Illustration 19: The value of an unknown resistance is obtained by using a post office box. Two consecutive readings of R are observed as the galvanometer deflects in the opposite direction for three different value of R_1. These two values are recorded under the column I and II in the following observation table. **(JEE MAIN)**

S.No.	R_1 (Ω)	R_2 (Ω)	R lies in between		X=R(R_2/ R_1)	
			I Ω	II Ω	I Ω	II Ω
1	10	10	16	17		
2	100	10	163	164		
3	1000	10	1638	1639		

Determine the value of the unknown resistance.

Sol: The table listed above computes the value of unknown resistance for different values of ratio R_2: R_1. The average of the final values will give the best estimate for the unknown resistance.

The observation table may be complete as follows:

S.No.	R_1 (Ω)	R_2 (Ω)	R lies in between		X=R(R_2/ R_1)	
			I Ω	II Ω	I Ω	II Ω
1	10	10	16	17	16.0	17.0
2	100	10	163	164	16.3	16.4
3	1000	10	1638	1639	16.38	16.39

The value of the unknown resistance lies in-between 16.38 Ω and 16.39 Ω

The unknown value may be the average of the two i.e. $X = \frac{16.38 + 16.39}{2} = 16.385\ \Omega$.

PROBLEM-SOLVING TACTICS

(a) Never think of current in terms of electrons and get confused in direction or vector analysis. Instead, it would be easier to think of current in terms of flow of positive charges because it is equivalent. However, my advice is to remember the reality in questions which intentionally deals with this concept.

(b) While solving a problem always remember that it is the resistivity and conductivity that is same for materials and not the resistance and conductance itself. This will help you avoid silly mistakes. Also note that Temperature dependence formula is very analogous to length expansion formula.

(c) The problems related to devices are quite easy and always remember that they are always solved by ratios and proportions. And one good thing is they do not require much of calculation too.

(d) Questions on combination of resistances can be solved more easily by identifying symmetry in breaking down the problem to basic series and parallel circuit.Symmetry, in this context implies equal resistances or equal distribution of current. This can help you in solving big complicated looking circuits.

(e) Questions related to power are easy and require use of law of conservation of energy.

(f) Applying Kirchhoff's Rules: Kirchhoff's rules can be used to analyse multi-loop circuit. The steps are summarized below:

(i) Draw a circuit diagram, and label all the quantities, both known and unknown. The number of unknown quantities must be equal to the number of linearly independent equations we obtain.

(ii) Assign a direction to the current in each branch of the circuit. (If the actual direction of current is opposite to that assumed initially, the value of current obtained will be a negative number.)

(iii) Apply the junction rule to all but one of the junctions. (Applying the junction rule to the last junction will not yield any independent equation.)

(iv) Apply the loop rule to the loops in the circuit.

Obtain as many independent equations using both the Kirchhoff's Laws as there are number of unknowns.

FORMULAE SHEET

1. Ohm's Law V = IR

2. Current flowing through cross-section area of conductor is $I = \int \vec{J}.d\vec{A}$

3. The current is defined as $I = \frac{q}{t} = \frac{nALe}{L/v_d} = nAev_d$

4. Current in terms of resistivity is defined as $I = \frac{E}{\rho}A$

5. Drift velocity for charge is $v_d = \frac{I}{neA}$

6. Time taken by charge to drift across conductor is $t = \frac{neA\ell}{I}$

7. The current density of a conductor is $\vec{J} = (ne)\vec{v}_d$

8. Conductivity σ is related to current density as $\vec{J} = \sigma \vec{E}$

9. Mobility of charges $\mu = \frac{v_d}{E}$

10. Resistivity of conductor is $\rho = \frac{E}{J} = \frac{1}{\sigma}$

11. For Series Network of resistance , net resistance $R_{eq} = \sum_{i=1}^{n} R_i$

12. Voltage division in two resistances (see Fig. 20.36)

$V = V_1 + V_2$ where $V_1 = \frac{R_1}{R_1 + R_2}V$ and $V_2 = \frac{R_2}{R_1 + R_2}V$

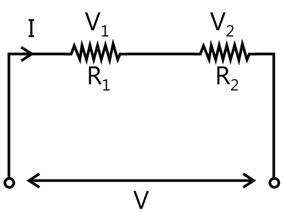

Figure 20.36

For Parallel Network of resistance, net resistance is $\frac{1}{R_{eq}} = \sum_{i=1}^{n}\left(\frac{1}{R_i}\right)$

13. Current division in two resistances (see Fig. 20.37)

$I = I_1 + I_2$, $I_1 = \frac{R_2}{R_1 + R_2} I$ and $I_2 = \frac{R_1}{R_1 + R_2} I$

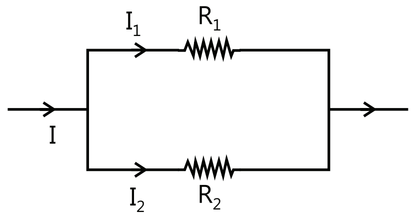

Figure 20.37

14. Kirchhoff's Voltage Law: For closed loop $\sum V_i = 0$

15. Kirchhoff's Current Law: At junction $\sum I_i = 0$

16. For circuit of series combination of cell, $I = \frac{\sum_i E_i}{\sum_i r_i + R}$ where E_i and r_i are values for i^{th} cell.

17. For circuit of parallel combination of cell, $E_{eq} = \frac{\sum \frac{E_i}{r_i}}{\sum \frac{1}{r_i}}$ and $R_{eq} = R + \frac{1}{\sum \frac{1}{r_i}}$

18. Relation of resistance to the resistivity of conductor is $R = \rho \frac{\ell}{A}$

19. Temperature dependence of resistivity is expressed as $\rho - \rho_0 = \rho_0 \alpha (T - T_0)$

20. Power consumed in any electrical device is P= IV and, resistive power dissipation $P = I^2 R = \frac{V^2}{R}$

21. For DC circuit of Resistance and Capacitance, (i) applied voltage $E = \frac{q}{C} + IR$,

(ii) Current in the circuit $I = I_o e^{-t/\tau}$ where $\tau_C = R_{eq}C$ is the time constant of the circuit

(iii) Charge stored by capacitor is $q = Q(1 - e^{-t/\tau})$

22. For potentiometer $E \propto \ell \Rightarrow R \propto \ell$

23. For Wheatstone bridge network of resistance $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

24. For meter bridge, the ratio of resistance $\frac{R_1}{R_2} = \frac{\ell_1}{\ell_2} = \frac{\ell_1}{100 - \ell_1}$

25. Internal resistance of cell is given by $r = \left(\frac{E}{V} - 1\right) R = \left(\frac{\ell_1}{\ell_2} - 1\right) R$