. Ans: Clockwise



Q15. Predict the polarity of the plate A of the capacitor, when a magnet is moved towards it, as is shown in the figure.



Q16.Two spherical bobs, one metallic and the other of glass, of the same size are allowed to fall freely from the same height above the ground. Which of the two would reach earlier and why?

Q17. A metallic piece gets hot when surrounded by a coil carrying high frequency alternating current. Why?

Q18. A choke coil and a bulb are connected in series to a d.c source. The bulb shines brightly .How does the brightness change when an iron core is inserted in the choke coil? Ans: No change.

Q19.Power factor of an ac circuit is 0.5. What will be the phase difference between voltage and current in the circuit? Ans: 60^0

Q20. Write expression for the average value of the a.c voltage $V = V_o \sin\omega t$ over the time interval $t = 0$ and $t = \pi/\omega$.

Q21.An electrical element X, when connected to an alternating voltage source, has the current through it leading the voltage by $\pi/2$ rad. Identify X and write an expression for its reactance.

Q22. A rod of length L, along East-West direction is dropped from a height H, if B be the magnetic field due to earth at that place and angle of dip is δ, then what is the magnitude of induced emf across two ends of the rod when the rod reaches the earth?

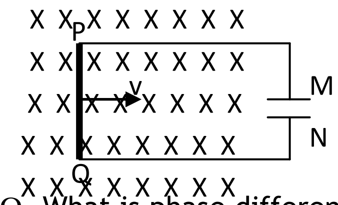
Q23. Mention the two characteristics properties of the material suitable for making core of transformer.

Q24.Can the voltage drop across the inductor and the capacitor in a series LCR circuit be greater than the applied voltage of the a.c. source? Justify your answer.

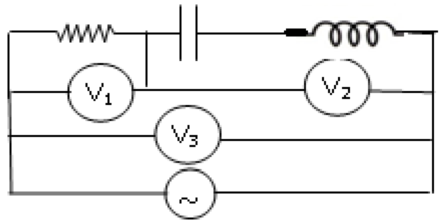
Q25. The instantaneous current and voltage of an a.c. circuit are given by $i = 10 \sin 300\, t$ A and $V = 200 \sin 300\, t$ V. What is the power dissipation in the circuit?

Q26. In series LCR circuit the voltage across R, L and C are 40V, 50V and 20V respectively. What is applied voltage? **Ans**: 50V

Q27.A rod PQ is connected to capacitor plates and placed in uniform magnetic field directed downwards perpendicular to pane of paper as shown in figure. What will be the polarity of plates of capacitor if rod moves to right?



Q28. In series LCR circuit R = 10Ω and impedance Z = 20Ω. What is phase difference between current and voltage? Ans 60^0



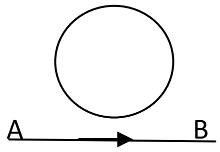
Q29.Which voltmeter gives zero reading at resonance and why?

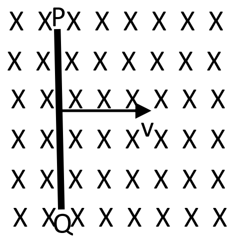
Q30.An aircraft flying horizontally with speed (v) having wings separation (ℓ) in a region where the Earth's magnetic field of uniform flux density (B) making angle θ with Earth's surface. What is magnitude of induced emf across the tips of wings? Ans: $e = B\ell v \sin\theta$

Q31. A coil of area A is kept perpendicular in magnetic field intensity (B). What is change in flux if the coil is rotated by 180^0. Ans: 2BA

Q32.An electron is moving along the line AB which lies in the same plane as a circular loop of conducting wire as shown in figure. What is direction of induced current in the loop?

Ans: Anticlockwise





Q33.A rod PQ is moving with uniform velocity (v) in a magnetic field (B) as shown in figure. In which direction the electron will shift to create a potential difference across the rod?

Ans: Downward

Q34.A thin ring of radius (r) carries uniformly distributed charge (q). The ring rotates at constant angular frequency (n) revolution /second about an axis passing through its centre and perpendicular to its plane. What is charge carried by the ring if the magnetic induction (B) is at its centre?

Q25.An a.c. source of voltage $V = V_o \sin\omega t$ is connected to an ideal inductor. Draw graphs of voltage V and current I versus ωt. CBSE 2016(E)

Q26.Explain why current flows through an ideal capacitor when it is connected to a a.c. source but not when it is connected to a d.c. source in a steady state. CBSE 2016 (E)

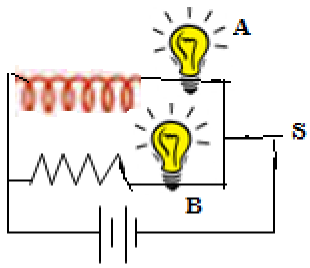
SHORT ANSWER TYPE QUESTIONS: 2-MARKS

Q1.Two identical bulb A and B are connected as shown in figure with inductance coil and resistors respectively .Both Inductance and resistors have same ohmic resistance R .The switch S is closed. Answer the following questions:

(i) Which bulb glows instantaneously?

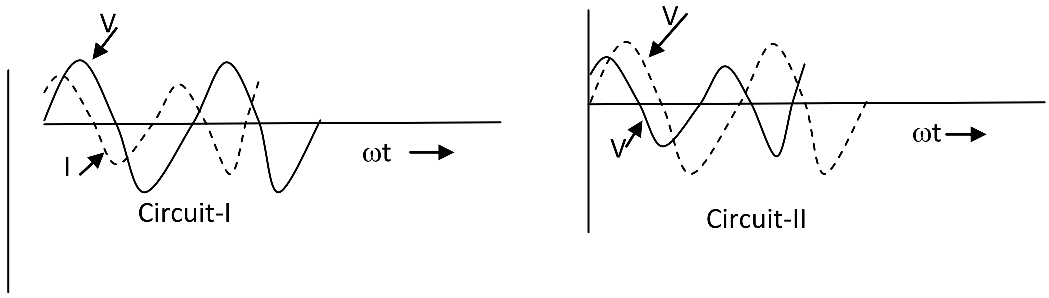
(ii) What will happen after some time?

Justify your answers.



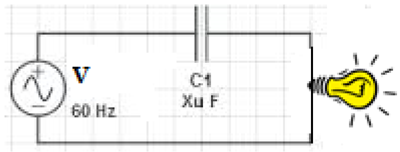
Q2. Define the term ‘power loss’ in a conductor of resistance R carrying a current I. In what form does this power loss appear? Show that to minimise the power loss in the transmission cables connecting the power stations to homes, it is necessary to have the connecting wires carrying current at enormous high values of voltage.

Q3. The following graphs depict the variation of voltage (V) and current (I) versus (ωt) for two different series LCR circuits.



State, giving reason, in which of the circuits capacitive impedance (XC) is (i) greater, (ii) smaller than the inductive impedance (XL).

Q4. A bulb is connected in series with a parallel plate capacitor as shown in figure. How does the brightness of bulb change when a dielectric slab is inserted between the plates parallel plate capacitor? Give reason.



Q5. Two identical loops, one of copper and another of iron, are rotated with same speed in the same magnetic field. In which case (i) emf (ii) current be more and why?

Q6. How is the mutual inductance of a pair of coils affected when

(i) separation between the coils is increased?

(ii) a thin iron sheet is placed between the two coils, other factors remaining the same?

Q7. A radio frequency choke is air cored coil whereas an audio frequency choke is iron cored. Give reasons for this difference.

Q8. A lamp is connected in series with a capacitor. Predict your observations for dc and ac connections. What happens in each case if the capacitance of the capacitor is reduced?

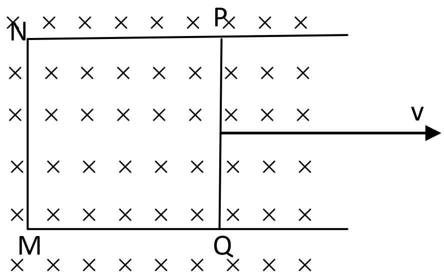
Q9. Briefly describe how electrical power is transmitted from a power house to a substation and eventually used by the consumers.

Q10. In a series LCR circuit, obtain the conditions under which (i) the impedance of the circuit is minimum and (ii) watt-less current flows in the circuit.

Q11. In an A.C. circuit, the instantaneous value of emf and current are E = 200 sin 314t Volts and I= sin (314t + π/3) . What is average power dissipation? **Ans:** 50W

Q12. "The Lentz's law supports the law of conservation of energy" Explain

Q13. A rectangular loop PQMN with movable arm PQ of length 15 cm and resistance 4Ω is placed in a uniform magnetic field of 0.25 T acting perpendicular to the plane of the loop as is shown in the figure. The resistances of the arms MN, NP and MQ are negligible. Calculate the (i) emf induced in the arm PQ and (ii) current induced in the loop when arm PQ is moved with velocity 25 m/s.



Hint: emf induced e = Bℓv =0.25x15x10^{-2} x 25 = 0.94V

Current I= e/R = 0.94/4 = 0.23A.

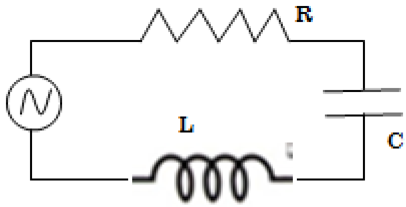
Q14.The figure shows a series LCR circuit connected to a variable frequency 220 V source with L = 80 mH, C = 50μF and R = 60 Ω.Determine

(i) the source frequency which derives the circuit in resonance;

(ii) the quality factor (Q) of the circuit.

Ans: (i) 500rad/s, 80Hz

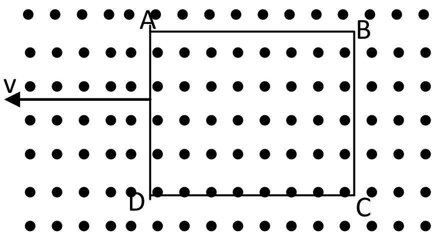
(ii) 0.67



Q15.A metallic square loop ABCD is moving in its own plane with velocity (v) in a uniform magnetic field (B) which is directed upward perpendicular to the plane of loop as shown in figure.

(i) Name the sides in which electric field / P.D. will be developed.

(ii) State the direction of current in the loop when it is passing out of given magnetic field.



Q16. The cross section of two solenoids A and B of equal length are same but number of turns in the solenoid A is double that of solenoid B. If coefficient of self-inductance of solenoid B is 6mH. What is self-inductance of solenoid 'A'? Ans: 24mH

Q17.Calculate the potential difference developed across axle of wheel of length 1.5m of train moving with speed 72km/h. Given that B_H = 0.4 x10^{-4}T and angle of dip= 30^0 at that place.

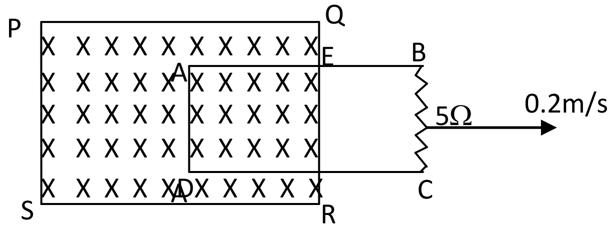
Q18.A capacitor of capacitance C farad is charged by a battery of emf V volt. The battery is disconnected across it so that a pure inductor of inductance L hennery is connected across it so that LC oscillations are set up. What will be the maximum value of current in the circuit?

Q19. A group of electric lamps having a total power rating of 900W is connected by an ac voltage V = 300 sin (314t + 60^0). What is rms value of current in the circuit? Ans: 6$\sqrt{2}$A

Q20.The coefficient of mutual inductance of two circuits A and B is 3mH and their respective resistances are 10Ω and 4Ω. How much current should change in 0.02s in the circuit A so that the induced current in B should be 0.006A? Ans: 0.16A

A21.A circuit ABCD is perpendicular to uniform magnetic field B = 5 x 10^{-2}T extending over the region PQRS and directed in the plane of paper. The circuit is pulled out with uniform speed 0.2m/s. Calculate the current in the 5Ω resistor and the direction of current during this time. Given that AD = 0.3m and AE = 0.4m

Ans: 0.6mA & current is clockwise in the circuit and B to C in the resistor.



SHORT ANSWER TYPE QUESTIONS: 3-MARKS

Q1. Deduce the expression for the average power dissipated in a series LCR circuit in terms of power factor. Hence show that average power dissipated at resonance is maximum.

Q2. A series L-C-R circuit is connected to an AC source. Using phasor diagram, derive the expression for impedance of the circuit. Plot a graph to show the variation of current with frequency of source, explaining the nature of variation.

Q3. Show that there is no power dissipation when an ideal inductor is connected with a.c.

Q4. Show that there is no power dissipation when an ideal capacitor is connected with a.c.

Q5. Distinguish between reactance and impedance. Sketch the graph showing the variation of impedance of LCR circuit with the frequency of applied voltage.

Q6. (a) An inductor L of inductance X_L is connected in series with a bulb B and an ac source. How would brightness of the bulb change when (a) number of turn in the inductor is reduced,

(b) An iron rod is inserted in the inductor and (c) a capacitor of reactance $X_C = X_L$ is inserted in series in the circuit. Justify your answer in each case.

Q7. (a) Show that the average power consumed in an inductor L connected to an a.c. source is zero.

(b) In a series LCR circuit, $X_L = R$ and the power factor of the circuit is P_1. When a capacitor with capacitance C such that $X_C = X_L$ is put in series, the power factor becomes P_2.

Find out P_1 / P_2.

Q8. You are given three circuit elements X, Y and Z. When the element X is connected across an a.c.source of a given voltage, the current and the voltage are in the same phase. When the element Y is connected in series with X across the source; voltage is ahead of the current in phase by $\pi/4$. But the current is ahead of the voltage in phase by $\pi/4$ when Z is connected in series with X across the source. Identify the circuit elements X, Y and Z.

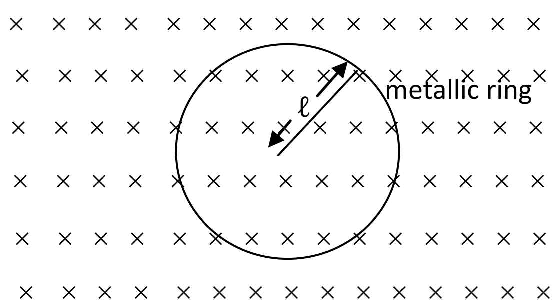
When all the three elements are connected in series across the same source, determine the impedance of the circuit.

Draw a plot of the current versus the frequency of applied source and mention the significance of this plot.

Q9. A metallic rod of length 'l' is rotated with a frequency 'v', with one end hinged at the centre and the other end at the circumference of a circular metallic ring, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere.

(a) Obtain the expression for the emf induced between the centre and the ring.

(b) Given that the rod has resistance 'R', then how much power will be generated?



Q10. A resistor of 100 Ω and a capacitor of $100/\pi$ μF are connected in series to a 220 V, 50 Hz a.c. supply.

(a) Calculate the current in the circuit.

(b) Calculate the (rms) voltage across the resistor and the capacitor. Do you find the algebraic sum of these voltages more than the source voltage? If yes, how do you resolve the paradox?

Q11. State Lenz's law. Illustrate, by giving an example, how this law helps in predicting the direction of the current in a loop in the presence of a changing magnetic flux.

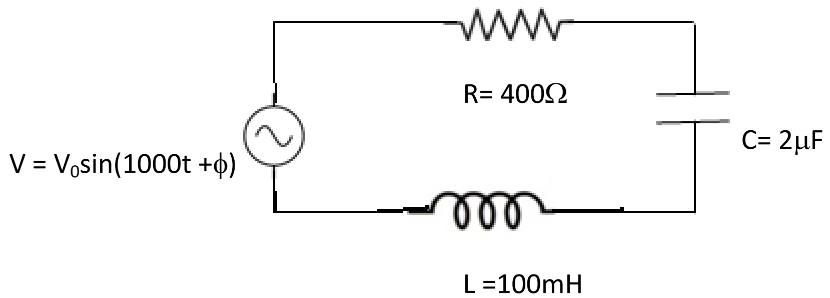
In a given coil of self-inductance of 5 mH, current changes from 4 A to 1 A in 30 ms. Calculate the emf induced in the coil.

Q12. A series LCR circuit is connected across an a.c. source of variable angular frequency 'ω'. Plot a graph showing variation of current 'i' as a function of 'ω' for two resistances R_1 and R_2 ($R_2 > R_1$). Answer the following questions using this graph:

(a) In which case is the resonance sharper and why?

(b) In which case is the power dissipation more and why?

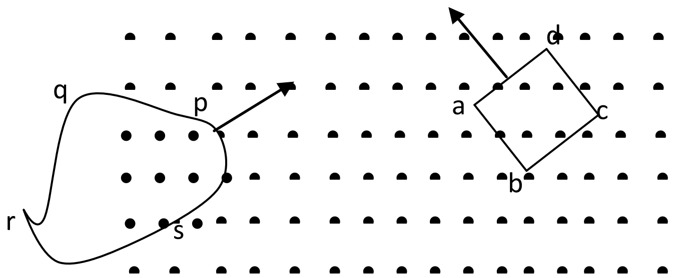
Q13. (a) Determine the value of phase difference between the current and the voltage in the given series LCR circuit.



(c) Calculate the value of the additional capacitor which may be joined suitably to the capacitor that would make the power factor of the circuit unity.

Q14. State Lenz's law. Describe a simple example to show that this law is in conformity with the principle of conservation of energy.

Using this law, predict, giving reasons, the directions of the induced currents in each of the two planar loops shown in the figure. The loop 'abcd' is moving out whereas the loop 'pqrs' is moving into the region of a uniform magnetic field directed normal to the planes of the loop and towards the reader.



Q15. A circuit contains inductor coil with L = 10H, capacitor of capacitance C = 40μF and resistor of resistance R = 60Ω. They are connected to ac source of 240V. Calculate

(i) The angular frequency of source which drives the circuit in resonance.

(ii) The current at the resonating frequency

(iii) The rms potential drop across the inductor at resonance.

Q16. A small town with a demand of 800kW of electric power at 220V is situated 15km away from an electric plant generating power at 440V. The resistance of the two wire line carrying power is 0.5 Ω/km. The town gets power from the line through a 4000-200V step-down transformer at a substation in the town.

(a) Estimate the line power loss in the form of heat.

(b) How much power must the plant supply, assuming there is negligible power loss due to leakage?

(c) Characterise the step- up transformer. NCERT

Q17. In a series LCR circuit, define the quality factor (Q) at resonance. Illustrate its significance giving one example. Show that power dissipated at resonance in LCR circuit is the maximum.

Q18. Derive the relationship between the peak and the rms value of current in an a.c. circuit.

Q19. An a.c source generating a voltage $V = V_m \sin\omega t$ is connected to a inductor of inductance L. Find the expression for the current (I), flowing through it, plot a graph of V and versus ωt to show that the voltage is $\pi/2$, ahead of the current.

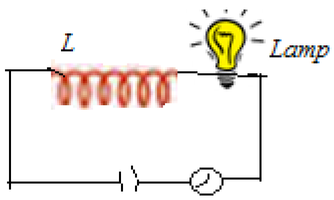
Q20. In series LCR circuit, the values of inductive reactance, capacitive reactance and resistance are 100Ω each. The inductor, capacitor and resistor are connected with a source of 100sin50t volt. Calculate the (i) net impedance of circuit (ii) maximum current in the circuit and (i) the maximum voltage across the capacitor. Ans: 100Ω, 1A, 100V

Q21. (i) Define mutual inductance.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil.**CBSE-2016-D**

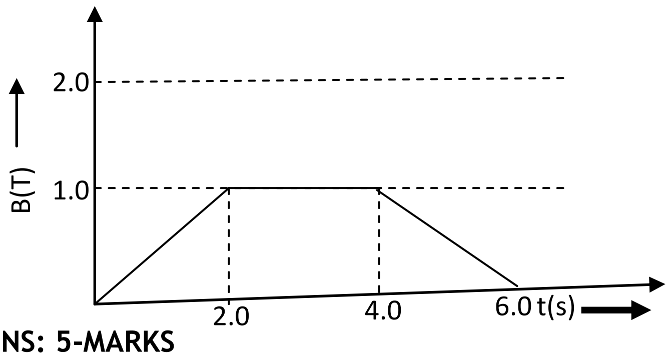
Q22.(i)When AC source is connected to an ideal inductor show that the average power supplied source over a complete cycle is zero.

(ii) A lamp is connected in series with an inductor and AC source. What happens to the brightness of the lamp when the key is plugged in and an iron rod is inserted inside the inductor? Explain**. All India-2016(C)**



Q23. Draw a schematic arrangement for winding of primary and secondary coils in a transformer with the two coils on separate limbs of the core. State its underlying principle and find the relation between the primary and secondary voltage in terms number of turns if the primary and secondary windings. How are the currents in the primary and secondary coils related to the voltages in the case of an ideal transformer? **CBSE-2016(E)**

Q24. The magnetic field through a single loop of wire, 12cm in radius and 8.5Ω resistance, changes with time as shown in the figure. The magnetic field is perpendicular to the plane of loop. Plot induced current as a function of time. **CBSE SQP-2016**



LONG ANSWER TYPE QUESTIONS: 5-MARKS

Q1. (a) Define mutual inductance and write its S.I. units.

(b) Derive an expression for the mutual inductance of two long co-axial solenoids of same length wound one over the other.

(c) In an experiment, two coils C_1 and C_2 are placed close to each other. Find out the expression for the emf induced in the coil C_1 due to a change in the current through the coil C_2.

Q2. (a) State Faraday's law of electromagnetic induction.

(b) Explain, with the help of a suitable example, how we can show that Lenz's law is a consequence of the principle of conservation of energy.

(c) Use the expression for Lorentz force acting on the charge carriers of a conductor to obtain the expression for the induced emf across the conductor of length l moving with velocity v through a magnetic field B acting perpendicular to its length.

Q3. (a) Using phasor diagram, derive the expression for the current flowing in an ideal inductor connected to an a.c. source of voltage, $v = v_0 \sin \omega t$. Hence plot graphs showing variation of (i) applied voltage and (ii) the current as a function of ωt.

(b) Derive an expression for the average power dissipated in a series LCR circuit.

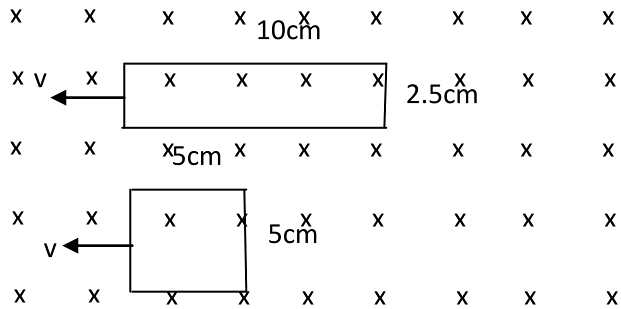
Q4. (a) Describe, with the help of a suitable diagram, how one can demonstrate that emf can be induced in a coil due to the change of magnetic flux. Hence state Faraday's law of electromagnetic induction.

(b) Two loops, one rectangular of dimensions 10 cm × 2·5 cm and second of square shape of side 5 cm are moved out of a uniform magnetic field $\vec{B}$ perpendicular to the planes of the loops with equal velocity v as is shown in the figure.

(i) In which case will the emf induced be more?

(ii) In which case will the current flowing through the two loops be less?

Justify your answer.



Q5. (a) State the principle of an a.c. generator.

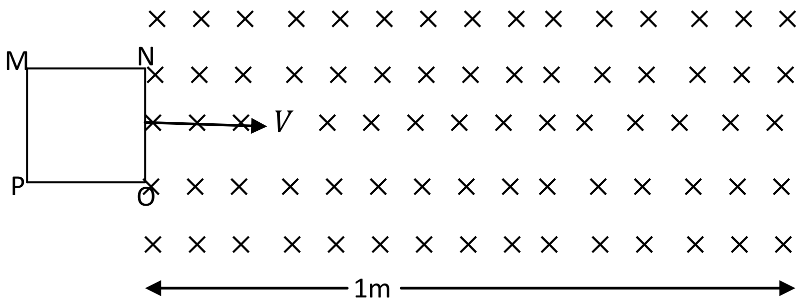
(b) Explain briefly, with the help of labelled diagram, its working and obtain the expression for the emf generated in the coil.

(c) Draw a schematic diagram showing the nature of the alternating emf generated by the rotating coil in the magnetic field during one cycle.

Q6. Draw a necessary arrangement for winding of primary and secondary coils in a step-up transformer. State its underlying principle and derive the relation between the primary and secondary voltages in terms of number of primary and secondary turns. Mention the two basic assumptions used in obtaining the above relation.

State any two causes of energy loss in actual transformers.

Q7. (a) Define self-inductance of a coil. Obtain an expression for the energy stored in a solenoid of self-inductance 'L' when the current through it grows from zero to 'I'. (b)A square loop MNOP of side 20 cm is placed horizontally in a uniform magnetic field acting vertically downwards as shown in the figure. The loop is pulled with a constant velocity of 20 cm s^{-1} till it goes out of the field.



(i) Depict the direction of the induced current in the loop as it goes out of the field. For how long would the current in the loop persist?

(ii) Plot a graph showing the variation of magnetic flux and induced emf as a function of time.

Q8. (a) Draw a schematic arrangement for winding of primary and secondary coil in a transformer when the two coils are wound on top of each other.

(b) State the underlying principle of a transformer and obtain the expression for the ratio of secondary to primary voltage in terms of the (i) number of secondary and primary windings and (ii) primary and secondary currents.

(c) Write the main assumption involved in deriving the above relations.

(d) Write any two reasons due to which energy losses may occur in actual transformers.

Q9. A metallic rod of length l and resistance R is rotated with a frequency v, with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius l, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere.

(a) Derive the expression for the induced emf and the current in the rod.

(b) Due to the presence of the current in the rod and of the magnetic field, find the expression for the magnitude and direction of the force acting on this rod.

(c) Hence obtain the expression for the power required to rotate the rod.

Q10. (a) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce a current which opposes the change of magnetic flux that produces it.

(b) The current flowing through an inductor of self-inductance L is continuously increasing. Plot a graph showing the variation of

(i) Magnetic flux versus the current

(ii) Induced emf versus dI/dt

(iii) Magnetic potential energy stored versus the current.

Q11. (a) Draw a schematic sketch of an ac generator describing its basic elements. State briefly its working principle. Show a plot of variation of

(i) Magnetic flux and

(ii) Alternating emf versus time generated by a loop of wire rotating in a magnetic field.

(b) Why is choke coil needed in the use of fluorescent tubes with ac mains?

Q12. (a) A series LCR circuit is connected to an a.c. source of variable frequency. Draw a suitable phasor diagram to deduce the expressions for the amplitude of the current and phase angle.

(b) Obtain the condition at resonance. Draw a plot showing the variation of current with the frequency of a.c. source for two resistances R_1 and R_2 ($R_2 > R_1$). Hence define the quality factor, Q and write its role in the tuning of the circuit.

Q13. (a) Draw a labelled diagram of a.c. generator and state its working principle.

(b) How is magnetic flux linked with the armature coil changed in a generator?

(c) Derive the expression for maximum value of the induced emf and state the rule that gives the direction of the induced emf.

(d) Show the variation of the emf generated versus time as the armature is rotated with respect to the direction of the magnetic field.

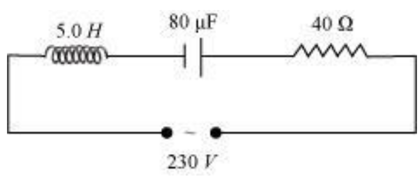
Q14. (a) Determine the source frequency which drives the circuit in resonance.

(b) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.

(c) Determine the rms potential drops across the three elements of the circuit.

(d) How do you explain the observation that the algebraic sum of the voltages across the three elements obtained in (c) is greater than the supplied voltage?

(e) What is quality factor of given LCR circuit at resonance?



Q15. (a) An a.c source generating a voltage $V = V_m \sin\omega t$ is connected to a capacitor of capacitance *C*. Find the expression for the current (I), flowing through it, plot a graph of V and *versus* ωt to show that the current is $\pi/2$, ahead of the voltage.

(b) A resistor of 200 Ω and a capacitor of 15 μF are connected in series to a 220 V, 50 Hz a.c source. Calculate the current in the circuit and the *rms* voltage across the resistor and the capacitor. Is the algebraic sum of these voltages more than the source voltage? If yes, resolve the paradox.

Q16.(a) Explain the meaning of mutual inductance of a solenoid S_1 with respect to the solenoid S_2. Consider two concentric circular coils, one of radius r_1 and the other of larger radius r_2 ($r << r_2$), placed coaxially with centres coinciding with each other. Obtain the expression for the mutual inductance of the arrangement.

(b) In an experimental arrangement of two coils C_1 and C_2 placed coaxially parallel to each other, find out the expression for the emf induced in the coil C_1 (of N_1 turns) corresponding to the change of current I_2 in the coil C_2 (of N_2 turns).

Q17. (i) An a.c. source of voltage V = V0 sin ωt is connected to a series combination of L, C and R. Use the phasor diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit in this condition called? **CBSE-2016-D**

(ii) In a series LR circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. Calculate P_1/P_2.

Q18. (i) Write the function of a transformer. State its principle of working with the help of a diagram. Mention various energy losses in this device.

(ii) The primary coil of an ideal step up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate

(a) number of turns in secondary

(b) current in primary

(c) voltage across secondary

(d) current in secondary

(e) power in secondary **CBSE-2016-D**

Q19.(i) Draw a labelled diagram of a step down transformer. State the principle of its working.

(ii) Express the tur ratio in the terms of voltages.

(iii)Find the ratio of primary and secondary currents in the terms of turn ratio in an ideal transformer.

(iv)How much current is drawn by the primary of a transformer connected to 220V supply when it delivers power to a 110V – 550W refrigerator? **Ans:2.5A All India-2016(C)**

Q20.(a)Explain the meaning of the term mutual inductance. Consider two concentric circular coils, one of radius r_1 and the other of radius r_2 ($r_1 < r_2$) placed coaxially with centres coinciding with each other. Obtain the expression for mutual inductance of the arrangement.

(b)A rectangular coil of area A, having number of turns N is rotated at ‘f’ revolutions per seconds in a uniform magnetic field B, the field being perpendicular to the coil. Prove that the maximum emf induced is $2\pi fNBA$. **All India-2016(C)**

VALUE BASED QUESTIONS:

Q1. Shoma was trying to heat water by means of immersion rod (connected directly to the main power supply) in a glass vessel containing water. As she tried to put her finger into the water to check if the water was warm enough, her teacher cautioned her against doing it. Based on the above information, answer the following questions:

(i) What value did Shoma’s teacher display by giving this advice?

(ii) Why is it considered dangerous to touch water when current is being passed into it? Will it be safer if Shoma had used distilled water?

(iii) Give an example where you have displayed or observed someone else displaying similar value in real life situation.

Q2. During a thunderstorm the live wire of the transmission line fell down on the ground from the poles in the street. A group of boys, who passed through, noticed it and some of them wanted to place the wire the side. As they were approaching the wire and trying to lift the cable, Anuj noticed it and immediately pushed them away, thus preventing them from touching the live wire. During pushing some of them got hurt. Anuj took them to doctor to get them medical aid.

Based on above paragraph, answer the following questions:

(a) Write two values which Anuj displayed during the incident.

(b) Why is it that bird can sit on a suspended live wire without any harm whereas touching it on the ground can give a fatal shock?

(c) The electric power from power plant is setup to very high voltage before transmitting it to distant consumers. Explain, why?

Q3. A group of students while coming from the school noticed a box marked “Danger H.T. 2200 V” at a substation in the main street. They did not understand the utility of such a high voltage, while they argued; the supply was only 220 V. They asked their teacher this question the next day. The teacher thought it to be an important question and therefore explained to the whole class.

Answer the following questions:

(a) What device is used to bring the high voltage down to low voltage of a.c. current and what is the principle of its working?

(b) Is it possible to use this device for bringing down the high dc voltage to the low voltage? Explain.

(c) Write the values displayed by the students and the teacher.

Q4. Sunita and her friends visited an exhibition. The policeman asked them to pass through a metal detector. Sunita’s friends were initially scared of it. Sunita, however, explained to them the purpose and working of the metal detector.

Answer the following questions:

(a) On what principle does a metal detector work?

(b) Why does the detector emit sound when a person carrying any metallic object walks through it?

(c) State any two qualities which Sunita displayed while explaining the purpose of walking through the detector.

Q5. Ajit had a high tension tower erected on his farm land. He kept complaining to the authorities to remove it as it was occupying a large portion of his land. His uncle, who was a teacher, explained to him the need for erecting these towers for efficient transmission of power. As Ajit realized its significance, he stopped complaining. Answer the following questions:

(a) Why is it necessary to transport power at high voltage?

(b) A low power factor implies large power loss. Explain.

(c) Write two values each displayed by Ajit and his uncle.

Q6. Hari is a student of Class X in a school near his village. His uncle gifted him a bicycle with a dynamo fitted in it. He was thrilled to find that while cycling during night, he could light the bulb and see the objects on the road clearly. He, however, did not know how this device works. He asked this question to his teacher. The teacher considered it an opportunity and explained the working of a dynamo to the whole class. Answer the following questions:

(a) State the principle and working of a dynamo.

(b) Write two values each displayed by Hari and his Science teacher.

Q7. One morning an old man walked bare-foot to replace the fuse wire in kit fitted with the power supply mains for his house. Suddenly he screamed and collapsed on the floor. His wife cried loudly for help. His neighbour's son Anil heard the cries and rushed to the place with shoes on. He took a wooden baton and used it to switch off the main supply.

Answer the following questions:

(i) What is the voltage and frequency of mains supply in India?

(ii) These days most of the electrical devices we use require a.c. voltage. Why?

(iii) Can a transformer be used to step up d.c. voltage?

(iv) Write two qualities displayed by Anil by his action.

Q8.Shiv had a high tension tower erected on his form land. He kept complaining to the authorities to remove it since it occupied a large portion of his land. His uncle, who was a teacher, explained to him the need for erecting these towers for efficient transmission of power. As shiv got convinced and realized its significance, he stopped complaining.

Based on the above paragraph, answer the following questions;

(a)Why is it necessary to transport power at high voltages?

(b) 'A low power factor implies large power loss'. Explain.

(c) Write two values displayed by Shiv and his uncle.**CBSE-2016(E)**

Q9.Ram is a student of class-X in a village school. His uncle gifted him a bicycle with a dynamo fitted in it. He was very excited to get it. While cycling during night, he could light the bulb and see the object the objects on the road. He, however, did not know this device works. He asked this question to his teacher. Teacher considered it an opportunity to explain the working to the whole class.

Answer the following questions:

(a) State the principle and working of a dynamo

(b) Write two values each displayed by Ram and his school teacher. **All India-2016(C)**

ANSWER KEY TO VERY SHORT ANSWER TYPE QUESTIONS: 1-MARK

A1. It is the opposition offered by a capacitor on passing a.c. through it. Its S.I. unit is Ω

A2. It is measure of the sharpness of resonance. It has no unit.

A3.A current is said to wattless if average power consumed over one complete cycle of a.c. is zero.

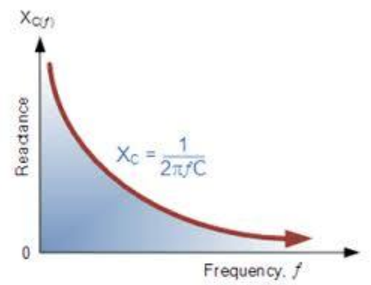
A4. The self-inductance of the coil is numerically equal to magnetic flux linked with it when unit current flow through it. Its S.I. unit is Henery, volt-second/ ampere, Weber/ampere

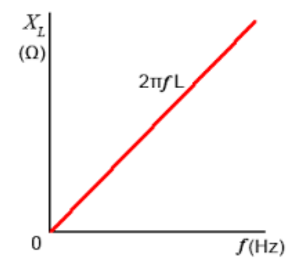
A5. No induced current, no question of direction

A6. Power factor = 1, it is the case of resonance of LCR circuit.

A7. Capacitive as current is leading the voltage by $\pi/2$.

A8. Variation of capacitive reactance with frequency:





A9. Variation of inductive reactance with frequency second figure above

A10. Current Q to P in first coil, and C to D in second coil.

A11. Choke controls a.c. without much(very less loss) loss of energy.

A12. When current is switched off, a large induced emf appears across the bulb making it to glow brightly for a moment. When stored energy is dissipated, the bulb stops glowing.

A13. Phase difference: Zero since it is condition of resonance.

A14. Clockwise.

A15.B has positive polarity.(We assume to connect a cell's terminal as per the direction (anti-clock wise)of flow of current, the plate which is connected to positive terminal of cell, will be positive.

A16. Glass bob because there is no electromagnetic induction due to presence of Earth's magnetic field, unlike in the case of metallic ball.

A17. Due to production of eddy current.

A18. No change because the source of current is d.c.

A19. Power factor = $\cos\phi = ½ \Rightarrow \phi = 60^0$

A20. Average value of a.c. = $0.637V_0$

A21.X-is a Capacitor, Reactance $X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C}$

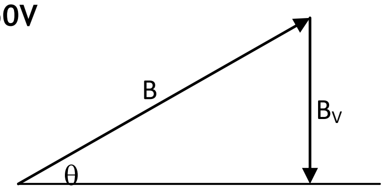
A22. Induced emf = B_H L v = B cosδ × L × $\sqrt{2gH}$

A23.(i) High permeability **(ii)** Low coericivity

A24. Yes, because $V_C + V_L = I(X_C + X_L) = I\left(\frac{1}{\omega C} + \omega L\right)$ hence voltage drop across C and L depend upon frequency of ac which may exceed the applied voltage.

A25. Power dissipation = ½ $I_0.V_0$ cosϕ = ½ × 10 x200 = 1000W

A26. V = $\sqrt{{V_R}^2 + (V_L - V_C)^2}$ = $\sqrt{(40)^2 + (50-20)^2} = \sqrt{2500}$ = **50V**



A27. Plate M is positive.

A28. Cosϕ = R/Z = 10/20 = ½ ⇒ ϕ = 60^0

A29. Voltmeter V_2 because at resonance $V_L - V_C = 0$

A30. Since emf is induced due to vertical component of Earth's magnetic field

Sinθ = Bv/B ⇒ B_V = Bsinθ

Induced emf = Bv ℓv = Bℓv sinθ

A31. Change in flux = BA- (-BA) = 2BA

A32. Anticlockwise.

A33.Downward

A34. $B = \frac{\mu_0 I}{2r} = \frac{\mu_0\, q\, n}{2r} \Rightarrow q = \frac{2Br}{\mu_0 n}$

ANSWER KEY SHORT ANSWER TYPE QUESTIONS: 2-MARKS

A1. Bulb B, because there will be additional opposition in the beginning due to self-induction phenomenon.

(ii) Both bulbs glow with equal brightness since ohmic resistance is same and there will be no self-induction.

A2. Electric energy lost per second in the resistor, is called power loss.

Power loss appears in the form of heat / e.m. radiations

Let V be the voltage across 'R' and I be the current through it, then P = VI ⇒ I = P/V

Power dissipated in the cable H = $I^2R = \frac{P^2R}{V^2} \Rightarrow P \propto \frac{1}{V^2}$

Hence energy transmission at high voltage minimise the power loss.

A3. (i)In first circuit $X_C > X_L$ since current is leading.

(ii)In second circuit $X_c < X_L$ since current is lagging the voltage.

A4. Brightness increases because capacitive reactance X_C (= $\frac{1}{\omega kC}$) deceases as the capacitance of capacitor increases on introduction of dielectric slab.

A5.(i) emf will be equal in both the loops.

(ii)Current will be more in copper loop because its resistance is lower than that of iron.

A6. Mutual induction (i) decreases (i) no mutual induction because the magnetic field lines get confined in the iron sheet.

A7. Inductive reactance is directly proportional to frequency of source. Frequency of radio waves is much higher than audio signals. The air cored choke coils provide sufficient reactance to radio frequencies but to increase reactance of choke coils for audio frequencies they are iron cored.

A8. No effect if capacitor is connected to d.c because dc is blocked by capacitor.

Brightness decreases if capacitor is connected to ac and its value is reduced. On reducing capacitance of capacitor the value of capacitive reactance (X_C) increases.

A9. Electrical power is transmitted to substation by using step up transformer at higher voltage to reduce the transmission loss of power.

From substations to consumers it is transmitted by using step down transformer at low voltage.

A10. (i) The impedance of circuit is minimum at resonance because at resonance $X_L = X_C$ so the impedance become just equal to resistance of circuit.

(ii) For wattless current to flow the value of resistance R should be zero.

A11. Induced emf = $B\ell v = 0.25 \times 15 \times 10^{-2} \times 25 = 0.94V$

Current $I = e/R = 0.94/4 = 0.23A$

A12. Average power dissipation = $I_{rms}V_{rms}\cos\phi = \frac{1}{2} \times 200 \times 1 \times \cos 60^0 = 50W$

A13. As per the Lenz's law the direction of induced emf/ current is such that is oppose the cause which is producing it. Hence the work is done against repulsion or attraction by external agency. This work done appears in the circuit in the form of energy (Electricity). So work done is converted into energy.

A14. $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{80 \times 10^{-3} \times 50 \times 10^{-6}}} = \frac{1}{\sqrt{40\,0 \times 10^{-8}}} = 500 rad/s$

Quality factor $Q = \frac{\omega_r L}{R} = \frac{500 \times 80 \times 10^{-3}}{60} = 0.67$

A15. In sides AD and BC but not in sides AB and CD since they are parallel to magnetic field.

Direction of current in the loop 'anticlockwise' when it is coming out of magnetic field.

A17. P.D. = $(B_V \tan\delta)\ell v$

$= 0.4 \times 10^{-4} \times \frac{1}{\sqrt{3}} \times 1.5 \times 20 = 0.4\sqrt{3} \times 10^{-3}V$

A18. We know that $\frac{1}{2} L I_0^2 = \frac{1}{2}CV^2$

$$I_0 = \sqrt{\frac{C}{L}}V$$

A19. $P = V_{rms} I_{rms} \cos\phi \Rightarrow 900 = \frac{300}{\sqrt{2}} \times I_{rms} \times \frac{1}{2}$

$I_{rms} = 6\sqrt{2}A$

A20. Induced emf in circuit B = $IR = 6\times10^{-3} \times 4 = 24\times10^{-3}$ V

$\therefore\ M\frac{dI}{dt} = 24 \times 10^{-3}$

$dI = \frac{24 \times 10^{-3} \times 0.02}{3 \times 10^{-3}} = 0.16A$

A21. $I = B\ell v/R = (5 \times 10^{-2} \times 0.3 \times 0.2)/5 = 0.6mA$

Current clockwise and B to C in the resistor.

ANSWER KEY SHORT ANSWER TYPE QUESTIONS: 3-MARKS

A1. Instanteneous voltage $V = V_0 \sin\omega t$

$I = I_0 \sin(\omega t + \phi)$

Instantaneous power 'P' supplied by the source P = VI

$= V_0 \sin\omega t \, I_0 \sin(\omega t + \phi) = \frac{V_0 I_0}{2}[\cos\phi - \cos 2(\omega t + \phi)]$

Average power over one complete cycle

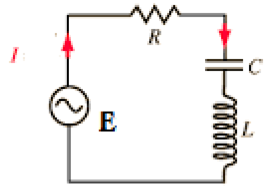
$P = \frac{V_0 I_0}{2}\cos\phi$ (because the power of time dependent term is zero)

$= \frac{V_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}} \cos\emptyset = V_{rms} I_{rms} \cos\phi$

At resonance V and I are in same phase i.e. $\phi = 0^0$ so $\cos\phi = 1$

$P = V_{rms} I_{rms}$ which is maxium.

A2. Instantaneous Voltage: $E = E_0 \sin \omega t$



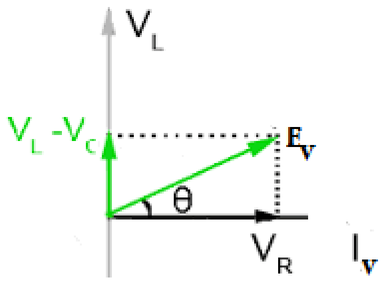
E_V : r.m.s. value of applied voltage

I_V : r.m.s. value of the current in the circuit.

$E_R = V_R = I_V R$ -- where V_R and I_v are in same phase

$E_V = V_L = I_V X_L$ -- leading the current I_V in phase by $\pi/2$

$E_C = V_C = I_V X_C$ -- lagging the current in phase by $\pi/2$



If we consider $V_L > V_C$ so net potential drop across L -C is $V_L - V_C$

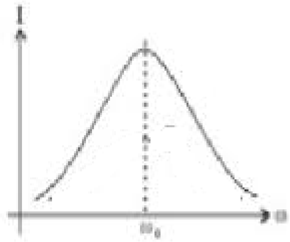
∴ **The applied voltage E_V is the phasor sum of the voltage drops V_R and $(V_L - V_C)$**

$$E_V = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{(I_v R)^2 + (I_V X_L - I_V X_C)^2}$$

$$= I_V \left(\sqrt{R^2 + (X_L - X_C)^2}\right)$$

$$\frac{E_V}{I_V} = \sqrt{R^2 + (X_L - X_C)^2}$$

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



As the source frequency approaches the frequency of LCR circuit, the impedance of circuit decreases and the current increases. The current become maximum at resonance because the impedance of circuit is minimum at resonance. After the resonance the impedance of circuit increases with increase of frequency so current decreases.

A3. Average power dissipated in inductor:

Instantaneous voltage **E** $= E_0 \sin \omega t$

Instantaneous current $I = I_0 \sin(\omega t - \pi/2) = -I_0 \cos \omega t$

Instantaneous power $p = E.I = (E_0 \sin \omega t)(-I_0 \cos \omega t) = -\frac{E_0 I_0}{2} \sin 2\omega t$

∴ Average power P = Average power over complete cycle

$$= \frac{1}{T}\int_0^T -\frac{E_0 I_0}{2}\sin 2\omega t.dt = 0$$

Hence average power consumed by ideal inductor is zero.

A4. Average power dissipated in Capacitor:

Instantaneous voltage **E** = $E_0 \sin(\omega t-\pi/2) = -E_0 \cos\omega t$

Instantaneous current I = $I_0 \sin\omega t$

Instantaneous power p = E.I = $-E_0 \cos\omega t . I_0 \sin\omega t = -\frac{E_0 I_0}{2}\sin 2\omega t$

∴ Average power P = Average power over complete cycle

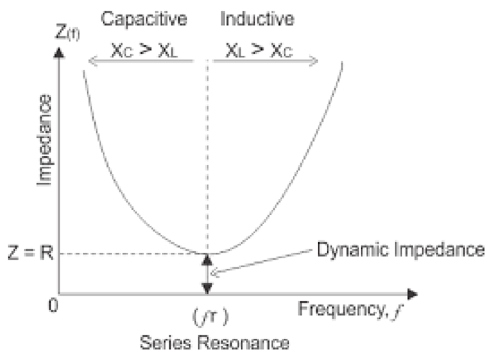
$$= \frac{1}{T}\int_0^T -\frac{E_0 I_0}{2}\sin 2\omega t.dt = 0$$

Hence average power consumed by ideal capacitor is zero.

A5. Difference between Resistance and Reactance:

S.No.	Reactance	Impedance
1	It is the opposition offered by capacitor or inductor	It is the effective opposition offered by circuit containing L, C and R
2	No power dissipation in pure reactance because voltage and current are at the phase difference of $\pi/2$	There is power dissipation as per relation $V_{rms}I_{rms}\cos\phi$, where ϕ is phase difference between voltage and current.

Variation of Impedance with frequency



A6.(a) Increases

$X_L = \omega L$

As the number of turns decreases, L decreases hence current through bulb increases /Voltage across bulb increases.

(b)Decreases

Iron rod increases the inductance which increases X_L, hence current through the bulb decreases/ voltage across bulb decreases.

(c)Increases

Under this condition ($X_C = X_L$) the current through the bulb will be maximum / increase.

A7.(a) For an ideal inductor connected to ac source

V = $V_0 \sin\omega t$ and current I = $I_0 \sin(\omega t-\pi/2)$

$$P_{avg} = \frac{1}{T}\int_0^T V_0 I_0 \sin\omega t.\cos\omega t.dt$$

$$= \frac{1}{T}\frac{V_0 I_0}{2}\int_0^T \sin 2\omega t.dt$$

$= \frac{1}{T}\frac{V_0 I_0}{2}\left[\frac{2\cos\omega t}{2\omega}\right]_0^T = 0$

(b) Power factor $\cos\phi = R/Z$

For LR circuit $X_L = R$

$Z = \sqrt{R^2 + R^2} = R\sqrt{2}$

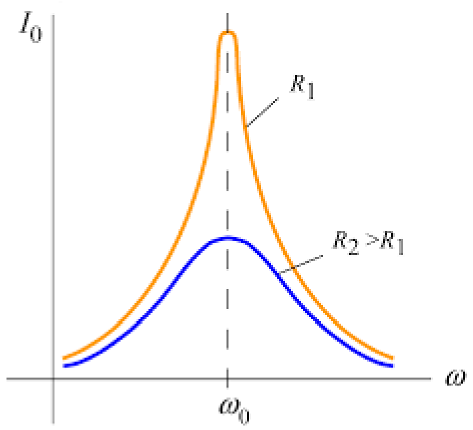
Power factor $P_1 = \cos\phi = \frac{R}{R\sqrt{2}} = 1/\sqrt{2}$

For LCR circuit $X_L = X_C$

$Z = \sqrt{R^2} = R$

Power factor $P_2 = R/R = 1$

$\Rightarrow \frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$



A8. Identification of elements

X- Resistor

Y- Inductor

Z- Capacitor

Impedance Z =R since $X_L = X_C$

(Only one curve is expected)

Significance, at $\omega = \omega_0$ (resonance frequency) current is maximum

(Alternatively: Gives information about sharpness of resonance or quality factor of the circuit

A9. **(a)** Induced emf $= \int_0^{\ell} B\omega r\,dr$

$e = \frac{1}{2} B\omega \ell^2$

$= \pi B \nu \ell^2$ (since $\omega = 2\pi\nu$)

(c) Powe $P = \frac{e^2}{R} = \frac{(\pi B \nu \ell^2)^2}{R} = \frac{\pi^2 B^2 \nu^2 \ell^4}{R}$

A10.(i) Current in the circuit $I = \frac{V}{\sqrt{R^2 + X_c^2}}$

Here $X_C^2 = \left(\frac{1}{C\omega}\right)^2 = \left(\frac{1}{\frac{100}{\pi}\times 10^{-6}\times 2\pi \times 50}\right)^2 = (100)^2 \Rightarrow X_C = 100$

$I = \frac{220}{\sqrt{100^2 + 100^2}} = \frac{2.2}{\sqrt{2}} = 1.55A$

(b)Voltage across the resistor V_R = 100x1.55 = 155V

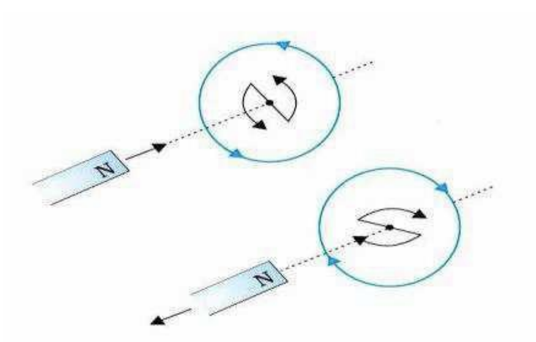
Voltage across capacitor V_C = 100 x 1.55 = 155V

Yes, sum of two voltages is greater than 220V but voltage across resistor and capacitor are not in phase.

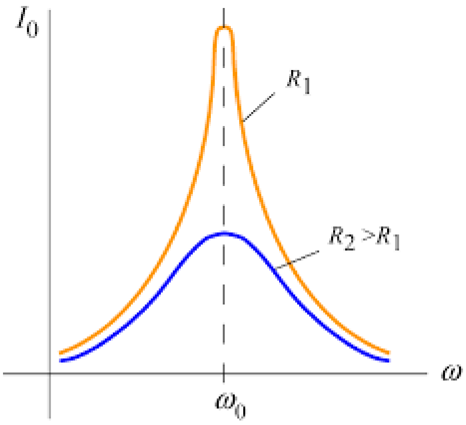
A11. Lenz"s law applies to closed circuit determining the direction of induced current states "The induced emf will appear in such a direction that it opposes the change that produced it."

When north pole of a magnet is brought towards a loop, the current is induced in anticlockwise direction. So there will be repulsion due to production of N-pole.

When north pole is moved away from the loop, the induced current in the loop will be in clockwise direction. So there will be attraction due to production of S-pole.



$|e| = L\frac{dI}{dt}$ = **5x 10^{-3} x $\frac{4-1}{30\times10^{-3}}$ = 0.5V**



A12. (a)Sharper for R = R_1

Sharpness of resonance = $\frac{\omega_0 L}{R} \alpha \frac{1}{R}$

(b) More power dissipation for R = R_1

At Resonance, power dissipation = $\frac{V^2}{R} \alpha \frac{1}{R}$ (for same V)

A13. Phase difference= tanϕ = $\frac{X_L - X_c}{R}$ = $\frac{\omega L - \frac{1}{\omega C}}{R}$

$X_L = \omega L$ = 1000x100x 10^{-3} = 100Ω

$X_C = \frac{1}{\omega C} = \left(\frac{1}{1000\times2\times10^{-6}}\right)$ = 500Ω

tanϕ = $\frac{500-100}{400}$ = 1

ϕ = 45^0

(b)When power factor = 1, we have $X_L = X_C$

$X_C' = \frac{1}{\omega C'}$ = 100Ω ⇒ C' = 10μF

Therefore we need to add additional capacitor of capacitance (10-2) μF = 8μF

A14. The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.

This law is in conformity with the principle of conservation of energy; consider a situation where induced current is in the direction opposite to that given by lenz's law. Then in this situation kinetic energy will continuously increase without expanding any energy and hence one can construct a perpetual motion machine by a suitable arrangement, which violates the conservation of energy.In irregular loop induced current will be in the sense. psrqp, as induced current will oppose the increase in magnetic flux.(Clock -wise)

In other loop, induced current will be in the sense abcda, as the induced current will oppose the decrease in magnetic flux.(Anticlock-wise)

A15.(i) ω = $\frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10\times40\times10^{-6}}}$ = 50rad/s

(ii)At resonance Z=R

I = V/R = 240/60 = 4A

(iii)$V_L = IX_L = I\omega L$ = 4 x 50x10 = 2000V

A16. Line resistance = length of two wire line x resistance per unit length = 2x15x0.5 = 15Ω

Voltage at which power is sent through the line = 4000V

Power supplied to town sub-station = 800kW = 8×10^5W

rms value of current in the line = $\frac{Power}{Voltage} = \frac{8 \times 10^5}{4000}$ = 200A

(a) Line power loss = $I^2R = (200)^2 \times 15$ = 600kW

(b) Power supplied by the plant = power received by sub-station + power loss

= 800 + 600 = 1400kW

(c) Voltage drop on the line = IR = 200x15 = 3000V

Voltage output of step up transformer at the plant = 4000 + 3000 = 7000V

Step up transformer at plant is 440-7000V

A17. Q-Factor of LCR circuit: The Q factor of a series resonant LCR circuit is an indicator of the sharpness of tuning at resonance. It is defined as the ratio voltage drop across L (or C) to voltage across R (applied voltage) at resonance.

$$Q = \frac{I X_L}{IR} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Significance: The value of Q – is large for low value of R and C or for large value of L. This means that the series resonant circuit will be more selective.

Power dissipation at resonance: At resistance Z = R and cosϕ = 1 so the current will be maximum at resonance

Power dissipation: I^2 R will be maximum.

A18. Relation between I_{rms} and I_0

$I = I_0 \sin \omega t$

Heat produced in resistance R for small time dt

$dH = I^2 R\, dt = (I_0 \sin \omega t)^2 = I_0{}^2 R \sin^2 \omega t$

Heat produced in complete cycle in time 'T'

$$H = \int_0^T dH = \int_0^T I_0{}^2 R \sin^2 \omega t\, dt = I_0{}^2 R \int_0^T \left(\frac{1-\cos 2\omega t}{2}\right) dt = \frac{I_0{}^2 R T}{2} \quad \text{--- (1)}$$

If I_V is the (or r.m.s.) value of ac , then heat produced in R in the same time (0 to T) is given by;

$H = I_V{}^2 R T$ ----(2)

From equation (1) and (2)

$I_V = I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707\, I_0$

Similarly $E_V = E_{rms} = 0.707\, E_0$

A19. A.C. Circuit containing Inductance only:

The applied alternating Voltage $E = E_0 \sin \omega t$ ---(1)

If I is the current in the circuit and dI/dt is the rate of change of current at that instant, then induced emf in L = ε = - LdI/dt. As applied voltage (E) is equal and opposite to induced emf at every instant if the inductor has zero resistance ;

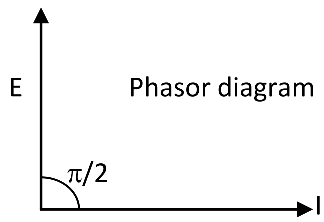
$\therefore$ E = - (- L $\frac{dI}{dt}$) = L $\frac{dI}{dt}$

$E_0 \sin \omega t = L \frac{dI}{dt}$

$dI = \frac{E_0}{L} \sin \omega t$, on integration both side

$I = \frac{E_0}{\omega L} (-\cos\omega t)$

$I = \frac{E_0}{\omega L} \sin(\omega t - \pi/2)$,



The current (I) will be maximum (I_0) for sin (ωt- π/2) = 1 , hence $I_0 = E_0 / \omega L$

$\therefore I = I_0 \sin(\omega t - \pi/2)$ ---(2)

From equation (1) and (2) , it is clear that voltage is leading the current in phase by π/2

A20.(i) $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(100)^2 + (100-100)^2} = 100\Omega$

(ii) Max. Current $I_0 = V_0/Z = 100/100 = 1A$

(iii)Voltage across capacitor = IX_C = 1x100 = 100V

A24.$\varepsilon = -\frac{d\phi}{dt}$ = - 0.023V

I = ε/R = -2.7mA for 0< t<2s.

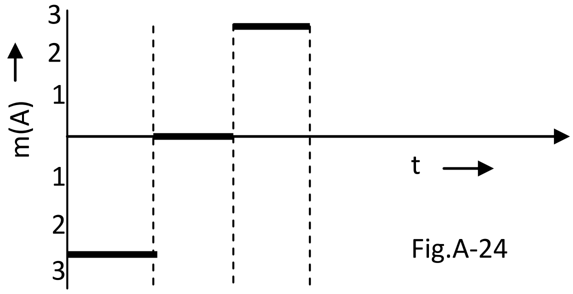


Fig.A-24

	0<t<2s	2<t<4s	4<t<6s
ε (V)	-0.023	0	+0.023
I(A)	-2.7	0	+2.7

ANSWER KEY LONG ANSWER TYPE QUESTIONS: 5-MARKS

A1.(a)The magnetic flux linked with other coil when current I is passing in the first coil;

$\phi = MI$

If I = 1A then $\phi = M$

Mutual inductance of two coils is equal to the magnetic flux linked with one coil when a unit current is passes in the other coil.

Or $e = -M\frac{dI}{dt}$

The mutual inductance is also equal to the induced emf set up in one coil when the rate of change of current following through other coil is unity.

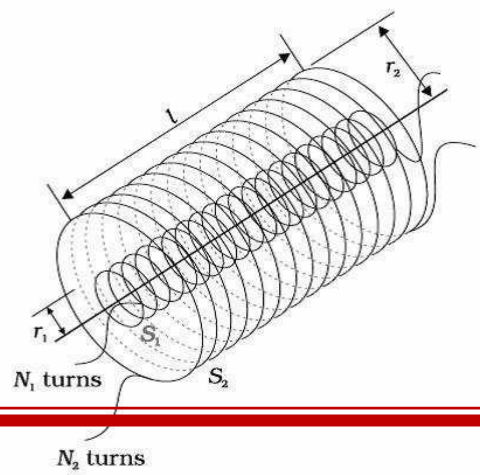
SI unit: Henery, Wb/A or Volt-second A^{-1} **(only one definition is sufficient)**

(b)Let a current I_2 flow through S_2.This sets up a magnetic fluxϕ_1 through each turn of the coil S_1.

Total flux linked with S_1

$N_1\phi_1 = M_{12} I_2$ .... (i)

where M_{12} is the mutual inductance between the two solenoids



Magnetic field due to the current I_2 in S_2 is

$= \mu_0 n_2 I_2$

Therefore, resulting flux linked with S_1.

$N_1 \phi_1 = [(n_1 \ell \pi\ r_1^2)][\mu_0 n_2 I_2]$............ (ii)

Comparing (i) & (ii), we get

$M_{12} I_2 = [(n_1 \ell \pi\ r_1^2)][\mu_0 n_2 I_2]$

$M_{12} = \mu_0 n_1 n_2\ \pi\ r_1^2 \ell$

(c) Magnetic flux be linked with coil C1 due to current in coil

We have : $\phi_1 \propto I_2$

$\Rightarrow \phi 1 = M I_2$

$\frac{d\phi_1}{dt} = M \frac{dI_2}{dt}$

$\Rightarrow e = - M \frac{dI_2}{dt}$

A2. Faraday‟s law - “The magnitude of the induced emf in a circuit is equal to the time rate of change of magnetic flux through the circuit.”

Induced emf $= -\frac{d\phi}{dt}$

(b) A bar magnet experiences a repulsive force when brought near a closed coil and attractive force when moved away from the coil, due to induced current. Therefore, external work is required to be done in the process.

(c) Since work done is moving the charge „q‟ across the length „l‟ of the conductor is

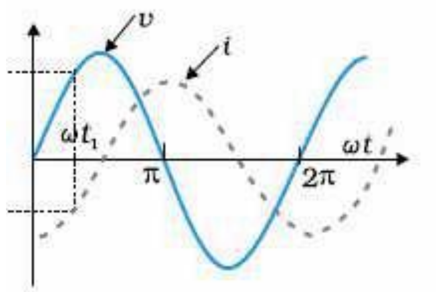
$W = qvB\ell$

Since emf is the work done per unit charge

$e = \frac{W}{q}$

$e = B \ell v$

A3 Graph showing variation of voltage and current as function of ωt.



The applied alternating Voltage $V = V_0 \sin \omega t$ ---(1)

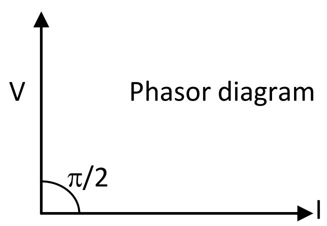
If I is the current in the circuit and dI/dt is the rate of change of current at that instant, then induced emf in $L = \varepsilon = - L dI/dt$. As applied voltage (E) is equal and opposite to induced emf at every instant if the inductor has zero resistance;

$\therefore\ V = -\left(-L\frac{dI}{dt}\right) = L\frac{dI}{dt}$

$V_0 \sin \omega t = L\frac{dI}{dt}$

$dI = \frac{V_0}{L} \sin \omega t$, on integration both side

$I = \frac{V_0}{\omega L}(-\cos\omega t)$



$I = \frac{V_0}{\omega L} \sin(\omega t - \pi/2)$,

The current (I) will be maximum (I_0) for $\sin(\omega t - \pi/2) = 1$, hence $I_0 = E_0 / \omega L$

$\therefore I = I_0 \sin(\omega t - \pi/2)$ ---(2)

From equation (1) and (2) , it is clear that voltage is leading the current in phase by $\pi/2$.

Average Power Dissipation in LCR circuit:

Let $X_L > X_C$ in ac circuit containing L,C and R;

The voltage and current equations will be ;

V = $V_0 \sin \omega t$ and Current $I = I_0 \sin(\omega t - \phi)$

Instantaneous power, $p = VI = (V_0 \sin \omega t)[I_0 \sin(\omega t - \phi)]$

$= V_0 I_0 \sin\omega t\, [\sin\omega t.\cos\phi - \cos\omega.\sin\phi]$

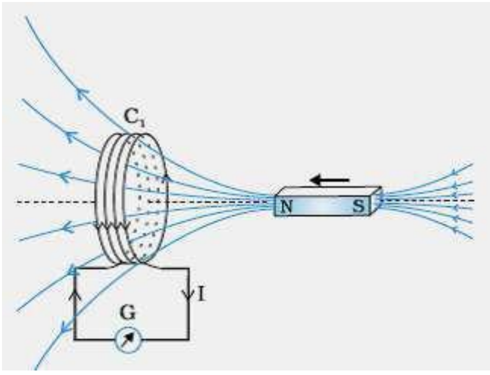
$= V_0 I_0\, [\sin^2 \omega t \cos\phi - \sin\omega t.\cos\omega t.\sin\phi]$

$= \frac{1}{2} V_0 I_0\, [1 - \cos 2\omega t)\cos\phi - \sin 2\omega t.\sin\phi]$

$= \frac{1}{2} V_0 I_0\, [\cos\phi - (\cos 2\omega t.\cos\phi + \sin 2\omega t \sin\phi)]$

$= \frac{1}{2} V_0 I_0\, [\cos\phi - \cos(2\omega t - \phi)]$

$= \frac{1}{2} V_0 I_0 \cos\phi - \frac{1}{2} E_0 I_0 \cos(2\omega t - \phi)$



$\therefore$ Average power dissipated over complete cycle;

$P_{av} = \frac{1}{2} V_0 I_0 \cos\phi - 0$ (this term is time dependent so its average is zero.)

$= \frac{V_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}} \cos\phi$

$\mathbf{P_{av} = V_{rms} \,.\, I_{rms} \cos\phi}$

A4. (a) When the bar magnet moves towards the coil, connected to a Galvanometer. The Galvanometer shows a deflection. This is due to change in the magnetic field/flux, linked with the coil. This shows that an emf is induced.

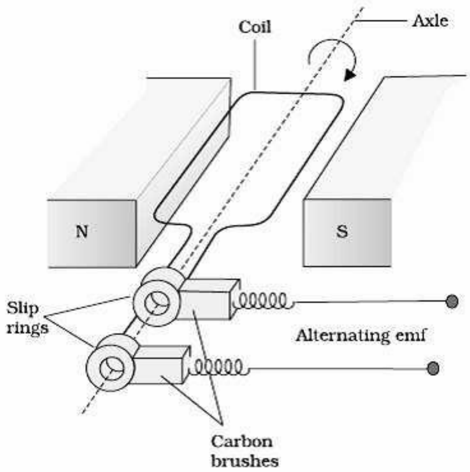
The magnitude of emf induce is directly proportional to the rate of change of magnetic flux in the circuit.

$e = -\frac{d\phi_E}{dt}$

b) (i) the emf induced $e = - B\ell v$

Emf will be more in case of square loop as the side perpendicular to the velocity is longer as compared to the rectangular loop.

(ii) Current will be less in rectangular loop, as it has more resistance and less induced emf.



A5. Principle: Whenever magnetic flux linked with a coil changes, an emf is setup in the coil.

Working

When the coil is rotated with constant angular speed ω , the angle between magnetic field vector B and area vector A of the coil changes at any instant

$\theta = \omega t$

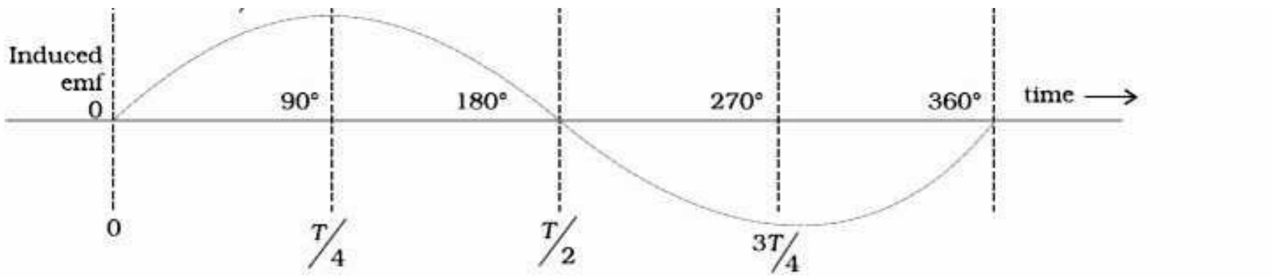
Magnetic flux at any time **'t'**

ϕ = NBAcosθ = NBAcosωt

Induced emf $= -\frac{d\phi}{dt} = -\frac{d\,(NBAcos\omega t)}{dt}$

e = NBA ωsinωt

(c)



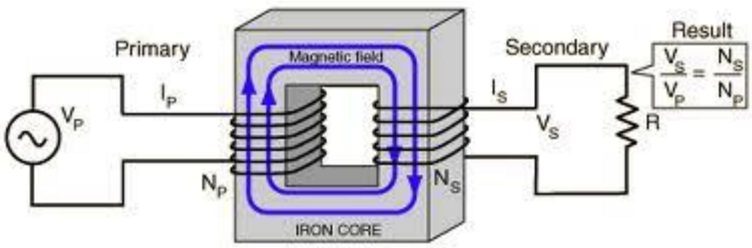
A6. Step up Transformer: It is a device used either to raise the alternating voltage with a corresponding decrease in current.

Principle: Whenever current through a coil changes, an emf is induced in the neighbouring coil.

In step up transformer:

$N_S > N_P$

Working



- When alternating voltage V_P is applied to the primary coil, an alternating flux (ϕ) is set up in the core.
- The alternating flux (ϕ) liked with both coils and induces emf (E_P) in the primary and emf (E_S) in the secondary coil.
- According to Faraday's Law of electromagnetic induction'

$E_P = -N_P\frac{d\phi}{dt}$, $E_S = -N_S\frac{d\phi}{dt}$

$\Rightarrow \frac{E_S}{E_P} = \frac{N_S}{N_P}$

Two assumptions (any two)

(i)The primary resistance and current are small

(ii) The flux linked with the primary and secondary coils is same / there is no leakage of flux from the core.

(iii)Secondary current is small

cause of Energy loss:

Hysteresis Loss (Iron Loss): The loss of energy when core of transformer is subjected to cycle of magnetisation and demagnetisation.

Eddy Current Loss: The loss of energy due production of unwanted eddy current in the core of transformer.

A7. Self inductance of a coil is numerically equal to magnetic flux linked with the coil when unit current passes through it. L= ϕ/I

OR

Self inductance of a coil is numerically equal to induced e.m.f. produced in it when rate of change of current is unity in it.

Expression for energy

Induced e.m.f. produced in coil,e = -L $\frac{dI}{dt}$

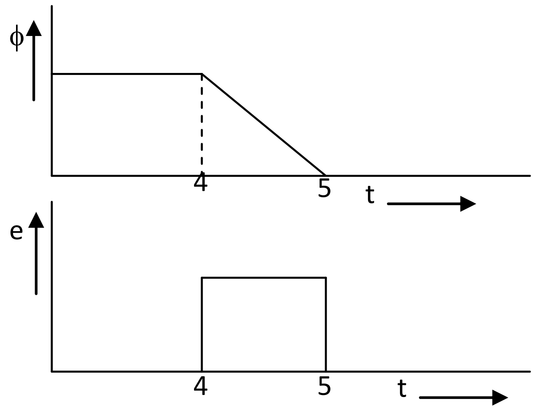
work done by the source, dw= +eIdt = LIdI

W = $\int_0^I LIdI$ = ½ LI^2

b) Direction of induced current – clockwise (MNOP)

Duration of induced current - 1s

Plot of graph



A8. **Principle:** Whenever current through a coil changes, an emf is induced in the neighbouring coil. **(see figure from answer-6)**

- When alternating voltage V_P is applied to the primary coil, an alternating flux (ϕ) is set up in the core.
- The alternating flux (ϕ) liked with both coils and induces emf (E_P) in the primary and emf (E_S) in the secondary coil.
- According to Faraday's Law of electromagnetic induction'

$E_P = -N_P \frac{d\emptyset}{dt}$, $E_S = -N_S \frac{d\emptyset}{dt}$

$\Rightarrow \frac{E_S}{E_P} = \frac{N_S}{N_P}$ ------- (i)

- If the resistance of the primary coil is negligible, then

$V_P = E_P$

and $E_S = V_S$ (when secondary coil is not connected to load) -----(ii)

- If current in primary and secondary coils are I_P and I_S respectively then, for ideal condition;

Input power = output power

$V_P.I_P = V_S.I_S$ -------- (iii)

- Transformation ratio ; using equation (i) and (iii) and fact (ii)

$$\frac{E_S}{E_P} = \frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S} = K$$

(c) Main assumptions

The primary resistance and current are small

(ii) The flux linked with the primary and secondary coils is same / there is no leakage of flux from the core.

(iii)Secondary current is small

(d)Hysteresis Loss (Iron Loss): The loss of energy when core of transformer is subjected to cycle of magnetisation and demagnetisation.

Eddy Current Loss: The loss of energy due production of unwanted eddy current in the core of transformer.

A9.(a) In one revolution

Change of area, dA = $\pi\ell^2$

Change of magnetic flux dϕ = $\vec{B}.\overrightarrow{dA}$ = BdAcos0^0 = B$\pi\ell^2$

Period of revolution =T

(i)Induced emf e = $\frac{B\pi\ell^2}{T}$ = $B\pi\ell^2\nu$

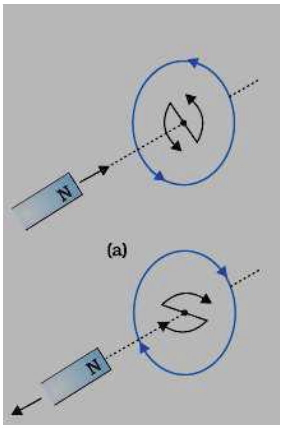
(ii)Induced current in the rod = e/R = $\frac{B\pi\ell^2\nu}{R}$

(b) Force on the rod F = IℓB = $\frac{\pi\nu\ell^3B^2}{R}$

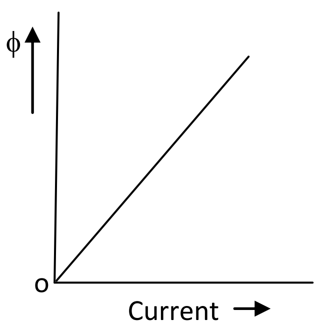
The external force required to rotate the rod opposes the Lorentz force acting on the rod / external force acts in the direction opposite to the Lorentz force

c) Power required to rotate the rod P = Fv = = $\frac{\pi\nu\ \ell^3B^2v}{R}$

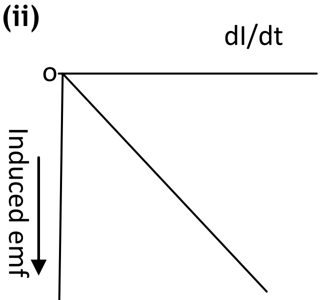
A10. When a bar magnet is brought close to the coil (fig a), the approaching North Pole of the bar magnet increases the magnetic flux linked to it. This produces an induced emf which produces (or tends to produce, if the coil is open) an induced current in the anti-clockwise sense. The face of the coil, facing the approaching magnet, then has the same polarity as that of the approaching pole of the magnet. The induced current, therefore, is seen to oppose the change of magnetic flux that produces it.



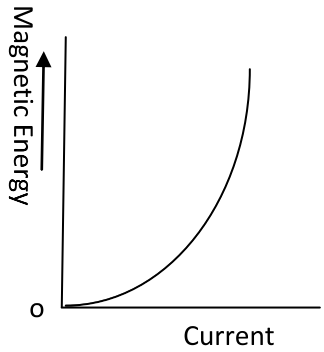
(i)



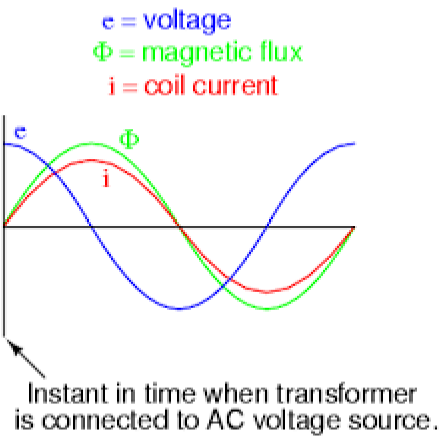
(ii)

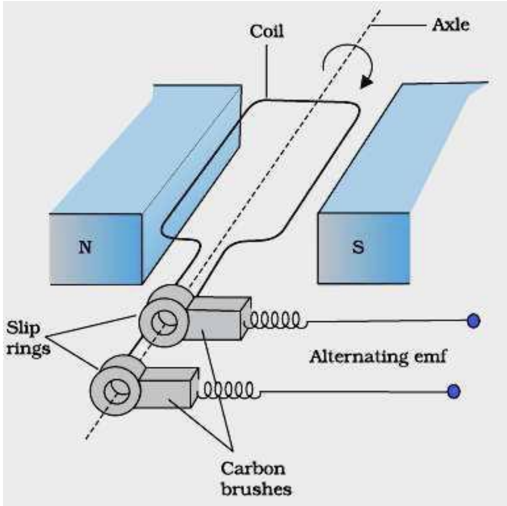


(iii)



A11.(a) It works on the process of electromagnetic induction, i.e. when a coil rotates continuously in a magnetic field, the effective area of the coil, linked (normally) with the magnetic field lines, changes continuously with time. This variation of magnetic flux with time results in the production of an (alternating) emf in the coil.





(b) A choke coil reduces the voltage across the fluorescent tube without wastage of power.

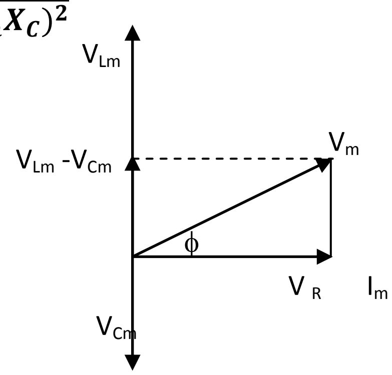
A12 .Magnitude of net voltage will be the sum of the voltage drops V_R and (V_{L} - V_C)

o

$$V_m = \sqrt{V_{Rm}^{\ 2} + (V_{Lm} - V_{Cm})^2} = \sqrt{(I_m R)^2 + (I_m X_L - I_m X_C)^2}$$

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

$$I_m = \frac{V_m}{\sqrt{R^2 + (X_L - X_C)^2}}$$



Phase difference: $\tan\emptyset = \frac{V_{Lm} - V_{Cm}}{V_{Rm}} = \frac{I_m(X_L - X_C)}{I_m R} = \frac{X_L - X_C}{R}$

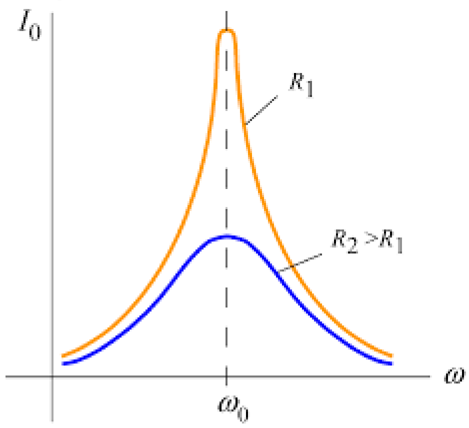
At resonance I_m is maximum $X_L = X_C$

Quality factor: It is defined as **Q** = $\frac{\omega_r L}{R}$

A larger value of quality factor corresponds to a sharper resonance.

In figure.

$I_m = I_0$



A13.See the figure from A.No. (11)

(a)It works on the principle of electromagnetic induction, i.e. when a coil continuously rotates in a magnetic field, the magnetic flux associated with it keeps on changing; thus an induced emf is produced in it.

b) When the coil rotates in a magnetic field, its effective area i.e. A cos , (i.e. area normal to the magnetic field) keeps on changing. Hence magnetic flux ϕ =NBAcosθ keeps on changing.

c) Let the coil be rotating with angular velocity 'ω ', at any instant't' when the normal to the plane of the coil makes an angle with the magnetic field.

Hence magnetic flux ϕ =NBAcosωt ,

Therefore induced emf(e) = $-\frac{d\phi}{dt}$

= NBAω sinωt

Induced emf will be maximum when = 90_0

Hence, max emf = NBAω

Direction of induced emf can be determined using Fleming's Right hand rule.

(d) See figure of A-6 part(c)

A16. Mutual inductance is the property of a pair of coils due to which an emf induced in one of coils due to change in current in the other coil.

When current I_1 is passed in the coil , the induced emf in the second coil

$e_2 = -M\, dI_1/dt$

$M = \frac{-e_2}{\frac{dI_1}{dt}}$

Let a current I_2 flows through the outer circular coil. Then

$B_2 = \mu_0 I_2 / 2r_2$

$\therefore \phi_1 = \pi r_1^2 B_2 = \frac{\mu_0 \pi r_1^2 I_2}{2r_2} = M_{12} I_2$

Thus $M_{12} = \frac{\mu_0 \pi r_1^2}{2r_2}$

Induced emf in coil C_1 due to the change in current through C_2

We have $N_1\phi_1 = M I_2$

For varying currents,

$$N_1\frac{d\phi_1}{dt} = M\frac{dI_2}{dt}$$

$-e = M\frac{dI_2}{dt}$

e = - $M\frac{dI_2}{dt}$

A17. Instantaneous Voltage: V = V_0 sin ωt

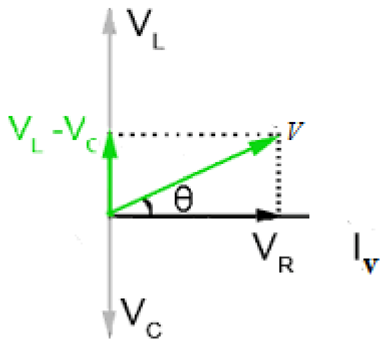
I_V : r.m.s. value of the current in the circuit.

$V_R = I_V R$ -- where V_R and I_v are in same phase

$V_L = I_V X_L$ -- leading the current I_V in phase by $\pi/2$

$V_C = I_V X_C$ -- lagging the current in phase by $\pi/2$

If we consider $V_L > V_C$ so net potential drop across L -C is V_L - V_C



∴ **The applied voltage E_V is the phasor sum of the voltage drops V_R and $(V_L - V_C)$**

$$V = \sqrt{V_R{}^2 + (V_L - V_C)^2} = \sqrt{(I_v R)^2 + (I_V X_L - I_V X_C)^2}$$

$$= I_V \left(\sqrt{R^2 + (X_L - X_C)^2}\right)$$

$$\frac{V}{I_V} = \sqrt{R^2 + (X_L - X_C)^2}$$

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

Phase difference $\tan\theta = \frac{V_L - V_C}{V_R} =$

When $X_L = X_C$ or $V_L = V_C$

Circuit is called Resonant circuit.

(ii) **Power factor P_1 = R/Z** $= \frac{R}{\sqrt{R^2 + R^2}} = \frac{1}{\sqrt{2}}$ (Here X_L = R given)

Power factor when capacitor C of Reactance XC = X_L is put in series in the circuit

P_2 = R/Z = R/R = 1 (as Z= R at resonance)

$P_1/P_2 = 1/\sqrt{2}$

A18.(i) Conversion of ac of low voltage into ac of high voltage & vice versa

Principle: Mutual induction statement.

Energy losses:

a. Leakage of magnetic flux

b. Eddy currents

c. Hysterisis loss

d. Copper loss

(ii) (a)N_P = 100, Transformation ratio K =100

Number of turns in the secondary coil N_s = 100x100 = 10000 (since $\frac{N_S}{N_P}$ = K)

(b)Input power = Input voltage x current in primary

1100= 220 x I_P

I_P = 5A

(c) $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

$\frac{V_S}{220} = 100$

V_S = 22000V

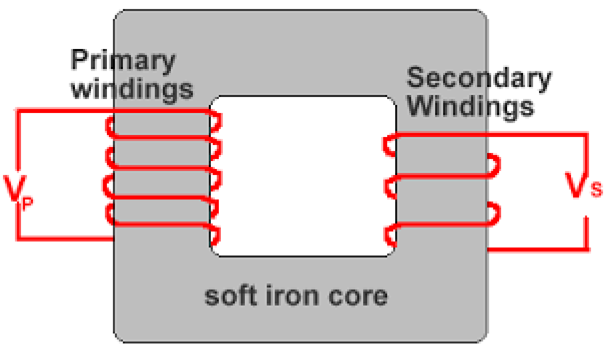
(d) $\frac{I_P}{I_S} = \frac{N_S}{N_P}$

$\frac{5}{I_S} = 100 \Rightarrow I_S = 0.05A$

(e)Power in secondary = power in primary =

1100W

A19. Step down transformer figure:



A20. (a)Mutual inductance is the property of a pair of coils due to which an emf induced in one of coils due to change in current in the other coil.

When current I_1 is passed in the coil, the induced emf in the second coil

$e_2 = -M\, dI_1/dt$

$M = \frac{-e_2}{\frac{dI_1}{dt}}$

Let a current I_2 flows through the outer circular coil. Then

$B_2 = \mu_0 I_2 / 2r_2$

$\therefore \phi_1 = \pi r_1^2 B_2 = \frac{\mu_0 \pi r_1^2 I_2}{2r_2} = M_{12} I_2$

Thus $M_{12} = \frac{\mu_0 \pi r_1^2}{2r_2}$

(b)Flux at any time $\phi = BA\cos\theta = BA\cos\omega t$

From Faraday's law

$e = -N\frac{d\phi}{dt} = NBAw\sin\omega t$

For maximum value $e_0 = NBA\omega = 2NBA\pi f$

ANSWER TO VALUE BASED QUESTIONS:

A1.(i) Concerned/ Caring(or any other one relevant value)

ii. Because, one can get electric shock, as water conducts electricity,

Yes, relatively safer, because distilled water is a bad conductor of electricity.

iii. Any example displaying similar value in real life situation.

A2.(a) Presence of mind, careful, helpful/Awareness etc. (any two).

(b) The two feet of the bird, sitting on the live wire, are at the same potential. Hence, no current passes through its body. The potential difference between the earth and the live wire when somebody touches a live wire, standing on the ground can result in a passage of current, so a fatal shock.

(c) Transmitting the power at a very high voltage is equivalent to lowering the current to a very low level, so Transmission losses ($= i^2R$) are minimized.

A3. (a) Transformer

Working Principle: Mutual induction

Whenever an alternative voltage is applied in the primary windings,an emf is induced in the secondary windings.

(b) No, There is no induced emf for a dc voltage in the primary

(c) Inquisitive nature/ Scientific temperament (any one)Conceren for students / Helpfulness / Professional honesty(any one)(Any other relevant values)

A4.(a) Resonance in a.c. circuit

(b) When a person walk through the gate, the impedance of circuit changes resulting significant change in current in the circuit that cause sound to be emitted as an alarm.

(c) Following rules and regulation, responsible citizen, scientific temperament, knowledgeable

A5.(a) For the same power at high voltage, current in the transmission wires becomes smaller.

power loss is less

b) If power factor is less, current in the cables is more so power loss is more

c) Values displayed

By Ajit (Any two) – Social Awareness, understanding nature, concern for society

By Uncle- Knowledgeable, professional honesty, concern for society. (other suitable values)

A6. Principle

When magnetic flux through a coil changes, an emf is induced across its ends.

Working :

When the coil (Armature) is rotated in a uniform magnetic field by some external means , the magnetic flux through it changes . So an emf is induced across the ends of the coil connected to an external circuit by means of slip rings and brushes.

(b) Two values displayed by Hari (Any two)

Scientific temperament / curiosity / learning attitude / any other quality

Two values displayed by Science teacher (Any two)

Responsive / caring and concerned / encouraging / any other quality

A7. (i) voltage = 220 V

frequency = 50 Hz

(ii) a) It can be stepped up / stepped down

b)It can be converted into d.c

c)Line losses can be minimised**(any one)**

(iii) No

(iv) Helping / Brave / Kind / Knowledge about AC or DC / Knowledge about insulator & conductors/ Awareness about safety precautions.(any two)

UNIT- V: Electromagnetic Waves:

VERY SHORT ANSWER TYPE QUESTIONS: 1 –MARK

Q1. Arrange the following electromagnetic waves in order of increasing frequency: Υ-rays, microwaves, infrared rays and ultraviolet rays.

Q2.What are the directions of electric and magnetic field vectors relative to each other and relative to direction of propagation of EM wave?

Q3. State the condition under which a microwave oven heats up food item containing water molecules.

Q4. Name the part of electromagnetic spectrum of wavelength 10^2m and mention its one application.

Q5. Name the part of electromagnetic spectrum of wavelength 10-^2m and mention its one application.

Q6. What is approximate wavelength of X-Rays?

Q7. Name the characteristics of e.m. wave that (i) increases (ii) remains constant in e.m. wave from radio wave region towards ultraviolet region.

Q8.What is the name given to the part of electromagnetic spectrum which is used for taking photographs of earth under foggy conditions from great heights?

Ans: Infrared

Q9. Why are micro waves considered suitable for radar systems used in aircraft navigation?

SHORT ANSWER TYPE QUESTIONS: 2-MARKS

1. An em wave exerts pressure on the surface on which it is incident. Justify.

Q2. (a) Write the mathematical expressions for electric and magnetic field components associated with an electromagnetic wave of frequency 'ν' and wavelength 'λ' propagating along the + z-axis.

(b) Draw the sketch of the plane electromagnetic wave propagating in the z-direction along with the components of oscillating electric and magnetic fields.

Q3. What is displacement current? Obtain expression for displacement current?

Q4. What does an e.m. wave consist of? On what factors does its velocity in vacuum depend?

Q5.Give two characteristics of e.m. waves. Write the expression for the velocity of electromagnetic waves in terms of permittivity and magnetic permeability of free space.

Q6.Find the wavelength of EM waves of frequency $5x10^{19}$Hz in free space. Give its two applications.

Q7.Why are infrared radiations referred to as heat waves? Name the radiations which are next to these radiations in e.m. spectrum having (i) shorter wavelength (ii) longer wavelength.

Q8. State the region why microwaves are best suited for the long distance transmission of signals?

Q9. Why does a galvanometer show a momentary deflection at the time of charging or discharging of a capacitor? Write the necessary expression to explain the observation.

Q10.(i)How are infrared waves produced? Write their one important use.

(ii)The thin Ozone layer on the top of stratosphere is crucial for human survival.Why?

SHORT ANSWER TYPE QUESTIONS: 3-MARKS

Q1. Show, by giving a simple example, how em waves carry energy and momentum?

(ii) How are microwaves produced? Why is it necessary in microwave ovens to select the frequency of microwaves to match the resonant frequency of water molecules?

Q2. (a) Write the formula for the velocity of light in material medium of relative permittivity ε_r and relative permeability μ_r.

(b) The following table gives the wavelength range of some constituents of the electromagnetic spectrum.

S.No.	Wavelength Range
1	1 mm to 700 nm
2	0.1 m to 1mm
3	400 nm to 1 nm
4	< 10^{-3} nm

Select the wavelength range and name the (associated) electromagnetic waves, which are used in

(i) Radar system for aircraft navigation.

(ii) Earth satellites to observe growth of crops.

Q3.Name the parts of the electromagnetic spectrum which is

(a) suitable for radar systems used in aircraft navigation

(b) used to treat muscular strain.

(c) used as a diagnostic tool in medicine.

Write in brief, how these waves can be produced.

Q4. How are electromagnetic waves produced? What is the source of the energy carried by a propagating electromagnetic wave? Identify the electromagnetic radiations used

(i) in remote switches of household electronic devices; and

(ii) as diagnostic tool in medicine.

Q5. (a) Which one of the following electromagnetic radiations has least frequency?

UV radiations, X-rays, Microwaves

(b) How do you show that electromagnetic waves carry energy and momentum?

(c) Write the expression for the energy density of an electromagnetic wave propagating in free space.

Q6. Arrange the following electromagnetic waves in the order of their increasing wavelength:

(a) γ-rays

(b) Microwaves

(c) X-rays

(d) Radio waves

How are infra-red waves produced? What role does infra-red radiation play in (i) maintaining the Earth's warmth and (ii) physical therapy?

Q7. How are the following types of electromagnetic waves produced?

(i) Microwaves.

(ii) Infra-red waves.

Write two important uses of each of the above electromagnetic radiations.

Q8.How is electromagnetic waves produced? What is the source of energy of these waves? Draw a schematic sketch of the electromagnetic waves propagating along the + x-axis. Indicate the directions of the electric and magnetic fields. Write the relation between the velocity of propagation and the magnitudes of electric and magnetic fields.

Q9.The electric field part of an electromagnetic wave in vacuum is

$$E = [\{(3.1 N/C) \cos [(1.8 \text{ rad/m})y + (5.4\times10^6 \text{ rad/s})t \}] i$$

(a) What are direction of wave propagation and the direction of vibration of magnetic field vector?

(b) What is wavelength of wave?

(c) What is amplitude of the magnetic field part of the wave?

Q10. (a)A capacitor is connected in series to an ammeter across a d.c. source. Why does the ammeter show a momentary deflection during the charging of the capacitor? What would be the deflection when it is fully charged?

(b) How is the generalized form of Ampere's circuital law obtained to include the term due to displacement current?

Q11. Answer the following the questions:

(a) Name the em waves which are produced during radioactive decay of a nucleus. Write their frequency range.

(b) Welders wear special glass goggles while working. Why? Explain.

(c) Why are infrared waves often called as heat waves? Give their one application.

Q12.Answer the following questions:

(i) Show, by giving a simple example, how em waves carry energy and momentum.

(ii) How are microwaves produced? Why is it necessary in microwave ovens to select the frequency of microwaves to match the resonant frequency of water molecules?

(iii) Write two important uses of infra-red waves.

Q13. Identify the following electromagnetic radiation as per the frequencies given below. Write one application of each.

(a)1mm (b) 10^{-12} m (c) 1nm

Hint: (a) Microwaves (b) X-rays (c) Infrared

Q14.Write the expression for the generalised form of Ampere's circuital law. Discuss its significance and describe briefly how the concept of displacement current is explained through charging / discharging of a capacitor in an electric circuit?

Q15. Write the expression for the generalized Ampere's circuital law. Through a suitable example, explain the significance of time-dependent term.

Q16. How are em waves produced by oscillating charges?

Draw a sketch of linearly polarized em waves propagating in the Z-direction. Indicate the directions of the oscillating electric and magnetic fields.**CBSE-2016-D**

Q17. Write Maxwell's generalization of Ampere's Circuital Law. Show that in the process of charging a capacitor, the current produced within the plates of the capacitor is

$I_D = \varepsilon_0 \frac{d\phi_E}{dt}$ **CBSE-2016-D**

where Φ_E is the electric flux produced during charging of the capacitor plates.

Q18.(i)Identify the part of the electromagnetic spectrum which is: **[CBSE:2016(C)]**

(a)suitable for radar system used in aircraft navigation.

(b)produced by bombarding a metal target by high speed electrons

(ii)Why does a galvanometer show a momentary deflection at the time of charging or discharging a capacitor? Write the necessary expression to explain this observation.

Q19. Identify the type of waves which are produced by following way and write one application for each:

(i) Radioactive decay of the nucleus,

(ii) Rapid acceleration and decelerations of electron in aerials,

(iii) Bombarding a metal target by high energy electron. **CBSE SQP :2016**

VALUE BASED QUESTIONS: 4 MARKS

Q1. When Sunita, a class XII student, came to know that her parents are planning to rent out the top floor of their house to a mobile company she protested. She tried hard to convince her parents that this move would be a health hazard. Ultimately her parents agreed:

(1)In what way can the setting up of transmission tower by a mobile company in a residential colony prove to be injurious to health?

(2) By objecting to this move of her parents, what value did Sunita display?

(3) Estimate the range of e.m. waves which can be transmitted by an antenna of height 20 m.

(Given radius of the earth: 6400 km)

Q2. Anuj's mother was having constant headaches. After a medical check-up, she was diagnosed with tumour. Anuj realized there was a telecommunication tower very close to their house. He enquired from the doctor if the radiation from the tower could have caused the tumour. As the doctor supported his anxiety, he lodged a complaint with the police and ultimately succeeded in getting the tower removed to a distant place away from the residential colony.

Answer the following:

(i) What values were displayed by Anuj?

(ii) Anuj made a rough estimate about the height of the antenna to be about 20 m from the ground. Calculate the maximum distance up to which radiations from the tower are likely to reach. Use the value of radius of the Earth = 6400 x10^3 m.

Hint (ii) d = $\sqrt{2hR} = \sqrt{2 \times 20 \times 6.4 \times 10^6}$ m = 16 km

Q3. Mrs Sunita was using ordinary electric heater for cooking food. One day she came to know that

LPG agency has opened in her town. She immediately applied for the gas connection. His son Rohit, who recently joined as an engineer, brought a microwave oven after getting his first salary. He told his mother "how to use the microwave oven in cooking some food items?" Now his mother is using LPG and microwave oven for cooking food.

Give the answer of following questions:

(a) Mention one value shown by each person.

(b) Why does a microwave oven take very less time to cook any food item in comparison to ordinary electric heater?

(c) What is the range of frequencies of microwaves?

(d) Mention one more use of microwaves.

ANSWER: VERY SHORT TYPE QUESTIONS: 1 –MARK

A1. Microwaves, infrared rays, ultraviolet rays, ϒ-rays

A2. Electric and magnetic field are perpendicular to each other and also perpendicular to wave propagation.

A3. Frequency of microwaves should match the resonant frequency of water molecules.

A4. Radio wave, Used in communication

A5. Microwave, radar communication.

A6. $0.1A^0$ to $100A^0$

A7. Frequency, speed in vacuum.

A8. Infrared

ANSWER: SHORT TYPE QUESTIONS: 2 –MARKS

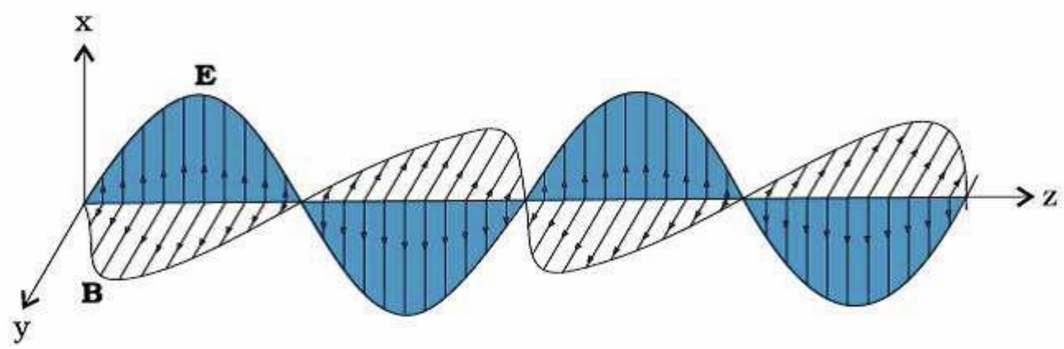
A1. An em wave carries a linear momentum with it. The linear momentum carried by a portion of wave having energy U is given by $p=U/c$. Thus, if the wave incident on a material surface is completely absorbed, it delivers energy U and momentum $p=U/c$ to the surface. If the wave is totally reflected, the momentum delivered is p= 2U/c is $p=2U/c$ because the momentum of the wave changes from p to $-p$. Therefore, it follows that an em waves incident on a surface exert a force and hence a pressure on the surface.

OR

Photons carry momentum (p = E/c). When photons are absorbed or reflected on a surface, the surface receives momentum kicks. This momentum transfer leads to radiation pressure.

Electromagnetic radiation applies radiation pressure equal to the Intensity (of light beam) divided by c (speed of light).

A2.



$E_x = E_0 \sin(Kz - 2\pi\nu t)$

$B_y = B_0 \sin(Kz - 2\pi\nu t)$

A3. Displacement Current: The displacement current is that current which appears in the region in which the electric field / electric flux is changing with time.

Expression for Displacement Current:

If A be the area of the plates of a capacitor and 'q' be the charge on the plates. The electric field E between

$$E = \frac{\sigma}{\epsilon_0} = \frac{q}{\epsilon_0 A}$$

$$E.A = \frac{q}{\epsilon_0}$$

$$= \text{electric flux, } \phi_E = \frac{q}{\epsilon_0}$$

$$\frac{d\phi_E}{dt} = \frac{1}{\epsilon_0}\frac{dq}{dt}$$

But $\frac{dq}{dt}$ is the rate of change of charge on the plates of capacitor. It is called displacement current and is given by;

$$I_D = \frac{dq}{dt} = \epsilon_0 . \frac{d\phi_E}{dt}$$

A4. The consists of electric and magnetic field vectors oscillating perpendicular to each other and also perpendicular to direction of wave propagation.

Velocity of wave depends upon permittivity (ε_0) and permeability (μ_0) of free space.

A5. The EM waves are transverse in nature because E and B are perpendicular to each other and they also perpendicular to direction of propagation of wave.

The speed of EM waves in vacuum is given by

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3\text{x } 10^8 \text{ m/s}$$

A6. Hint: Use $c = \nu\lambda$, Microwaves: used to get information regarding atomic structure, used by Detectors

A7. Because they produce heating effect/ heat up the materials on which they fall.

Shorter wavelength: Visible light: Longer Wavelength: Microwaves:

A8. Because they have short wavelength so they do not bend around the corners of any obstacle.

A9. Due to conduction current (I_C) in the conducting wires and a displacement current between the plates of capacitor.

Displacement current $I_d = \epsilon_0 \frac{d\phi_E}{dt}$ where ϕ_E represents electric flux.

ANSWER: SHORT TYPE QUESTIONS: 3 -MARKS

A1. (i) Consider a plane perpendicular to the direction of propagation of the wave.

An electric charge, on the plane, will be set in motion by the electric and magnetic fields of em wave, incident on this plane. This illustrates that em waves carry energy and momentum.

(ii) Microwaves are produced by special vacuum tubes like the klystron, / Magnetron/ Gunn diode. The frequency of microwaves is selected to match the resonant frequency of water molecules, so that energy is transferred efficiently to the kinetic energy of the molecules.

A2. **(a)** $v = \frac{1}{\sqrt{\mu_0\ \mu_r\ \varepsilon_0 \varepsilon_r}}$

(b) (i) 1mm to 700nm (Infrared).

(ii) 0.1m to 1mm (microwaves).

(iii) X-rays

(iv)Gamma rays

A3. (a) Microwave

Production: Klystron/magnetron/Gunn diode (any one)

(b) Infrared Radiation

Production: Hot bodies / vibrations of atoms and molecules (any one)

(c) X-Rays

Production: Bombarding high energy electrons on metal target/ x-ray tube/inner shell electrons(any one).

A4. Electromagnetic waves are produced by accelerated / oscillating charges which produce oscillating electric field and magnetic field (which regenerate each other).

Source of the Energy: Energy of the accelerated charge. (or the source that accelerates the charges)

Identification:

(1) Infra-red radiation

(2) X – rays

A5. (a)Microwaves

b) Electric charges can acquire energy and momentum from e.m. waves.

(c) $U = U_E + U_B = ½\, \varepsilon_0 E^2 + ½ \frac{B^2}{2\mu_0}$

A6. Gamma(γ) rays, X-rays, Microwaves, Radio waves

Infrared rays are produced by hot bodies / vibration of atoms and molecules

Infrared rays: (i) Maintain Earth's warmth through greenhouse effect

(ii) Produce heat

A7.(i) Microwaves are produced by special vacuum tubes called Klystrons / Magnetrons / Gun diodes / Point contact diodes. (any one)

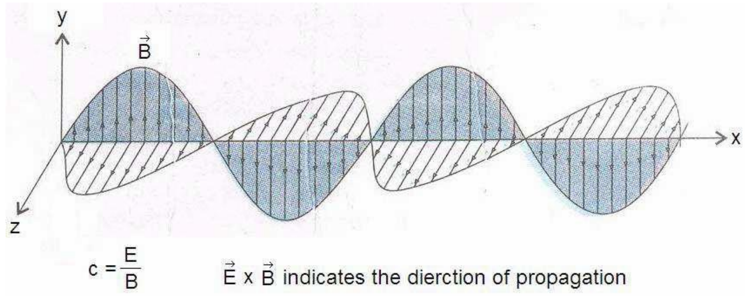
Uses: Radar system, Ovens, Communication (any two)

ii) Infrared waves are produced by vibration of atoms and hot bodies.

Uses: Physical therapy, remote switches in household electronic systems, detectors in earth satellites (any two)

A8. Production: Electromagnetic waves are produced by "accelerated Charges"

The battery/ Electric field that accelerates the charge carriers is the source of energy of em waves.



Directions of E Along y-axis/ Along z-axis

Directions of B Along z- axis/ Along y-axis

Relation: C= E/B

A14. Generalised form of Ampere's circuital law $\oint \vec{B}.\vec{d\ell} = \mu_0 [I_C + \epsilon_0 \frac{d\phi_E}{dt}]$

It signifies that the magnetic field is not just due to the conduction current (I_C) due to flow of charge but also due to the time rate of change of electric field called displacement current.

During the charging and discharging of a capacitor the electric field between the plates of capacitor will change so there will a change in electric flux (displacement current) between the plates.

A15. According to generalized Ampere's circuital law; $\oint \vec{B}\vec{d\ell} = \mu_0 I_c + \mu_0 \in_0 \frac{d\phi_E}{dt}$

$= \mu_0(I_c + \in_0 \frac{d\phi_E}{dt})$

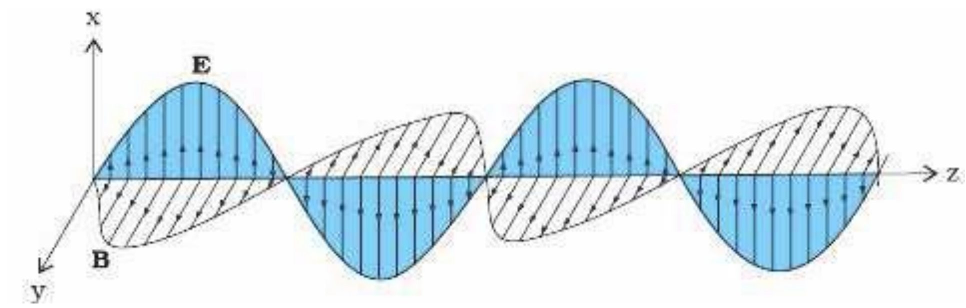
The time dependent term ($\in_0 \frac{d\phi_E}{dt}$) represents displacement current.

It exists in the region in which the electric flux (ϕ_E) / electric field changes with time.

Example: During charging and discharging of a capacitor, the current wires connecting capacitor plates to the source is conduction current whereas in between the plates it is displacement current due change of electric field between the plates which makes circuit complete.

The conduction current is always equal to the displacement current.

A16.A charge oscillating with some frequency, produces an oscillating electric field in space, which in turn produces an oscillating magnetic field perpendicular to the electric field, this process goes on repeating, producing em waves in space perpendicular to both the fields.



Directions of Electric field (**E**) and Magnetic field (**B**) are perpendicular to each other and also perpendicular to direction of propagation of em waves.

A17. Ampere's circuital law is given by as .

$$\oint \vec{B}.\overrightarrow{d\ell} = \mu_0 I_C$$

But for a circuit containing capacitor, during its charging / discharging the current within the plates of the capacitor varies, (producing displacement current). Therefore, the above equation, as generalized by Maxwell, is given as .

$$\oint \vec{B}.\overrightarrow{d\ell} = \mu_0 I_C + \mu_0 I_d$$

During the process of charging of capacitor, electric flux (ϕ_E) between the plates of capacitor changes with time, which produces the current within the plates of capacitor. This current, being proportional to , $\frac{d\emptyset_E}{dt}$

We have $I_d = \varepsilon_0 \frac{d\emptyset_E}{dt}$

A18. (i) (a)Microwaves

b. X-rays

ii Due to conduction current in the connecting wires and a displacement current between the plates

$$I_d = \varepsilon_0 \frac{d\emptyset_E}{dt}$$

A19.(i) Gamma rays : Treatment of tumors

(ii) Radio waves: Radio and television communication systems

(iii)X –rays : Study of crystals

ANSWER TO VALUE BASED QUESTIONS:

A1. Electromagnetic radiations emitted by an antenna can cause

(a) Cardiac problem

(b) Cancer

(c) Giddiness and headache

(any one of the above / or any other effect on health)

(ii) Scientific temperament, awareness (**any one / any other correct value**)

A2. (i)(a) Concern

b. Scientific temperament

c. Keen observer

d. Alertness (or any other two correct values.)

(ii) d = $\sqrt{2hR}$ = $\sqrt{2 \times 20 \times 6.4 \times 10^6}$ = 2$\times$ 8 $\times$ 10^3 = 16km

A3. (a) Mother: Fast learner, ready to change herself, adaptive nature.

Son: showing concern, caring, loving to his mother.

(b) When microwaves are made to pass through cooking material, they transfer their energy directly to water molecules with heating the cooking pots. In traditional cooking, the transfer of heat energy takes place through conduction / convection process that take more time to cook the food.

(c) **3 x 10^{11} to 1 x 10^{9} Hz** (d) They are use in RADAR.