Current Electricity — Assignment 1

Class 12 Physics · Topic-wise question bank covering every concept of the chapter · Narayan Gurukul Academy

Instructions: (1) Attempt all questions. This worksheet walks through every concept of the chapter, topic by topic.
(2) The interactive MCQ version of these questions (with instant answer reveal) is available on the notes page.
(3) Universal values: g = 10 m/s^2 unless stated. Give answers with correct SI units.

Electric Current and Drift Velocity

MCQ Questions (choose the correct option)

1. Electric current through a conductor is the
   (A) rate of flow of charge
   (B) flow of voltage
   (C) product of voltage and resistance
   (D) ratio of charge to voltage
2. The drift velocity of electrons in a conductor is proportional to the
   (A) applied electric field
   (B) square of the electric field
   (C) number of collisions per second
   (D) mass of the electron
3. If n is the number of free electrons per unit volume, the current density in a conductor is
   (A) j = n e v_d
   (B) j = n e / v_d
   (C) j = n v_d / e
   (D) j = e v_d / n
4. Conventional current direction is taken as
   (A) opposite to the flow of electrons
   (B) along the flow of electrons
   (C) along the flow of positive holes only
   (D) perpendicular to the electron flow

1 Mark Questions

1. Define electric current. Write its SI unit.
2. What is current density? Write its SI unit.
3. Define drift velocity of electrons in a conductor.
4. Write the relation between current, drift velocity and the free-electron number density.

2 Mark Questions

1. A current of 5 A flows through a wire for 2 minutes. How much charge crosses any section of the wire?
2. A steady current of 3.0 A flows through a copper wire of area of cross-section 2.0×10^{-6} m^2. Find the drift velocity of the free electrons if their number density is 8.5×10^{28} m^{-3}.
3. Distinguish between the drift speed and the thermal speed of free electrons in a conductor. Which is the larger at room temperature?
4. How does the drift velocity of electrons in a metallic conductor change when (i) the temperature is increased and (ii) the potential difference across the conductor is doubled?

3 Mark Questions

1. The number density of free electrons in a copper conductor is $8.5 \times 10^{28}\ m^{-3}$. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section is $2.0 \times 10^{-6}\ m^2$ and it carries a current of 3.0 A.

2. Show that the current density in a conductor is j = n e v_d, and hence derive the relation I = n A e v_d.

3. A wire of cross-sectional area $1.0 \times 10^{-6}\ m^2$ carries a current of 2.0 A. If the free-electron number density is $8.5 \times 10^{28}\ m^{-3}$, find the time taken by an electron to drift through a 1.0 cm length of the wire.

Ohm's Law and Resistance

MCQ Questions (choose the correct option)

1. Ohm's law asserts that
   (A) the plot of I versus V is linear, i.e. R is independent of V
   (B) R = V/I for every device
   (C) R is always constant
   (D) I is proportional to R

2. The resistance of a conductor of resistivity ρ, length L and area of cross-section A is
   (A) R = ρL/A
   (B) R = ρA/L
   (C) R = L/(ρA)
   (D) R = A/(ρL)

3. When the temperature of a metallic conductor is raised, its resistance
   (A) increases
   (B) decreases
   (C) remains the same
   (D) first increases then becomes zero

4. Which element does NOT obey Ohm's law?
   (A) a semiconductor diode
   (B) a copper wire
   (C) a nichrome wire
   (D) a standard carbon resistor

1 Mark Questions

1. State Ohm's law.

2. Write the formula for resistivity of a material and state its SI unit.

3. How does the resistance of a metal change when its temperature rises?

4. Define one ohm.

2 Mark Questions

1. A negligibly small current is passed through a wire of length 15 m and uniform cross-section $6.0 \times 10^{-7}\ m^2$, and its resistance is measured to be 5.0 Ω. Find the resistivity of the material.

2. At room temperature (27.0 °C) the resistance of a heating element is 100 Ω. Find the temperature of the element when its resistance becomes 117 Ω, given the temperature coefficient of the material is $1.70 \times 10^{-4}\ °C^{-1}$.

3. A silver wire has a resistance of 2.1 Ω at 27.5 °C and 2.7 Ω at 100 °C. Determine the temperature coefficient of resistivity of silver.

4. Distinguish between resistance and resistivity of a conductor.

3 Mark Questions

1. Derive the relation $R = \rho L/A$ for a conducting wire in terms of the microscopic quantities m, n, e and τ, and state the physical assumptions involved.

2. A wire of resistance 5 Ω is stretched so that its length becomes double. Find its new resistance, assuming the volume and resistivity remain unchanged.

3. Explain why the resistance of a metal increases while that of a semiconductor (e.g. carbon) decreases with temperature. Support your answer with the concept of relaxation time τ and drift velocity.

Combination of Resistances

MCQ Questions (choose the correct option)

1. Resistors R_1, R_2, R_3 connected in series give an equivalent resistance
   - (A) $R_1 + R_2 + R_3$
   - (B) $1/R_1 + 1/R_2 + 1/R_3$
   - (C) $R_1R_2R_3/(R_1+R_2+R_3)$
   - (D) $(R_1 + R_2 + R_3)/3$
2. Two resistors of 4 Ω and 6 Ω connected in parallel give an equivalent resistance
   - (A) 2.4 Ω
   - (B) 10 Ω
   - (C) 24 Ω
   - (D) 0.4 Ω
3. To obtain the maximum resistance from n identical resistors each of resistance R, they must be connected
   - (A) in series
   - (B) in parallel
   - (C) in any combination
   - (D) alternately in series and parallel
4. The ratio of the maximum to the minimum resistance obtainable from n identical resistors each of resistance R is
   - (A) n^2
   - (B) n
   - (C) 1/n
   - (D) n^3

1 Mark Questions

1. Write the formula for the equivalent resistance of resistors connected (i) in series and (ii) in parallel.

2. Why is the equivalent resistance of a parallel combination smaller than the smallest individual resistance?

3. State the ratio of maximum to minimum resistance obtainable with n identical resistors of resistance R.

4. What is the effective resistance of two identical resistors R connected in parallel?

2 Mark Questions

1. Three resistors 1 Ω, 2 Ω and 3 Ω are combined in series and connected to a battery of emf 12 V (negligible internal resistance). Find the total resistance and the potential drop across each resistor.

2. Three resistors 2 Ω, 4 Ω and 5 Ω are combined in parallel and connected to a battery of emf 20 V (negligible internal resistance). Determine the current through each resistor and the total current drawn.

3. Given resistors 1 Ω, 2 Ω and 3 Ω, combine them to obtain an equivalent resistance of (i) 11/3 Ω, (ii) 11/5 Ω, (iii) 6 Ω and (iv) 6/11 Ω.

4. A ladder network (as in Fig. 3.31(i)) has four identical loops: each loop is a 1 Ω + 1 Ω series combination in parallel with a 2 Ω + 2 Ω series combination. Find the total end-to-end resistance.

3 Mark Questions

1. Given n resistors each of resistance R, how will you combine them to get (i) the maximum and (ii) the minimum effective resistance? What is the ratio of the maximum to the minimum resistance?

2. Determine the equivalent resistance of the networks shown in Fig. 3.31: (i) the ladder of four loops built from 1 Ω and 2 Ω resistors, and (ii) five resistors each of resistance R in series.

3. A wire of resistance 12 Ω is bent to form a closed square. Find the resistance between two diagonally opposite corners of the square.

Kirchhoff's Laws

MCQ Questions (choose the correct option)

1. Kirchhoff's junction rule is based on the conservation of
   (A) charge
   (B) energy
   (C) linear momentum
   (D) magnetic flux
2. Kirchhoff's loop rule is based on the conservation of
   (A) energy
   (B) charge
   (C) mass
   (D) momentum
3. At a junction, currents I_1 and I_2 enter while I_3 leaves. The junction rule gives
   (A) $I_1 + I_2 = I_3$
   (B) $I_1 - I_2 = I_3$
   (C) $I_1 + I_2 + I_3 = 0$
   (D) $I_1 = I_2 + I_3$
4. A network with b branches and n junctions has this many independent loop equations
   (A) b − n + 1
   (B) n − b + 1
   (C) b + n − 1
   (D) b − n

1 Mark Questions

1. State Kirchhoff's junction rule.
2. State Kirchhoff's loop rule.
3. Name the conservation law underlying each of Kirchhoff's two rules.
4. State the sign convention for applying the loop rule to resistors and batteries while traversing a loop.

2 Mark Questions

1. Using Kirchhoff's junction and loop rules, write three independent equations for the five branch currents of the bridge network of Fig. 3.30 (AB = 10 Ω, BC = 5 Ω, CD = 10 Ω, DA = 5 Ω, BD = 5 Ω, source 10 V in series with 10 Ω across A–C).

2. At a junction, a current of 5 A enters and the currents leaving are I_1 and I_2. If I_2 = 2 A, find I_1.

3. Distinguish between Kirchhoff's junction rule and loop rule, and state the conservation principle behind each.

4. Explain why Kirchhoff's junction rule remains valid even when the connecting wires at a junction are bent or reoriented.

3 Mark Questions

1. State Kirchhoff's two laws and justify each with a conservation principle. Under what conditions are they valid in a circuit?

2. A cell of emf 4 V and internal resistance 2 Ω is connected in parallel with a cell of emf 2 V and internal resistance 2 Ω, and a 6 Ω resistor is connected across the common terminals. Using Kirchhoff's laws find the current in the 6 Ω resistor.

3. A circuit contains two loops sharing a common branch: loop 1 has a 6 V battery (r = 1 Ω) and loop 2 a 3 V battery (r = 1 Ω), with a 3 Ω resistor in the shared branch. Use Kirchhoff's laws to find the current through the shared 3 Ω resistor.

Wheatstone Bridge and Meter Bridge

MCQ Questions (choose the correct option)

1. A Wheatstone bridge is balanced when
   (A) P/Q = R/S
   (B) P·R = Q·S
   (C) P + Q = R + S
   (D) P/Q = S/R, with P, Q, R, S taken in cyclic order ACBD

2. At balance, the galvanometer in a Wheatstone bridge
   (A) shows zero deflection
   (B) shows maximum deflection
   (C) deflects permanently to the right
   (D) deflects permanently to the left

3. In a metre bridge, if the balance point is l cm from end A, then
   (A) R/S = l/(100 − l)
   (B) R/S = (100 − l)/l
   (C) R/S = l/100
   (D) R·S = l(100 − l)

4. The connections between resistors in a Wheatstone or metre bridge are made of thick copper strips to
   (A) minimise the resistance of the connections
   (B) increase the resistivity
   (C) prevent the galvanometer from deflecting
   (D) increase the sensitivity of the galvanometer

1 Mark Questions

1. State the balance condition of a Wheatstone bridge.

2. What is the function of the galvanometer in a metre bridge experiment?

3. Why is a metre bridge also called a slide-wire bridge?

4. Why are the connecting strips of a metre bridge made of thick copper?

2 Mark Questions

1. In a metre bridge, the balance point is found to be at 39.5 cm from the end A when the resistor S in the right gap is 12.5 Ω. Determine the resistance R. Why are the connections between resistors in a Wheatstone or metre bridge made of thick copper strips?

2. Determine the balance point of the metre bridge of the question above if the resistors R and S are interchanged.

3. What happens if the galvanometer and the cell are interchanged at the balance point of a metre bridge? Would the galvanometer show any current?

4. The four arms of a Wheatstone bridge are PQ = 2 Ω, QR = 4 Ω, RS = 3 Ω and SP = 6 Ω. Is the bridge balanced? A 3 Ω resistor is now placed in parallel with QR — is the bridge still balanced?

3 Mark Questions

1. Describe, with a labelled diagram, how an unknown resistance is determined experimentally using a metre bridge.

2. Derive the balance condition P/Q = R/S of a Wheatstone bridge using Kirchhoff's laws.

3. In a metre bridge experiment the balance point shifts from 39.5 cm to 60.5 cm when R and S are interchanged. If S = 12.5 Ω, find R and show that the balance condition is unchanged when the galvanometer and cell are interchanged.

EMF, Internal Resistance and Cells

MCQ Questions (choose the correct option)

1. The terminal voltage of a cell of emf ε and internal resistance r when it delivers current I is
   (A) V = ε − Ir
   (B) V = ε + Ir
   (C) V = ε
   (D) V = Ir − ε

2. The maximum current that can be drawn from a cell of emf ε and internal resistance r is
   (A) ε/r
   (B) r/ε
   (C) ε r
   (D) 2ε/r

3. n identical cells each of emf ε joined in series give a total emf of
   (A) n ε
   (B) ε/n
   (C) n^2 ε
   (D) ε

4. While a secondary cell is being charged, its terminal voltage is
   (A) greater than its emf
   (B) less than its emf
   (C) equal to its emf
   (D) zero

1 Mark Questions

1. Define the emf of a cell.

2. Write the relation between emf ε, terminal voltage V, current I and internal resistance r.

3. When is the terminal voltage of a cell equal to its emf?

4. What is the difference between the emf and the terminal voltage of a cell?

2 Mark Questions

1. A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor and delivers a current of 0.5 A. Find the resistance of the resistor and the terminal voltage of the battery.
2. A storage battery of emf 8.0 V and internal resistance 0.5 Ω is being charged by a 120 V dc supply using a series resistor of 15.5 Ω. Find the terminal voltage during charging and state the purpose of the series resistor.
3. Six lead-acid secondary cells each of emf 2.0 V and internal resistance 0.015 Ω are joined in series to supply a resistance of 8.5 Ω. Find the current drawn from the supply and the terminal voltage.
4. The storage battery of a car has an emf of 12 V and an internal resistance of 0.4 Ω. What is the maximum current that can be drawn from the battery?

3 Mark Questions

1. Derive the expression for the power delivered by a cell of emf ε and internal resistance r to an external resistance R. For what value of R is the power maximum?
2. A secondary cell after long use has an emf of 1.9 V and a large internal resistance of 380 Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?
3. Explain why a low-voltage supply that must give high currents needs a very low internal resistance, and why a high-tension (HT) supply of 6 kV must have a very large internal resistance.

Ammeter, Voltmeter and Galvanometer

MCQ Questions (choose the correct option)

1. A galvanometer is used to
   - (A) detect and measure small currents
   - (B) measure large voltages directly
   - (C) measure power
   - (D) measure resistance without any current
2. To convert a galvanometer into an ammeter, a
   - (A) small shunt is connected in parallel
   - (B) large resistance is connected in series
   - (C) small resistance is connected in series
   - (D) large shunt is connected in series
3. To convert a galvanometer into a voltmeter, a
   - (A) high resistance is connected in series
   - (B) low resistance is connected in parallel
   - (C) high resistance is connected in parallel
   - (D) low resistance is connected in series
4. An ammeter is connected in the circuit in series and a voltmeter in
   - (A) parallel
   - (B) series
   - (C) series–parallel
   - (D) either series or parallel

1 Mark Questions

1. State the function of an ammeter and how it is connected in a circuit.
2. State the function of a voltmeter and how it is connected in a circuit.
3. Why must an ammeter have a very low resistance and a voltmeter a very high resistance?

4. Why does a shunt used with a galvanometer have a very small resistance?

2 Mark Questions

1. A galvanometer of resistance 20 Ω gives full-scale deflection for a current of 10 mA. Find the shunt resistance that converts it into an ammeter of range 0–5 A.

2. The same galvanometer (20 Ω, 10 mA) is to be converted into a voltmeter of range 0–50 V. Find the resistance that must be connected in series.

3. Explain why a galvanometer is converted into an ammeter with a low shunt in parallel rather than with a series resistance, and why a voltmeter uses a large series resistance rather than a shunt.

4. A galvanometer of resistance G gives full-scale deflection for a current I_g. It is shunted with S. Give the formula for the range of the resulting ammeter.

3 Mark Questions

1. Describe how a galvanometer is converted into an ammeter, and derive the expression for the shunt resistance $S = I_g G/(I - I_g)$.

2. Describe how a galvanometer is converted into a voltmeter, and derive the expression for the required series resistance $R = V/I_g - G$.

3. A galvanometer of resistance 30 Ω gives full-scale deflection for a current of 2 mA. Find (i) the shunt needed to measure currents up to 2 A and (ii) the series resistance needed to measure voltages up to 2 V.

Potentiometer

MCQ Questions (choose the correct option)

1. A potentiometer measures the emf of a cell because at balance it
   - (A) draws no current from the cell
   - (B) draws a large current
   - (C) uses the cell's internal resistance
   - (D) amplifies the cell's emf

2. For two cells of emfs ε_1 and ε_2 giving balance lengths l_1 and l_2 on the same potentiometer wire
   - (A) $\varepsilon_1/\varepsilon_2 = l_1/l_2$
   - (B) $\varepsilon_1/\varepsilon_2 = l_2/l_1$
   - (C) $\varepsilon_1 \varepsilon_2 = l_1 l_2$
   - (D) $\varepsilon_1 - \varepsilon_2 = l_1 - l_2$

3. For a cell of balance length l_1 (open circuit) and l_2 (with R shunted), the internal resistance is
   - (A) $r = (l_1/l_2 - 1) R$
   - (B) $r = (l_2/l_1 - 1) R$
   - (C) $r = (l_1 - l_2) R$
   - (D) $r = (l_1 + l_2) R/l_1$

4. For a balance point to exist on the potentiometer wire, the driver cell's emf must be
   - (A) greater than the emf to be measured
   - (B) smaller than the emf to be measured
   - (C) exactly equal to the emf to be measured
   - (D) of any value

1 Mark Questions

1. Why does a potentiometer measure the emf of a cell more accurately than a voltmeter?

2. State the principle of a potentiometer.
3. What is a balance point in a potentiometer experiment?
4. Why is a very high resistance (e.g. 600 kΩ) connected in series with the galvanometer in a potentiometer circuit?

2 Mark Questions

1. In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm of the wire. When the cell is replaced by another cell the balance point shifts to 63.0 cm. What is the emf of the second cell?
2. A 2.0 V potentiometer with a standard cell of emf 1.02 V balances at 67.3 cm. A cell of unknown emf ε balances at 82.3 cm. Find ε.
3. A 2.0 V potentiometer is used to determine the internal resistance of a 1.5 V cell: the balance point is 76.3 cm in open circuit and 64.8 cm when a resistor of 9.5 Ω is connected across the cell. Determine r.
4. What purpose does the high resistance of 600 kΩ serve in the potentiometer circuit of Exercise 3.22, and is the balance point affected by it?

3 Mark Questions

1. Describe, with a labelled circuit diagram, how a potentiometer is used to compare the emfs of two cells.
2. Describe, with a labelled circuit diagram, how a potentiometer is used to measure the internal resistance of a cell, and derive the formula $r = (l_1/l_2 - 1) R$.
3. A potentiometer wire of length 10 m and total resistance 10 Ω is driven by a 2.0 V cell of internal resistance 0.40 Ω. A standard cell of 1.02 V balances at 67.3 cm. (i) Find the potential gradient along the wire. (ii) Would the method work if the driver cell had an emf of 1.0 V instead of 2.0 V?