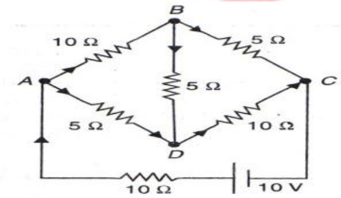
CHAPTER 1 : Electrostatics

1. What is a dielectric? Why does the capacitance of a parallel plate capacitor increase on introduction of a dielectric in between its two plates? Derive an expression for the capacitance of such a capacitor having two identical plates each of area A and separated by distance x. The space between the plates has a medium of dielectric constant k.
2. Derive an expression for the energy stored in a parallel plates capacitor with air is a the medium between its plates. Air is now replaced by a dielectric medium of dielectric constant k. How does it change the total energy of the capacitor is
   (i) the capacitor remains connected to the same battery?
   (ii) The capacitor is disconnected from the battery?
3. Define the term electric field intensity. Write its SI unit. Derive an expression for the electric field intensity at a point on the axis of an electric dipole.
4. State Gauss' theorem in electrostatics. Use it to obtain an expression for the electric field intensity at a point near a uniformly charged infinite plate sheet.
5. A dielectric slab of thickness $'t'$ is kept in between the plates, each of area $'A'$, of a parallel plate capacitor separated by a distance $'d'$. Derive an expression for the capacitance of this capacitor for $t << d$.
6. (a) Explain briefly how a capacitor stores energy on charging. Obtain an expression for the energy thus stored.
   (b) A battery of 10 V is connected to a capacitor of 0.1 F. The battery is now removed and the capacitor is then connected to a second uncharged capacitor of same capacitance. Calculate the total energy stored in the system.
7. (a) Define the term 'electrostatic potential'. Give the dependence of electrostatic potential due to a small electric dipole at a far off point lying on (i) the axial line, and (ii) equatorial line.
   (b) Briefly explain the principle of a capacitor. Obtain the expression for the capacitance of a parallel plate capacitor.
8. Draw electric field lines between the plates of a parallel plate capacitor with (i) air and (ii) dielectric as the medium.
   A parallel plate capacitor with air as dielectric is connected to a power supply and charged to a potential difference V_0. After disconnecting from power supply, a sheet of insulating material is inserted between the plates completely filling the space between them. How will its (i) capacity, (ii) electric field and (iii) energy change? Given that the capacity of capacitor with air as medium is C_0 and permittivity of air and medium are ε_0 and ε respectively.
9. Derive an expression for the energy stored in a parallel plate capacitor, with air as the medium between the plates.
   A parallel plate capacitor of capacitance 100 μF is charged to 200 V. After disconnecting it from the battery, using an insulated handle, the distance between the plates is doubled. Find
   (i). Potential difference between the plates, and
   (ii). Energy stored in the capacitor, after separation between the plates has been increased.
10. Give the principle of working of a Van de Graff generator. With the help of a labeled diagram, describe its construction and working. How is the leakage of charge minimized from the generator?
11. Obtain the expression for the capacitance of a parallel plate capacitor.
    Three capacitors of capacitance C_1, C_2 and C_3 are connected (i) in series, (ii) in parallel. Show that the energy stored in the combination is the same as that in the parallel combination.

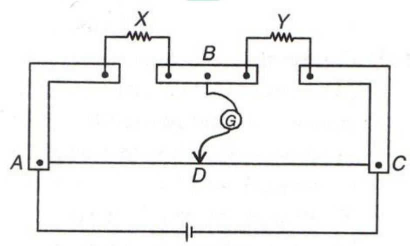
12. Derive an expression for the electric potential at a point along the axial line of an electric dipole. At a point due to a point charge, the values of electric field intensity and potential are 32 N/C and 16 J/C respectively. Calculate (i) magnitude of the charge and (ii) distance of the charge from the point of observation.

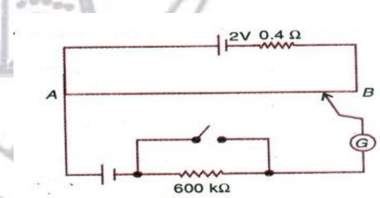
Chapter 2 : Current Electricity

1. Determine the current in each branch of the network shown in figure.



2. (a) In a metre bridge shown below, the balance point is found to be at 39.5 cm from the end A, when the resistor Y is of 12.5 Ω. Determine the resistance of X. Why are the connections between resistors in a Wheatstone or metre bridge made of thick copper strips?
(b) Determine the balance point of the bridge above if X and Y are interchanged.
(c) What happens if the galvanometer and cell are interchanged at the balance point of the bridge? Would the galvanometer show any current?

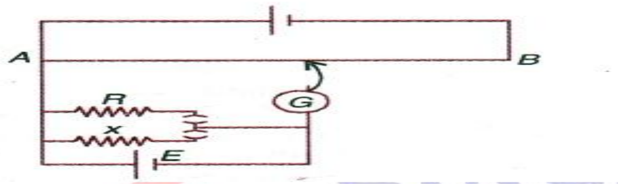




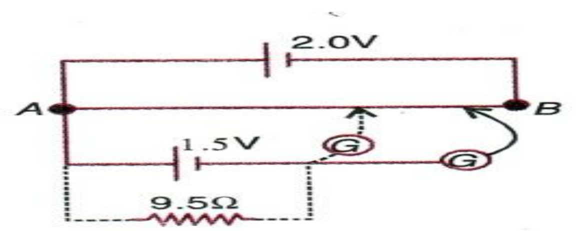
3. Figure shows a potentiometer with a cell of 2.0 v and internal resistance 0.40 Ω maintaining a potential drop across the resistor wire AB. A standard cell which maintains a constant e.m.f. of 1.02 V (for very moderate currents upto a few mA) gives a balance point at 67.3 cm length of the wire. To ensure very ow currents drawn from the standard cell, a very high resistance of 600 k Ω is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown e.m.f. E and the balance point found similarly, turns out to be at 82.3 cm length of the wire.

(a) What is the value E?
(b) What purpose does the high resistance of 600 k Ω have?
(c) Is the balance point affected by this high resistance?
(d) Is the balance point affected by this high resistance?
(e) Would the method work in the above situation if the driver cell of the potentiometer had an e.m.f. of 1.0 V instead of 2.0 V?
(f) Would the circuit work well or determining an extremely small e.m.f.say of the order of a few mV (such as the typical e.m.f. of a thermo-couple)? If not, how will you modify the circuit?

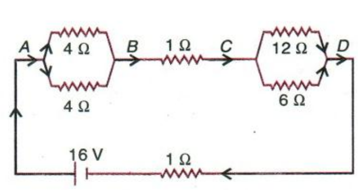
4. Figure shows a potentiometer circuit for comparison of two resistances. The balance point with a standard resistor R = 10.0 Ω is found to be 58.3 cm, while that with the unknown resistance X is 68.5 cm. Determine the value of X. What might you do if you failed to find a balance point with the given cell of e.m.f. E?

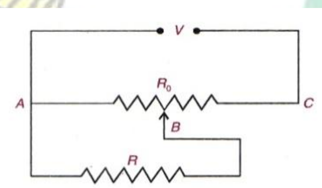


5. Figure shows a 2.0 V potentiometer used for the determination of internal resistance of 1.5 V cell. The balance point of the cell is open circuit is 76.3 cm. when a resistor of 9.5 Ω is used in the external circuit of the cell, the balance point shifts to 64.8 cm length of the potentiometer wire. Determine the internal resistance of the cell.



6. (a) Three resistors 1 Ω, 2 Ω, and 3 Ω are combined in series. What is the total resistance of the combination?
   (b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.
7. A network of resistances is connected to a 16 V battery with internal resistance of 1 Ω as shown in figure.
   (a) Compute the equivalent resistance of the network.
   (b) Obtain the current in each resistor and
   (c) Obtain voltage drops $V_{AB'} = V_{BC}$ and $V_{CD'}$



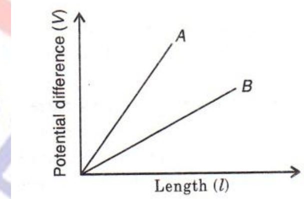


8. (a) Three resistors 2 Ω, 4 Ω, and 5 Ω are combined in parallel. What is the total resistance of the combination?
   (b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.
9. The four arms of a Wheatstone bridge have the following resistances :
   AB = 100 Ω, BC = 10 Ω, CD = 5 Ω and DA = 60 Ω.
   A galvanometer of 15 Ω resistance is connected across BD. Calculate the current through the galvanometer when a potential difference of 10 V is maintained across AC.
10. In a meter bridge, the null point is found at a distance of 33.7 cm from A. If now a resistance of 12 Ω is connected in parallel with S, the null point occurs at 51.9 cm. Determine the values of R and S.

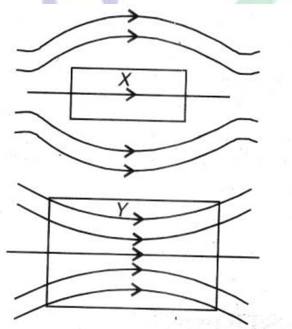
11. A resistance of R Ω draws current from a potentiometer. The potentiometer has a total resistance R_0 Ω (in Fig.). A voltage V is supplied to the potentiometer. Derive an expression for the voltage across R when the sliding contact is in the middle of the potentiometer.

Chapter 3 : Magnetic Effects of Current & Magnetism

1. Bars, A, B and C, made from three different types of materials, are put, one-by-one, in a non-uniform magnetic field. While bars B and C tend to move from the weak to the strong field region, bar A tends to move from the strong to the weak field region. The effect, observed in bar C, is much stronger, than that observed in bar B. Identify the class of materials, to which the three bars, belong.
   Show, with the help of diagrams, the behaviour of field lines due to external magnetic field near bars A, B and C.

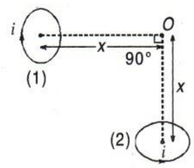


2. A uniform magnetic field gets modified as shown below, when two specimens X and $Y$are placed in it.



   (i) Identify the two specimens X and Y.
   (ii) State the reason for the behaviour of the field lines in X and Y.
3. Explain briefly the elements required to specify the earths magnetic field at a given place. How does the value of angle of dip vary form the earth's equator to the north pole?
4. Name the three types of magnetic materials which behave differently when placed in a non-uniform magnetic field. Give two properties for each of them.
5. Where on the earth's surface is the value of vertical component of the earth's magnetic field zero? The horizontal component of the earth's magnetic field at a given place is 0.4 x 10^{-4} Wb/m^2 and angle of dip is 30^o. Calculate the value of (i) vertical component, (ii) the total intensity of the earth's magnetic field.
6. Where on the earth's surface is the value of the vertical component of earth's magnetic field zero? A bar magnet of magnetic moment 1.5 JT^{-1} lies aligned with the direction of a uniform magnetic field of 0.22 t. Calculate the amount of work done to turn the magnet so as to align its magnetic moment (i)normal to the field direction, (ii) opposite to the field direction.
7. A diamagnetic materials and a paramagnetic material of the same shape and size are in turn kept in an external uniform magnetic field. Draw the modification of the magnetic lines of force in the two cases. How does the intensity of magnetisation of a paramagnetic material vary with temperature?
8. Derive an expression for the torque experienced by a magnetic dipole in a uniform magnetic field. Hence obtain the expression for the potential energy of the dipole.
9. A short bar magnet of magnetic moment 0.9 JT^{-1}, is placed with its axis at 45^o to a uniform magnetic field. If it experiences a torque of 0.063 joule, (i) Calculate the magnitude of the magnetic field and (ii) What orientation of the bar magnet corresponds to the stable equilibrium in the magnetic field?

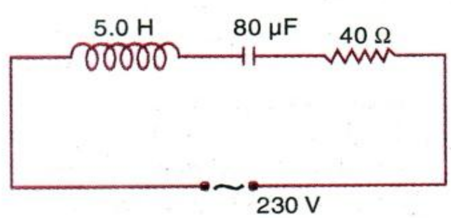
10. (a) With the help of a labelled diagram, explain the principle and working of a moving coil galvanometer.
(b) Two parallel coaxial circular coils of equal radius $'R'$ and equal number of turns $'N'$, carry equal currents $'I'$ in the same direction andn are separated by a distance $'2R'$. Find the magnitude and direction of the net magnetic field produced at the mid-point of the line joi8ning their centres.
11. (a) State Biot-Savart's law. Using this law, derive the expression for the magnetic field due to a current carrying circular loop of radius 'R', at a point which is at a distance $'x'$ from its centre along the axis of the loop.
(b) Two small identical circular loops, marked (1) and (2), carrying equal currents, are placed with the geo-metrical 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.



12. Explain the principle and working of a cyclotron with the help of a labelled diagram. 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, what is the kinetic energy of the proton beam produced by the accelerator? Express your answer in units of MeV. (e = 1.6 10^{-19} C, m_P = 1.67 x 10^{-27} kg, 1 MeV = 1.602 x 10^{-13}J).

Chapter 4 : Electromagnetic Magnetic Induction & A.C.

1. The given circuit diagram show a series LCR circular connected to a variable frequency 230 V source.



(i). Determine the source frequency which drives the circuit in resonance.
(ii). Obtain the impedance of the circu8it and the amplitude of current tat the resonating frequency.
(iii). Determine the rms potential drops across the three elements of the circuit.
(iv). How do you explain the observation that the algebraic sum of the voltages across the three elements obtained in (iii) is greater than the supplied voltage?
2. The primary coil of an ideal step-up transformer has 100 turns and the transformation ratio is also 100. The input voltage and power are 220 V and 1100 W respectively. Calculate
(i) number of turns in the secondary
(ii) the current in the primary
(iii) voltage across the secondary
(iv) the current in the secondary
(v) power in the secondary

3. With the help of a neat labelled diagram, explain the principle, construction and working of an a.c. generator.
4. Explain, with the help of a neat and labelled diagram, the principle, construction and working of a transformer.
5. What is induced emf? Write Faraay's law of electromagnetic induction. Express it mathematically. C conducting rod of length $'l'$, with one end pivoted, is rotated with a uniform angular speed $'\omega'$ in a vertical plane, normal to a uniform magnetic field $'B'$. Deduce an expression for the emf induced in this rod.
   In India, domestic power supply is at 220 V, 50 Hz, while in USA it is 110V, 50 Hz. Give one advantage and one disadvantage of 220 V supply over 110V supply.
6. Draw a labelled diagram to explain the principle and working of an a.c. generator. Deduce the expression for the e.m.f. generated. Can the current produced be an a.c. generator be measured with a moving coil ammeter? Give reason for your answer.

7. Write the principle of an a.c. generator.
   An a.c. generator consists of a coil of 50 turns and area 2.5 m^2 rotating at an angular speed of 60 rad s^{-1} in a uniform magnetic field B = 0.30 T between two fixed pole pieces. The resistance of the circuit including that of the coil is 500 Ω.
   (i). Find the maximum current drawn from the generator.
   (ii). What will be the orientation of the coil with respect to the magnetic field to have (a) maximum, (b) zero magnetic flux?
   (iii). Would the generator work if the coil were stationary and instead the pole pieces rotated together with the same speed as above?
8. Draw a labelled diagram of an a.c. generator. Write the principle on which it works.
   An a.c. generator consists of a coil of 100 turns and cross-sectional area of 3 m^2 rotating at a constant angular speed of 60 radian/sec in a uniform magnetic field of 0.04 T. The resistance of the coil is 500 ohm. Calculate (i) maximum current drawn from the generator and (ii) maximum power dissipation in the coil.
9. With the help of a labelled diagram, explain the working principle of a step-up transformer. In an ideal transformer, number of turns in the primary and secondary are 200 and 1000 respectively. If the power input to the primary is 10 kW at 200 V, calculate (i) output voltage and (ii) current in primary.
10. Distinguish between reactance and resistance. An alternating emf is applied across a capacitor. Show mathematically that curren tin it leads the applied emf by phase angle of $\frac{\pi}{2}$. What is capacitive reactance of such a circuit? Write the unit of capacitive reactance. Draw a graph showing the variation of capacitive reactance with the frequency of a.c. current.
11. What is meant by impedance? Give its unit. Using a phasor diagram or otherwise derive the expression for the impedance of an a.c. circuit containing l, C and R in series. Find the expression for resonant frequency.

Chapter 5 : Electromagnetic Waves

1. Draw a labeled diagram of Hertz's experimental set-up to produce electromagnetic waves. Explain the generation of electromagnetic waves using this set-up.
2. Write the order of frequency range and one use of each of the following electromagnetic radiation.
   (i) Microwaves (ii) Ultra-violet rays (iii) Gamma rays
3. Draw a labeled diagram of the experimental set-up used by Hertz to produce electromagnetic waves. Explain how the electromagnetic waves are detected
4. Give reasons for the following.

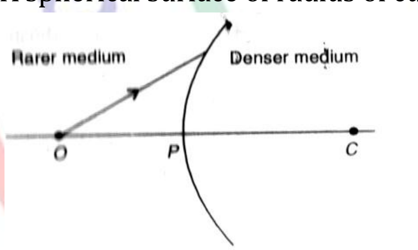
(i). Long distance radio broadcasts use short-wave bands.
(ii). The small ozone layer on top of the stratosphere is crucial for human survival.
(iii). Satellites are used for long distance TV transmission.

5. Write two applications each of (i) microwaves, (ii) infra-red waves, and (iii) radio waves.
6. Name the constituent radiation of electromagnetic spectrum which
   (a) is used in satellite communication.
   (b) is used for studying crustal structure.
   (c)is similar to the radiations emitted during decay of radioactive nuclei.
   (d) has its wavelength range between 390 nm and 770 nm.
   (e) is absorbed from sunlight by ozone layer.
   (f) produces intense heating effect.
7. Name the radiations of electromagnetic spectrum which are used in
   (i) warfare to look through fog.
   (ii) radar and geostationary satellites.
   (iii) studying the structure and properties of atoms and molecules.

Chapter 6 : Ray Optics

1. Derive the expression for the refractive index of the material of the of the prism in terms of the angle of the prism and angle of minimum deviation. Use this formula to calculate the angel of minimum deviation for an equilateral triangular prism of refractive index $\sqrt{3}$.
   (a) Calculate magnifying power of the compound microscope, if the final image is formed at the near point.
   (b) Calculate the length of the compound microscope also.
2. (i) State with reason, which lens is preferred as objective and eye-piece.
   (ii) Calculate the magnifying power of the telescope, if the final image is formed at the near point.
   (iii) How do the light gathering power of a telescope change, if the aperture of a telescope change, if the aperture of the objective lens is doubled?
3. Draw a labeled ray diagram of an astronomical telescope used in the normal adjustment position. Write the expression for its magnifying power.
   Two astronomical telescopes T_1 and T_2 have the same magnifying power. The ratio of apertures of their objectives is 3 : 2.
   (i) Which one of the two produces image of greater intensity?
   (ii) Which one of the two has larger resolving power?
   Explain your answer in each case.
4. Draw a labelled ray diagram showing the image formation by a compound microscope. Write the expression for its magnifying power.
   Define the term resolving power of microscope. How does the resolving power of a compound microscope change on
   (i) decreasing the diameter of its objective lens?
   (ii) increasing the focal length of its objective lens?
   Justify your answer in each case.

5. Show by a diagram the image formation of a point by a thin double convex lens having radii of curvature R_1 and R_2. Hence derive the formula $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, where f is the focal length and is refractive index of material of the lens.
6. Draw a labelled diagram of a compound microscope when the image is formed at infinity. Deduce the expression for its magnifying power. How can the magnifying power be increased?
7. Draw a labelled diagram to show image formation in an astronomical telescope. Write an expression for its magnifying power. Why should the objective lens of such a telescope have large diameter?
8. Draw a labelled ray diagram to show image formation by a terrestrial telescope. Write expression for its magnifying power.
   In a compound microscope, the focal lengths of the objective and eye-piece are 1.0 cm and 2.0 cm, respectively. The tube length of the microscope is 20 cm. Calculate its magnification. Why must both the objective and the eye-piece of a compound microscope have short focal lengths?
9. (a) Derive the relation $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ for a bioconvex lens. How is the approximate value of the focal length of such a lens estimated in the laboratory?
   (b) A beam of light converges to a point P. A lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converge if the lens is (i) a convex lens of 20 cm focal length and (ii) a concave
   lens of 16 cm focal length?
10. With the help of a ray diagram, show the formation of image of a point object by refraction of light at a spherical surface separating two media of refractive indices n_1 and n_2 ($n_2 > n_1$) respectively. Using this diagram, derive the relation
    $$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$
    Write the sign conventions used. What happens to the focal length of convex lens when it is immersed in water?
11. A spherical surface of radius of curvature R, separates a rarer and a denser medium as shows in the figure.



Complete the path of the incident ray of light, showing the formation of a real image. Hence derive the relation connecting object distance $'u'$, image distance $'v'$, radius of curvature R and the refractive indices n_1 and n_2 of the two media.

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