CLASS XII : ASSIGNMENT : CH-3 : CURRENT ELECTRICITY : PHYSICS

CHAPTER 3

Electric Current, Electric Current Density, Drift velocity, Mobility

1. A wire is carrying current. Is it charged?
2. Why do free electrons in a metal wire, flowing by themselves, not cause any current flow in the wire?
3. When electrons drift in a metal from lower to higher potential, does it mean that all the free electrons of the metal are moving in the same direction?
4. What is the current flowing through a conductor if 1 million electrons are crossing in 1 millisecond through a cross-section of it.
5. If 3.2×10^{17} electrons pass through a wire in 0.5 sec, Calculate the current through it on each electron is 1.6×10^{-19} C.
6. If $q = 2t^2 + 3$, find current at t = 2 sec?
7. If $q = t^2 + 4t + 3$. Find (i) instantaneous current at t = 3 sec and (ii) average current from t = 0 to t = 2 sec.
8. $I = t^2 + 1$, Find charge flowing through a cross-section between 0 to 3 sec. Also, find the number of electrons that have flown during this time interval.
9. An electron beam has an aperture of $1mm^2$. A total of 6×10^{16} electrons go through any perpendicular cross-section per second. Find (i) the current and (ii) the current density in the beam.
10. If the temperature of a good conductor increases, how does the relaxation time of electrons in the conductor change?
11. How does the random motion of free electrons in a conductor get affected when a potential difference is applied across its ends?
12. If the potential difference V applied across a conductor is increased to 2V, how will the drift velocity of the electron change?
13. A potential difference V is applied across a conductor of length. How is the drift velocity affected when V is doubled and l is halved?
14. A wire whose cross-sectional area is increasing linearly from its one end to the other is connected across a battery of V volts. Which of the following quantities remain constant in the wire?

    (i) Drift speed (iii) Electric current

    (ii) Current density (iv) Electric field
15. Two conducting wires X and Y of the same diameter across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires.
16. Clarify your elementary notions about current in a metallic conductor by answering the following queries :
17. (a) The electron drift speed is estimated to be only a few mms^{-1} for currents established almost the instant a circuit is closed.

    (b) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why then do the electrons acquire a steady drift speed?

    (c)If the electron drift speed is so small, and the electron's charge is small, how can we still obtain large amounts of current in a conductor?

    (d) When electrons drift in a metal from lower to higher potential, does it mean that all the ''free'' electrons of the metal are moving in the same direction?

    (e) Are the paths of electrons straight lines between successive collisions (with the positive ions of the metal) in the (i) absence of electric field, (ii) presence of the electric field?
18. (a) Write the nature of the path of free electrons in a conductor in the (i) presence of an electric field (ii) absence of an electric field.

    (b) Between two successive collisions each free electron acquires a velocity from 0 to v where $v = \frac{eE\tau}{m}$. What is the average velocity of a free electron in the presence of an electric field? Do all electrons have the same average velocity?

    (c) How does this average velocity of free electrons, in the presence of an electric field vary with temperature?
19. Is current density a vector or a scalar quantity? Deduce the relation between current density and potential difference across a current carrying conductor of length l, area of cross-section A, and number density of free electrons n. How does the current density, in a conductor vary with (a) increases in potential gradient? (b)

Increase in temperature? (c) Increase in length? (d) Increase in area of cross-section? (Assume that the other factors remain constant in each case). www.physicsinduction.com

20. Calculate the drift speed of the electrons when 1 A of current exists in a copper wire of cross section $2mm^2$. The number of free electrons in 1 cm^3 of Cu is 8.5×10^{22}.

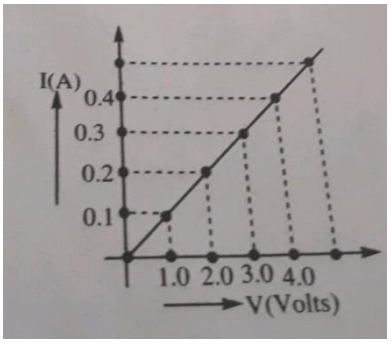
21. (a) Two spherical conductors of radii R_1 and R_2 ($R_2 > R_1$) are charged. If they are connected by a conducting wire, find out the ratio of the surface charge densities on them.
(b) A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

Ohm's Law

22. A potential difference of 200 V is applied across the ends of a conductor of resistance 50 Ω. Calculate the number of free electrons flowing through it in 1 sec. charge on electron is 1.6×10^{-19}C.

23. While studying the dependence of potential difference (V) across a resistor on the current (I) Passing through it, in order to determine the resistance of the resistor, a student took 5 readings for different values of current and plotted a graph between V and I. He got a straight line graph passing through the origin. What does the straight line signify? Write the method of determining resistance of the resistor using this graph.

24. In an experiment to study the dependence of current on potential difference across a resistor, a student obtained the graph as shown in the diagram. Find the value of resistance of the resistor



25. The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below –

I(amperes)	0.5	1	2	3	4
V(volts)	1.6	3.4	6.7	10.2	13.2

Plot a graph between V and I and calculate the resistance of that resistor.

Resistance and Resistivity

26. What is the unit of conductance?

27. Why are alloys used for making standard resistance coils?

28. Show on a graph the variation of resistivity with temperature for a typical semiconductor.

29. Resistivities of copper, silver and manganin are $1.7\times10^{-8}\Omega m$, $1.0\times10^{-8}\Omega m$ and $44\times10^{-8}\Omega m$ respectively which of these is the best conductor?

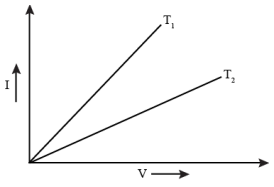
30. Plot a graph showing the variation of resistance of a conducting wire as a function of radius, keeping the length of the wire and its temperature as constant. www.physicsinduction.com

31. Two metallic wires each of length L, area of cross section A_1 and A_2 having resistivity ρ_1 and ρ_1 are connected in parallel across a dc battery. Obtain an expression for the effective resistivity of this combination.

32. Two wires of equal length, one of copper and the other of manganin have the same resistance. Which wire is thicker?

33. A 4 Ω non insulated resistance wire is bent in the middle by 180^0 and both the halves are twisted with each other. What will be its new resistance?

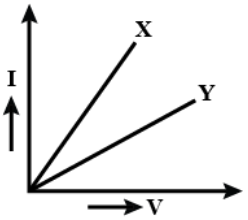
34. V-I graph for a metallic wire at two different temperatures T_1 and T_2 is shown in figure. Which of the two temperatures is higher and why?



35. 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 mms^{-1}.Yet large current of the order of few amperes can be set up in the wire. Explain briefly.

36. A wire of length L_o has a resistance R_o. It is gradually stretched till its length becomes $2L_o$.
(i) Plot a graph showing variation of its resistance R with its length L during stretching.
(ii) What will be its resistance when its length becomes $2L_o$?

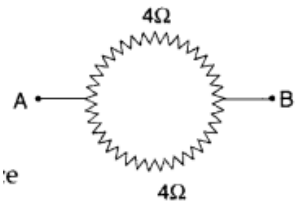
37. V−I graph for the metallic wires X and Y at constant temperature are as shown in figure: Assuming that the two wires have same length and same diameter, explain as to which of the two wires has higher resistivity and why?



Combination of resistors

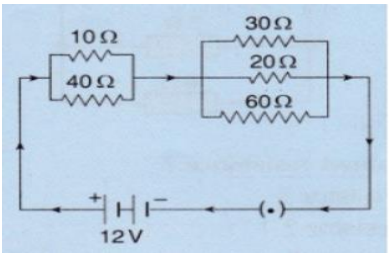
38. Two metallic wires of the same material have the same length but cross-sectional area is in the ratio 1 : 2. They are connected (i) in series and (ii) in parallel. www.physicsinduction.com
Compare the drift velocities of electrons in the two wires in both the cases (i) and (ii).

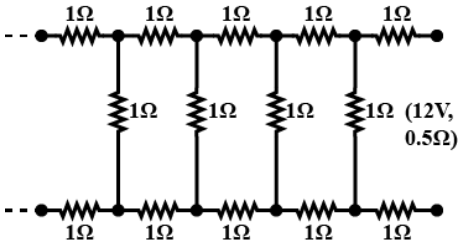
39. A wire of resistance 8R is bent in the form of a circle. What is the effective resistance between the ends of a diameter AB?



40. Suppose the resistors R_1, R_2 and R_3 have the same values 5Ω, 10Ω, 30Ω respectively, which have been connected to a battery of 12V. Calculate (a) the current through each resistor (b) the total current in the circuit, (c) the total circuit resistance

41. Draw the current drawn from a 12 V supply with internal resistance 0.5 Ω by the infinite network shown in figure, each resistor has 1Ω resistance.





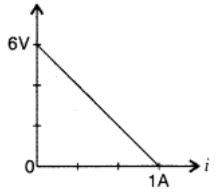
Cell, emf and Internal Resistance

42. State one condition for maximum current to be drawn from the cell?

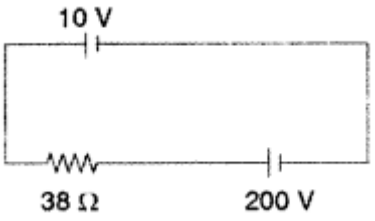
43. The storage battery of a car has an emf of 12V. If the internal resistance of the battery is 0.4Ω, what is the maximum current that can be drawn from the battery? www.physicsinduction.com

44. A cell of emf 'E' and internal resistance r is connected across a variable resistor 'R'. Plot a graph showing variation of terminal voltage 'V' of the cell versus Resistance R. Predict from the graph the condition under which V becomes equal to E.

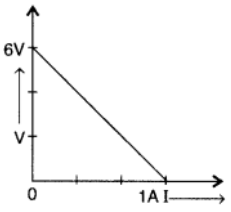
45. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is as shown in the figure. What is the emf of each cell?



46. A 10 v battery of negligible internal resistance is connected across a 200 V battery and a resistance of 38Ω as shown in the figure. Find the value of the current in circuit.

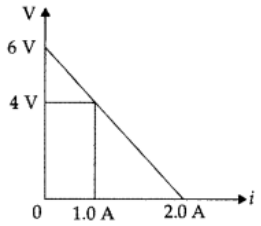


47. The plot of the variation of potential difference A across a combination of three identical cells in series, versus current is shown along the question. What is the emf and internal resistance of each cell?



48. A resistance R is connected across a cell of emf ε and internal resistance r. A potentiometer now measures the potential difference between the terminals of the cell as V. write the expression for 'r' in terms of ε, V and R.

49. The figure shows a plot of terminal voltage 'V' versus the current 'i' of a given cell. Calculate from the graph:
(a) emf of the cell and
(b) internal resistance of the cell.



50. A cell of emf 'E' and internal resistance V 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 = 4 Ω, the current is 1 A and when R is increased to 9 Ω, the current reduces to 0.5 A. Find the values of the emf E and internal resistance r. (Delhi 2012)

Electric Power, electric energy, Joule's law of heating effect

51. Prove that in parallel combination of electrical appliances, total power consumption is equal to the sum of the powers of the individual appliances. www.physicsinduction.com

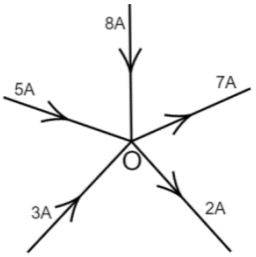
52. Which has greater resistance: 1 KW electric heater or a 100W filament bulb, both marked for 220V?

53. A heating element is marked 210 V, 630 W. What is the value of current drawn by the element when connected to a 210 V dc source?

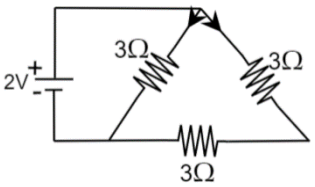
54. Nichrome and copper wire of same length and same radius are connected in series. Current I is passed through them. Which wire gets heated up more? Justify your answer.

Kirchhoff's rule

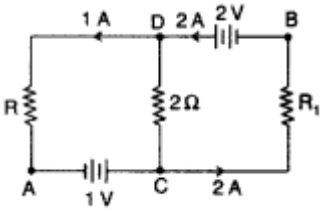
55. What is the value of current I at O in the adjoining circuit?



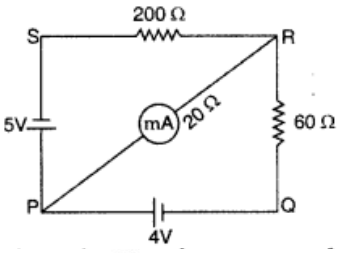
56. Mark the direction of current in the circuit as per Kirchhoff's first rule. What is the value of the main current in the shown network?



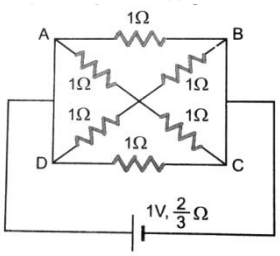
57. In the given circuit, assuming point A to be at zero potential, use Kirchhoff's rules to determine the potential A at point B.



58. The network PQRS, shown in the circuit diagram, has the batteries of 4 V and 5 V and negligible internal resistance. A milliammeter of 20 Ω resistance is connected between P and R. Calculate the reading in the milliammeter.



59. Find the current drawn from a cell of emf 1V and internal resistance 23Ω connected to the network shown in the figure. E=1V , r=23Ω.

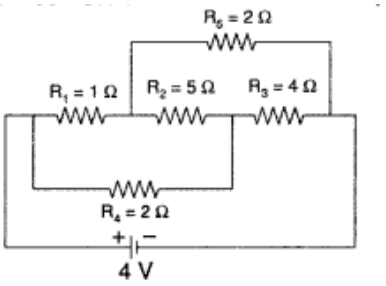


Wheatstone Bridge

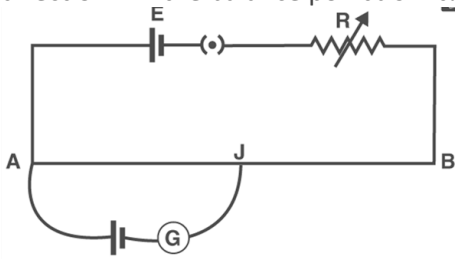
60. What do you say about the sensitiveness of Wheatstone bridge?

61. Explain with the help of a circuit diagram, how the value of an unknown resistance can be determined using a Wheatstone bridge?

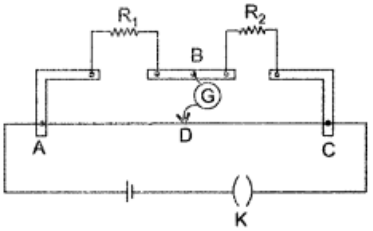
62. Find the current drawn from the cell:



63. AB is a potentiometer wire. If the value of R is increased, in which direction will the balance point J shift?



64. In the meter bridge experimental set up, shown in the figure, the null point 'D' is obtained at a distance of 40 cm from end A of the meter bridge wire. If a resistance of 10 Ω is connected in series with R_1, null point is obtained at AD = 60 cm. Calculate the values of R_1 and R_2.



A Common technique is ***folding the circuit*** on a vertical or horizontal line. If the circuit is symmetrical then we can fold on the line of symmetry. In the original circuit the voltages on each of the mirrored node pairs would be identical so we can use one set of resistors but at twice the current so half the resistance (R/2).
Note that the resistors on the axis of symmetry did not change their value.
The circuit so formed is different but it *is* **equivalent**. Internally you have changed the circuit but when looked at from the outside (the left wire and right wire) you can't tell the difference. If you measure the resistance between the two outer terminals it is the same in both cases. www.physicsinduction.com
In electrical circuits, if the components and their arrangement are identical on either side of a central axis, the circuit is said to have **mirror symmetry.** Symmetrical circuits have the property that the voltage and current relationships at corresponding points are equal, making analysis and problem-solving easier.

65. FIND THE EQUIVALENT RESISTANCE.

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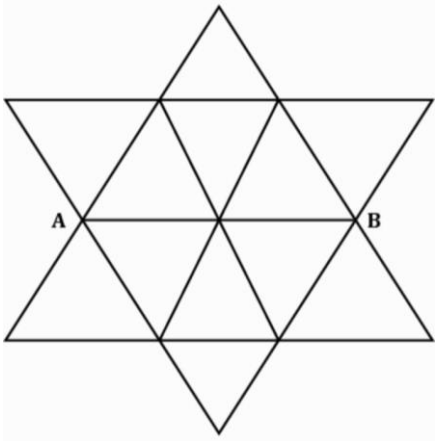
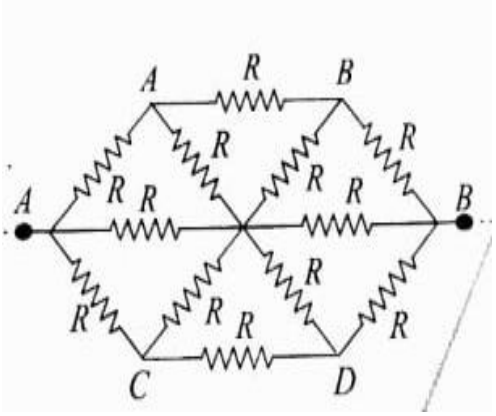
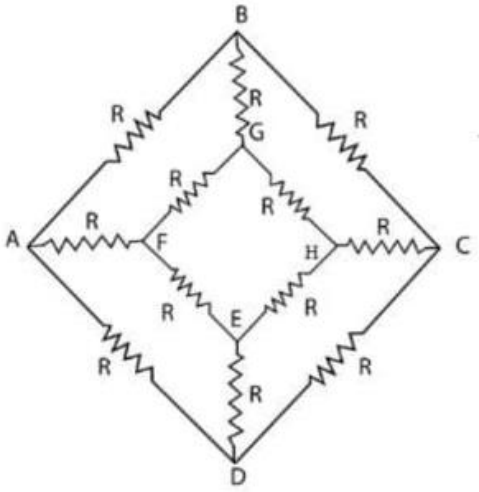
a)


A
B

b)


A
R
B
R
R
R
R
R
R
R
R
R
R
R
R
A
B
R
R
R
C
D

c)


B
R
G
R
R
R
R
R
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R
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F
H
C
R
E
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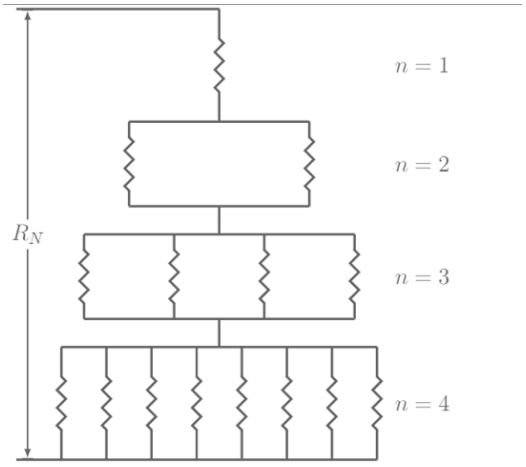
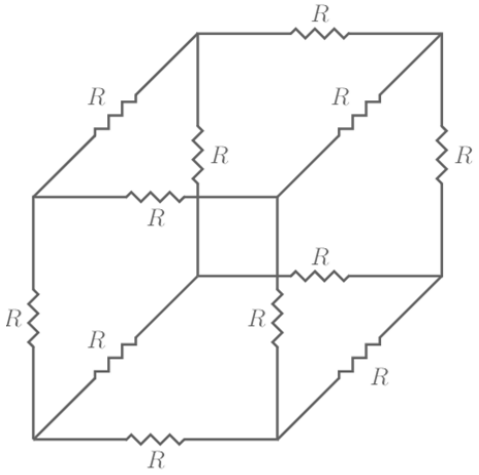
R
R
R
R
D

d)


$n = 1$
$n = 2$
R_N
$n = 3$
$n = 4$

e)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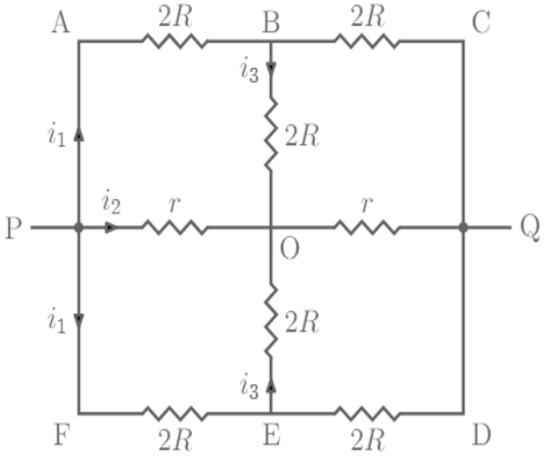
f)


A
2R
B
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C
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2R
i_2
r
r
P
Q
O
i_1
2R
i_3
F
2R
E
2R
D