fo/u fopkjr Hkh# tu] ugh vkjEHk dke] foifr n[k NkM rjr e/;e eu dj ';keA
i#"k flg ldYi dj] lgr foifr vud] ^cuk^ u NkM /;; dk] j?kcj jk[k VdAA

jfpr% ekuo /keZ i.krk
lnx# Jh j.kNkMnklth egkjkt

STUDY PACKAGE

Subject : PHYSICS

Topic : CURRENT ELECTRICITY

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CURRENT ELECTRICITY

Teko Classes, Maths : Suhag R. Kariya (S. R. K. Sir), Bhopal Phone : 0 903 903 7779, 0 98930 58881.

1. ELECTRIC CURRENT :

Electric charges in motion constitute an electric current. Any medium having practically free electric charges, free to migrate is a conductor of electricity. The electric charge flows from higher potential energy state to lower potential energy state. Positive charge flows from higher to lower potential and negative charge flows from lower to higher. Metals such as gold, silver, copper, aluminium etc. are good conductors.

2. ELECTRIC CURRENT IN A CONDUCTOR :

In absence of potential difference across a conductor no net current flows through a corss section. When a potential difference is applied across a conductor the charge carriers (electrons in case of metallic conductors) flow in a definite direction which constitutes a net current in it . These electrons are not accelerated by electric field in the conductor produced by potential difference across the conductor. They move with a constant drift velocity . The direction of current is along the flow of positive charge (or opposite to flow of negative charge). $i = nv_deA$, where V_d = drift velocity .

3. CHARGE AND CURRENT :

The strength of the current i is the rate at which the electric charges are flowing. If a charge Q coulomb passes through a given cross section of the conductor in t second the current I through the conductor is given by $I = \frac{Q}{t} = \frac{\text{Coulomb}}{\text{second}} = \frac{Q}{t}$ ampere .

Ampere is the unit of current . If i is not constant then $i = \frac{dq}{dt}$, where dq is net charge transported at a section in time dt.

In a current carrying conductor we can define a vector which gives the direction as current per unit normal, cross sectional area.

$$\text{Thus } \vec{J} = \frac{I}{S}\hat{n} \quad \text{or} \quad I = \vec{J} \cdot \vec{S}$$

Where $\hat{n}$ is the unit vector in the direction of the flow of current.

For random J or S, we use $I = \int \vec{J} \cdot \vec{ds}$

4. RELATION IN J, E AND ν_D:

In conductors drift vol. of electrons is proportional to the electric field in side the conductor as – $\nu_d = \mu E$

where μ is the mobility of electrons

current density is given as $J = \frac{I}{A} = ne\,\nu_d$

$= ne(\mu E) \quad = \sigma E$

where $\sigma = ne\mu$ is called conductivity of material and we can also write $\rho = \frac{1}{\sigma} \rightarrow$ resistivity of material. Thus $E = \rho J$. It is called as differential form of Ohm's Law.

5. SOURCES OF POTENTIAL DIFFERENCE & ELECTROMOTIVE FORCE :

Dry cells, secondary cells, generator and thermo couple are the devices used for producing potential difference in an electric circuit. The potential difference between the two terminals of a source when no energy is drawn from it is called the **" Electromotive force"** or **" EMF "** of the source. The unit of potential difference is volt.

$$1 \text{ volt} = 1 \text{ Amphere} \times 1 \text{ Ohm.}$$

6. ELECTRICAL RESISTANCE :

The property of a substance which opposes the flow of electric current through it is termed as electrical resistance. Electrical resistance depends on the size, geometery, temperature and internal structure of the conductor.

7. LAW OF RESISTANCE :

The resistance R offered by a conductor depends on the following factors :

$R \propto L$ (length of the conductor) ; $R \propto \frac{l}{A}$ (cross section area of the conductor)

at a given temperature $R = \rho \frac{l}{A}$.

Where ρ is the resistivity of the material of the conductor at the given temperature . It is also known as **specific resistance** of the material .

8. DEPENDENCE OF RESISTANCE ON TEMPERATURE :

The resistance of most conductors and all pure metals increases with temperature , but there are a few in which resistance decreases with temperature . If R_o & R be the resistance of a conductor at 0º C and θº C , then it is found that $R = R_o(1 + \alpha\theta)$.

Here we assume that the dimensions of resistance does not change with temperature if expansion coefficient of material is considerable. Then instead of resistance we use same property for resistivity as $\rho = \rho_0(1 + \alpha\theta)$

The materials for which resistance decreases with temperature, the temperature coefficient of resistance is negative.

Where α is called the temperature co-efficient of resistance . The unit of α is K^{-1} of $^oC^{-1}$ reciprocal of resistivity is called conductivity and reciprocal of resistance is called conductance (G) . S.I. unit of G is ohm.

9. OHM'S LAW :

Ohm's law is the most fundamental of all the laws in electricity . It says that the current through the cross section or the conductor is proportional to the applied potential difference under the given physical condition . V = RI . Ohm's law is applicable to only metalic conductors .

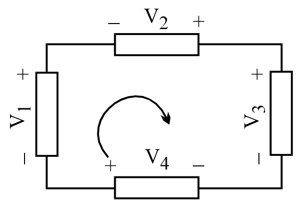
10. KRICHHOFF'S LAW'S :

I - Law (Junction law or Nodal Analysis) : This law is based on law of conservation of charge . It states that " The algebric sum of the currents meeting at a point is zero " or total currents entering a junction equals total current leaving the junction .

$\Sigma I_{in} = \Sigma I_{out}$. It is also known as KCL (Kirchhoff's current law) .

II - Law (Loop analysis) : The algebric sum of all the voltages in closed circuit is zero.

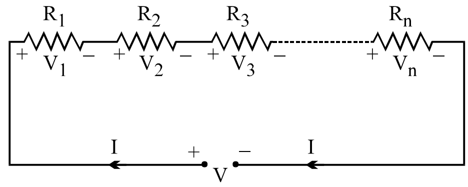
$\Sigma IR + \Sigma EMF = 0$ in a closed loop . The closed loop can be traversed in any direction . While traversing a loop if higher potential point is entered, put a + ve sign in expression or if lower potential point is entered put a negative sign .



$-V_1 - V_2 + V_3 - V_4 = 0$. Boxes may contain resistor or battery or any other element (linear or non-linear). It is also known as **KVL (Kirchhoff's voltage law)** .

11. COMBINATION OF RESISTANCES :

A number of resistances can be connected and all the complecated combinations can be reduced to two different types, namely series and parallel .



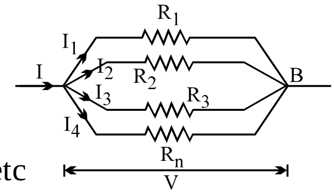
(i) RESISTANCE IN SERIES :

When the resistances are connected end toend then they are said to be in series . The current through each resistor is same . The effective resistance appearing across the battery .

$R = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots + R_n$ and

$V = V_1 + V_2 + V_3 + \ldots\ldots\ldots\ldots + V_n$.

The voltage across a resistor is proportional to the resistance



$V_1 = \dfrac{R_1}{R_1+R_2+\ldots\ldots+R_n}$ V;$V_2 = \dfrac{R_2}{R_1+R_2+\ldots\ldots+R_n}$ V ; etc

(ii) RESISTANCE IN PARALLEL :

A parallel circuit of resistors is one in which the same voltage is applied across all the components in a parallel grouping of resistors $R_1, R_2, R_3, \ldots\ldots, R_n$.

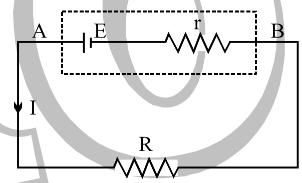
CONCLUSIONS :

(a) Potential difference across each resistor is same .

(b) $I = I_1 + I_2 + I_3 + \ldots\ldots\ldots\ I_n$.

(c) Effective resistance (R) then $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \ldots\ldots\ldots + \dfrac{1}{R_n}$.

(d) Current in different resistors is inversally proportional to the resistance .



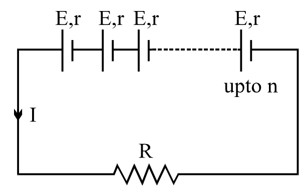
$I_1 : I_2 : \ldots\ldots\ldots\ I_n = \dfrac{1}{R_1} : \dfrac{1}{R_2} : \dfrac{1}{R_3} : \ldots\ldots\ldots : \dfrac{1}{R_n}$.

$I_1 = \dfrac{G_1}{G_1+G_2+\ldots\ldots+G_n}$ I , $I_2 = \dfrac{G_2}{G_1+G_2+\ldots\ldots+G_n}$ I , etc .

where $G = \dfrac{I}{R}$ = Conductance of a resistor .

12. EMF OF A CELL & ITS INTERNAL RESISTANCE :

If a cell of emf E and internal resistance r be connected with a resistance R the total resistance of the circuit is (R + r) .



$I = \dfrac{E}{R+r}$; $V_{AB} = \dfrac{E}{R+r}$ where

E = Terminal voltage of the battery .If $r \to 0$, cell is Ideal & $V \to E$.

13. GROUPING OF CELLS :

(i) CELLS IN SERIES :

Let there be n cells each of emf E , arranged in series.Let r be the internal resistance of each cell.

The total emf = nE . Current in the circuit $I = \dfrac{nE}{R+nr}$.

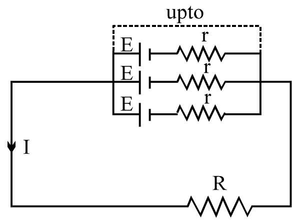
If nr << R then $I = \dfrac{nE}{R}$ $\longrightarrow$ Series combination should be used .

If nr >> R then $I = \dfrac{E}{r}$ $\longrightarrow$ Series combination should not be used .

(ii) **CELLS IN PARALLEL :**

If m cells each of emf E & internal resistance r be connected in parallel and if this combination be connected to an external resistance then the emf of the circuit = E .

Internal resistance of the circuit = $\frac{r}{m}$.



$I = \frac{E}{R+\frac{r}{m}} = \frac{mE}{mR+r}$.

If $mR << r$; $I = \frac{mE}{r}$ $\longrightarrow$ Parallel combination should be used .

If $mR >> r$; $I = \frac{E}{R}$ $\longrightarrow$ Parallel combination should not be used .

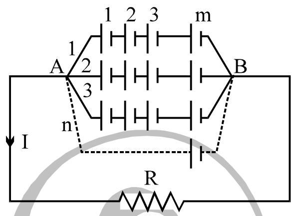
(iii) **CELLS IN MULTIPLE ARC :**

mn = number of identical cells .

n = number of rows

m = number of cells in each rows .

The combination of cells is equivalent to single cell of :



(a) emf = mE & **(b)** internal resistance = $\frac{mr}{n}$

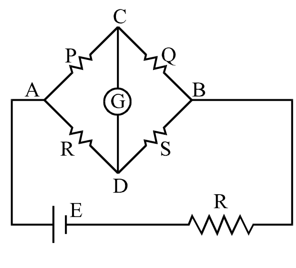
Current $I = \frac{mE}{R+\frac{mr}{n}}$. For maximum current nR = mr or

$R = \frac{mr}{n}$ = internal resistance of battery .

$I_{max} = \frac{nE}{2r} = \frac{mE}{2R}$.

WHEAT STONE NETWORK :

When current through the galvanometer is zero (null point or balance point) $\frac{P}{Q} = \frac{R}{S}$. When PS > QR; $V_C < V_D$ & PS <QR ; $V_C > V_D$ or PS = QR $\Rightarrow$ products of opposite arms are equal. Potential difference between C & D at null point is zero . The null point is not affected by resistance of G & E. It is not affected even if the positions of G & E are inter changed. $I_{CD} \propto (QR - PS)$.

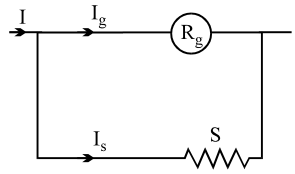


14. **POTENTIOMETER :**

A potentiometer is a linear conductor of uniform cross-section with a steady current set up in it. This maintains a uniform potential gradient along the length of the wire . Any potential difference which is less then the potential difference maintained across the potentiometer wire can be measured using this . The potentiometer equation is $\frac{E_1}{E_2} = \frac{I_1}{I_2}$.

15. AMMETER :

It is a modified form of suspended coil galvanometer it is used to measure current . A shunt (small resistance) is connected in parallel with galvanometer to convert into ammeter . $S = \frac{I_g R_g}{I - I_g}$; An ideal ammeter has zero resistance . where

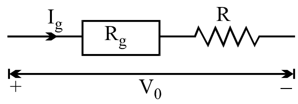


I_g = Maximum current that can flow through the galvanometer .
I = Maximum current that can be measured using the given ammeter .

16. VOLTMETER :

A high resistance is put in series with galvanometer . It is used to measure potential difference .

$I_g = \frac{V_o}{R_g + R}$.



$R \to \infty$, Ideal voltmeter .

17. RELATIVE POTENTIAL :

While solving an electric circuit it is convinient to chose a reference point and assigning its voltage as zero. Then all other potential are measured with respect to this point . This point is also called the common point .

18. ELECTRICAL POWER :

The energy liberated per second in a device is called its power . The electrical power P delivered by an electrical device is given by P = VI , where V = potential difference across device & I = current. If the current enters the higher potential point of the device then power is consumed by it (i.e. acts as load) . If the current enters the lower potential point then the device supplies power (i.e. acts as source) .

Power consumed by a resistor $P = I^2R = VI = \frac{V^2}{R}$.

19. HEATING EFFECT OF ELECTRIC CURRENT :

When a current is passed through a resistor energy is wested in over coming the resistances of the wire . This energy is converted into heat .

$W = VIt$ Joule ; $= I^2 Rt$ Joule ;$= \frac{V^2}{R}t$ Joule .

20. JOULES LAW OF ELECTRICAL HEATING :

The heat generated (in joules) when a current of I ampere flows through a resistance of R ohm for T second is given by :

$H = I^2 RT$ Joules ; $= \frac{I^2 RT}{4.2}$ Calories .

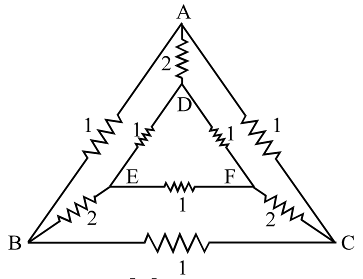
If current is variable passing through the conductor then we use for heat produced in resistance in time 0 to t is: $H = \int_0^t I^2 R dt$

21. UNIT OF ELECTRICAL ENERGY CONSUMPTION :

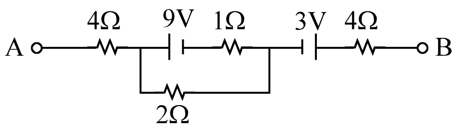
1 unit of electrical energy = Kilowatt hour = 1 KWh = 3.6×10^6 Joules.

EXERCISE # I

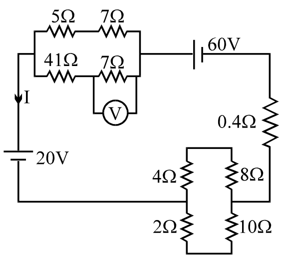
Q.1 A network of nine conductors connects six points A, B, C, D, E and F as shown in figure. The figure denotes resistances in ohms. Find the equivalent resistance between A and D.



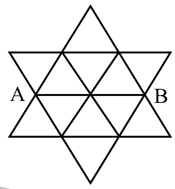
Q.2 In the circuit shown in figure potential difference between point A and B is 16 V. Find the current passing through 2Ω resistance.



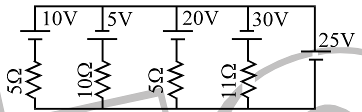
Q.3 Find the current I & voltage V in the circuit shown.



Q.4 Find the equivalent resistance of the circuit between points A and B shown in figure is: (each branch is of resistance = 1Ω)

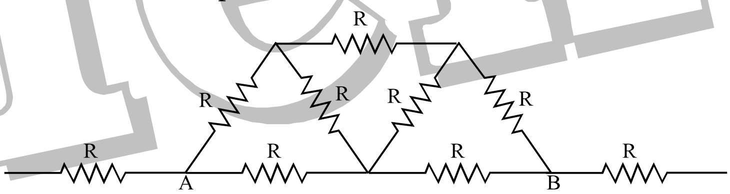


Q.5 Find the current through 25V cell & power supplied by 20V cell in the figure shown.

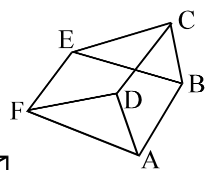


Q.6 If a cell of constant E.M.F. produces the same amount of the heat during the same time in two independent resistors R_1 and R_2, when they are separately connected across the terminals of the cell, one after the another, find the internal resistance of the cell.

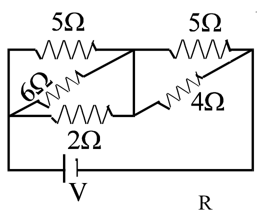
Q.7 Find the effective resistance of the network (see figure) between the points A and B. Where R is the resistance of each part.



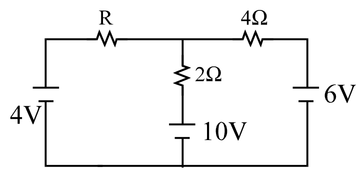
Q.8 In the circuit shown in figure, all wires have equal resistance r. Find the equivalent resistance between A and B.



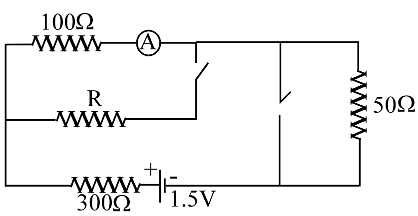
Q.9 Find the resistor in which maximum heat will be produced.



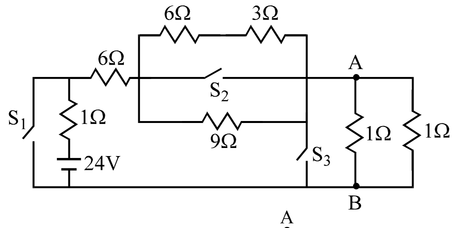
Q.10 For what value of R in circuit, current through 4Ω resistance is zero.



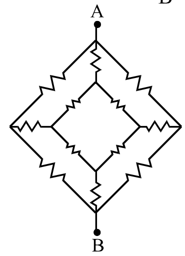
Q.11 In the circuit shown in figure the reading of ammeter is the same with both switches open as with both closed. Then find the resistance R. (ammeter is ideal)



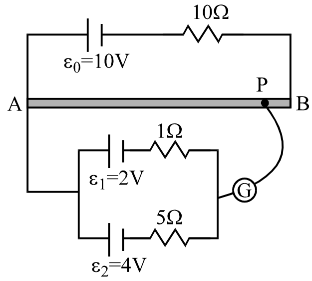
Q.12 If the switches S_1, S_2 and S_3 in the figure are arranged such that current through the battery is minimum, find the voltage across points A and B.



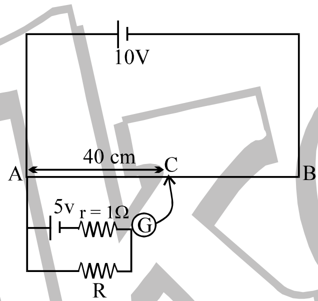
Q.13 The figure shows a network of resistor each heaving value 12Ω. Find the equivalent resistance between points A and B.



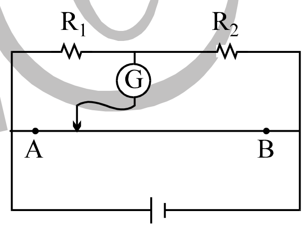
Q.14 A battery of emf $\varepsilon_0 = 10$ V is connected across a 1 m long uniform wire having resistance 10Ω/m. Two cells of emf $\varepsilon_1 = 2$V and $\varepsilon_2 = 4$V having internal resistances 1Ω and 5Ω respectively are connected as shown in the figure. If a galvanometer shows no deflection at the point P, find the distance of point P from the point a.



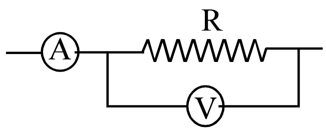
Q.15 A potentiometer wire AB is 100 cm long and has a total resistance of 10ohm. If the galvanometer shows zero deflection at the position C, then find the value of unknown resistance R.



Q.16 In the figure shown for gives values of R_1 and R_2 the balance point for Jockey is at 40 cm from A. When R_2 is shunted by a resistance of 10 Ω, balance shifts to 50 cm. find R_1 and R_2. (AB = 1 m):

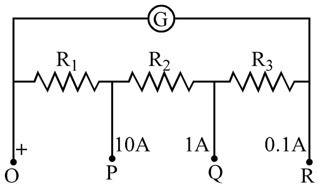


Q.17 A part of a circuit is shown in figure. Here reading of ammeter is 5 ampere and voltmeter is 96V & voltmeter resistance is 480 ohm. Then find the resistance R



Q.18 An accumulator of emf 2 Volt and negligible internal resistance is connected across a uniform wire of length 10m and resistance 30Ω. The appropriate terminals of a cell of emf 1.5 Volt and internal resistance 1Ω is connected to one end of the wire, and the other terminal of the cell is connected through a sensitive galvanometer to a slider on the wire. What length of the wire will be required to produce zero deflection of the galvanometer ? How will the balancing change (a) when a coil of resistance 5Ω is placed in series with the accumulator, (b) the cell of 1.5 volt is shunted with 5Ω resistor ?

Q.19 The resistance of the galvanometer G in the circuit is 25Ω. The meter deflects full scale for a current of 10 mA. The meter behaves as an ammeter of three different ranges. The range is 0–10 A, if the terminals O and P are taken; range is 0 – 1 A between O and Q ; range is 0 – 0.1 A between O and R. Calculate the resistance R_1, R_2 and R_3.



List of recommended questions from I.E. Irodov.

3.147, 3.149, 3.150, 3.154, 3.155, 3.169, 3.175, 3.176, 3.179, 3.186, 3.189, 3.190, 3.194, 3.196, 3.207

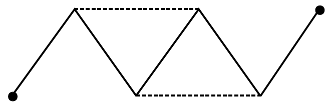
EXERCISE # II

Q.1 A triangle is constructed using the wires AB , BC & CA of same material and of resistance α, 2α & 3α respectively. Another wire of resistance $\alpha/3$ from A can make a sliding contact with wire BC. Find the maximum resistance of the network between points A and the point of sliding wire with BC.

Q.2(a) The current density across a cylindrical conductor of radius R varies according to the equation $J = J_0\left(1-\frac{r}{R}\right)$, where r is the distance from the axis. Thus the current density is a maximum J_o at the axis r = 0 and decreases linearly to zero at the surface r = R. Calculate the current in terms of J_o and the conductor's cross sectional area is $A = \pi R^2$.

(b) Suppose that instead the current density is a maximum J_o at the surface and decreases linearly to zero at the axis so that $J = J_0 \frac{r}{R}$. Calculate the current.

Q.3 What will be the change in the resistance of a circuit consisting of five identical conductors if two similar conductors are added as shown by the dashed line in figure.



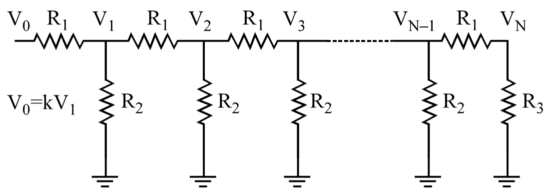
Q.4 The current I through a rod of a certain metallic oxide is given by $I = 0.2\ V^{5/2}$, where V is the potential difference across it. The rod is connected in series with a resistance to a 6V battery of negligible internal resistance. What value should the series resistance have so that :

(i) the current in the circuit is 0.44

(ii) the power dissipated in the rod is twice that dissipated in the resistance.

Q.5 A piece of resistive wire is made up into two squares with a common side of length 10 cm. A currant enters the rectangular system at one of the corners and leaves at the diagonally opposite corners. Show that the current in the common side is 1/5th of the entering current. What length of wire connected between input and output terminals would have an equivalent effect.

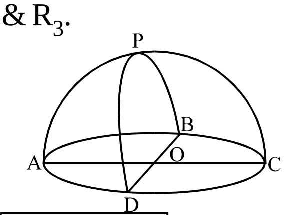
Q.6 A network of resistance is constructed with R_1 & R_2 as shown in the figure. The potential at the points 1, 2, 3,.., N are V_1, V_2, V_3 , .., V_n respectively each having a potential k time smaller than previous one. Find:



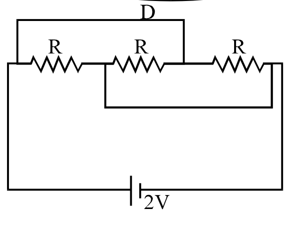
(i) $\frac{R_1}{R_2}$ and $\frac{R_2}{R_3}$ in terms of k

(ii) current that passes through the resistance R_2 nearest to the V_0 in terms V_0, k & R_3.

Q.7 A hemisphere network of radius a is made by using a conducting wire of resistance per unit length r. Find the equivalent resistance across OP.



Q.8 Three equal resistance each of R ohm are connected as shown in figure. A battery of 2 volts of internal resistance 0.1 ohm is connected across the circuit. Calculate R for which the heat generated in the circuit is maximum.



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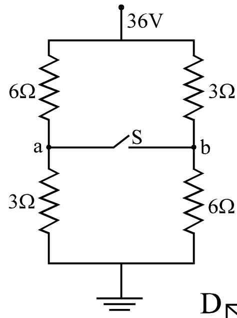
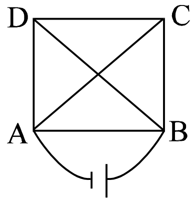
Q.9 A person decides to use his bath tub water to generate electric power to run a 40 watt bulb. The bath tube is located at a height of 10 m from the ground & it holds 200 litres of water. If we install a water driven wheel generator on the ground, at what rate should the water drain from the bath tube to light bulb? How long can we keep the bulb on, if the bath tub was full initially. The efficiency of generator is 90%.($g = 10 m/s^{-2}$)



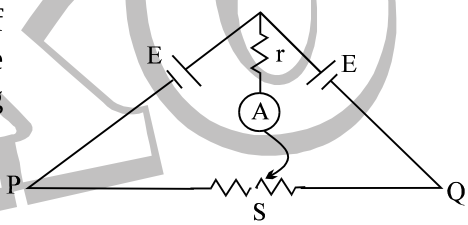
Q.10 In the circuit shown in figure, calculate the following :
(i) Potential difference between points a and b when switch S is open.
(ii) Current through S in the circuit when S is closed.



Q.11 The circuit shown in figure is made of a homogeneous wire of uniform cross-section. ABCD is a square. Find the ratio of the amounts of heat liberated per unit time in wire A-B and C-D.

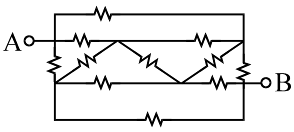
Q.12 A rod of length L and cross-section area A lies along the x-axis between x = 0 and x = L. The material obeys Ohm's law and its resistivity varies along the rod according to $\rho(x) = \rho_0 e^{-x/L}$. The end of the rod at x = 0 is at a potential V_0 and it is zero at x = L.
(a) Find the total resistance of the rod and the current in the wire.
(b) Find the electric potential in the rod as a function of x.

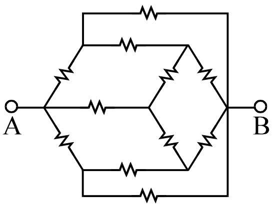
Q.13 In the figure. PQ is a wire of uniform cross-section and of resistance R_0. A is an ideal ammeter and the cells are of negligible resistance. The jockey J can freely slide over the wire PQ making contact on it at S. If the length of the wire PS is $f = 1/n^{th}$ of PQ, find the reading on the ammeter. Find the value of 'f' for maximum and minimum reading on the ammeter.



Q.14 An ideal cell having a steady emf of 2 volt is connected across the potentiometer wire of length 10 m. The potentiometer wire is of magnesium and having resistance of 11.5 Ω/m. An another cell gives a null point at 6.9 m. If a resistance of 5Ω is put in series with potentiometer wire, find the new position of the null point..

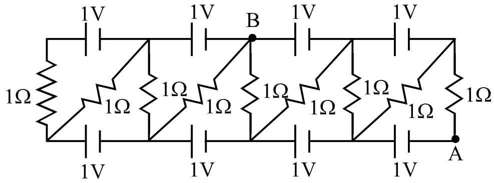
Q.15 Find the equivalent resistance of the following group of resistances between A and B. Each resistance of the circuit is R

(a) 

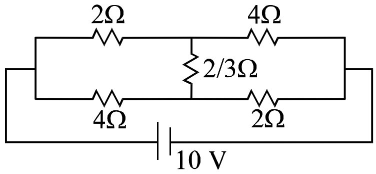
(b) 

Q.16 An enquiring physics student connects a cell to a circuit and measures the current drawn from the cell to I_1. When he joins a second identical cell is series with the first, the current becomes I_2. When the cells are connected are in parallel, the current through the circuit is I_3. Show that relation between the current is $3 I_3 I_2 = 2 I_1 (I_2 + I_3)$

Q.17 Find the potential difference $V_A - V_B$ for the circuit shown in the figure.



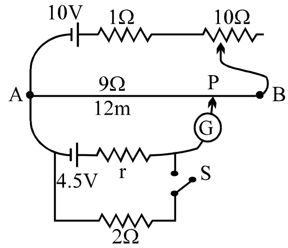
Q.18 A resistance R of thermal coefficient of resistivity = α is connected in parallel with a resistance = 3R, having thermal coefficient of resistivity = 2α. Find the value of α_{eff}.



Q.19 Find the current through $\frac{2}{3}\Omega$ resistance in the figure shown.

Q.20 A galvanometer having 50 divisions provided with a variable shunt s is used to measure the current when connected in series with a resistance of 90 Ω and a battery of internal resistance 10 Ω. It is observed that when the shunt resistance are 10Ω, 50Ω, respectively the deflection are respectively 9 & 30 divisions. What is the resistance of the galvanometer? Further if the full scale deflection of the galvanometer movement is 300 mA, find the emf of the cell.

Q.21 In the primary circuit of potentiometer the rheostat can be varied from 0 to 10Ω. Initially it is at minimum resistance (zero).



(a) Find the length AP of the wire such that the galvanometer shows zero deflection.

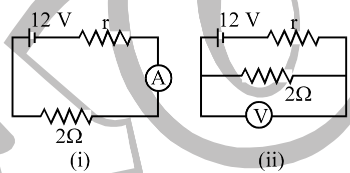
(b) Now the rheostat is put at maximum resistance (10Ω) and the switch S is closed. New balancing length is found to 8m. Find the internal resistance r of the 4.5V cell.

Q.22 A galvanometer (coil resistance 99 Ω) is converted into a ammeter using a shunt of 1Ω and connected as shown in the figure (i). The ammeter reads 3A. The same galvanometer is converted into a voltmeter by connecting a resistance of 101 Ω in series. This voltmeter is connected as shown in figure(ii). Its reading is found to be 4/5 of the full scale reading. Find

(a) internal resistance r of the cell

(b) range of the ammeter and voltmeter

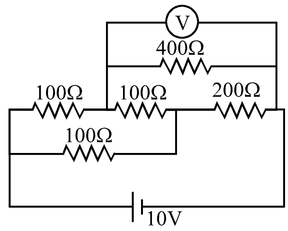
(c) full scale deflection current of the galvanometer



(i) (ii)

EXERCISE # III

Q.1 An electrical circuit is shown in the figure. Calculate the potential difference across the resistance of 400 ohm, as will be measured by the voltmeter V of resistance 400 ohm, either by applying Kirchhoff's rules or otherwise. [JEE'96, 6]



Q.2(i) A steady current flows in a metallic conductor of nonuniform cross-section. The quantity /quantities constant along the length of the conductor is / are : [JEE'97,1+2+5]

(A) current, electric field and drift speed
(B) drift speed only
(C) current and drift speed
(D) current only

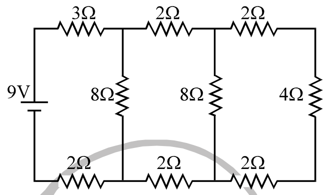
(ii) The dimension of electricity conductivity is _________.

(iii) Find the emf (E) & internal resistance (r) of a single battery which is equivalent to a parallel combination of two batteries of emfs V_1 & V_2 & internal resistances r_1 & r_2 respectively with their similar polarity connected to each other

Q.3 In the circuit shown in the figure, the current through :

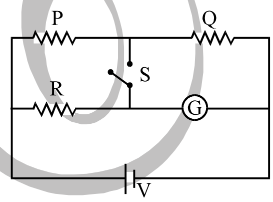
(A) the 3Ω resistor is 0.50 A
(B) the 3Ω resistor is 0.25 A
(C) 4 Ω resistor is 0.50 A
(D) the 4Ω resistor is 0.25 A

[JEE'98, 2]



Q.4 In the circuit shown, $P \neq R$, the reading of the galvanometer is same with switch S open or closed. Then

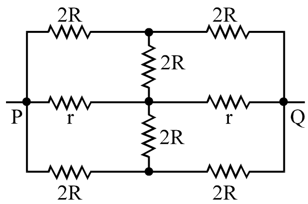
(A) $I_R = I_G$ (B) $I_P = I_G$ (C) $I_Q = I_G$ (D) $I_Q = I_R$ [JEE'99, 2]



Q.5 The effective resistance between the points P and Q of the electrical circuit shown in the figure is

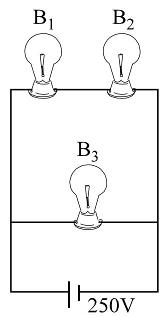
(A) 2 Rr / (R + r)
(B) 8R(R + r)/(3R + r)
(C) 2r + 4R
(D) 5 R/2 + 2r

[JEE 2002 (Scr), 3]

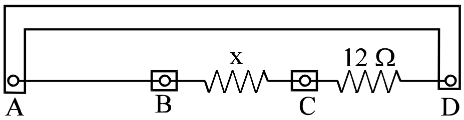


Q.6 A 100 W bulb B_1, and two 60 W bulbs B_2 and B_3, are connected to a 250 V source, as shown in the figure. Now W_1, W_2 and W_3 are the output powers of the bulbs B_1, B_2 and B_3 respectively. Then

(A) $W_1 > W_2 = W_3$
(B) $W_1 > W_2 > W_3$
(C) $W_1 < W_2 = W_3$
(D) $W_1 < W_2 < W_3$ [JEE 2002 (Scr), 3]



Q.7 A thin uniform wire AB of length 1 m, an unknown resistance X and a resistance of 12 Ω are connected by thick conducting strips, as shown in figure. A battery and a galvanometer (with a sliding jockey connected to it) are also available. Connections are to be made to measure the unknown resistance X using the principle of Wheatstone bridge. Answer the following question.



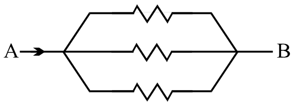
(a) Are there positive and negative terminals on the galvanometer?

(b) Copy the figure in your answer book and show the battery and the galvanometer (with jockey) connected at appropriate points.

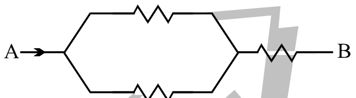
(c) After appropriate connections are made, it is found that no deflection takes place in the galvanometer when the sliding jockey touches the wire at a distance of 60 cm from A. Obtain the value of resistance X.

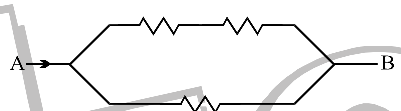
[JEE' 2002, 1 + 2 + 2]

Q.8 Arrange the order of power dissipated in the given circuits, if the same current is passing through all circuits and each resistor is 'r' [JEE' 2003 (Scr)]

(I) 

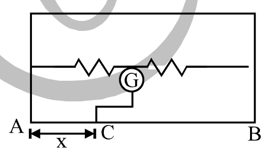
(II) 

(III) 

(IV) 

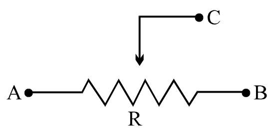
(A) $P_2 > P_3 > P_4 > P_1$ (B) $P_3 > P_2 > P_4 > P_1$ (C) $P_4 > P_3 > P_2 > P_1$ (D) $P_1 > P_2 > P_3 > P_4$

Q.9 In the given circuit, no current is passing through the galvanometer. If the cross-sectional diameter of AB is doubled then for null point of galvanometer the value of AC would [JEE' 2003 (Scr)]

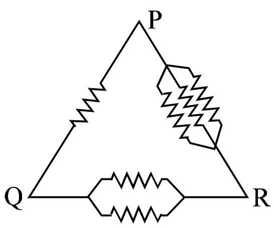


(A) x (B) x/2 (C) 2x (D) None

Q.10 How a battery is to be connected so that shown rheostat will behave like a potential divider? Also indicate the points about which output can be taken. [JEE' 2003]

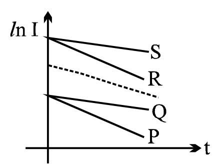


Q.11 Six equal resistances are connected between points P, Q and R as shown in the figure. Then the net resistance will be maximum between



(A) P and Q
(B) Q and R
(C) P and R
(D) any two points [JEE' 2004 (Scr)]

Q.12 In an RC circuit while charging, the graph of *l*n I versus time is as shown by the dotted line in the adjoining diagram where I is the current. When the value of the resistance is doubled, which of the solid curves best represents the variation of *l*n I versus time? [JEE' 2004 (Scr)]



(A) P (B) Q (C) R (D) S

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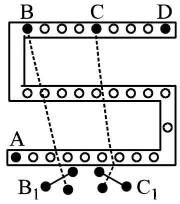
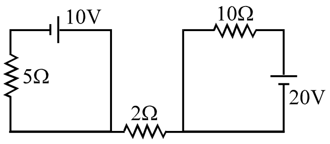
Q.13 For the post office box arrangement to determine the value of unknown resistance, the unknown resistance should be connected between [JEE' 2004 (Scr)]



(A) *B* and *C* (B) *C* and *D*
(C) *A* and *D* (D) B_1 and C_1

Q.14 Draw the circuit for experimental verification of Ohm's law using a source of variable D.C. voltage, a main resistance of 100 Ω, two galvanometers and two resistances of values 10^6 Ω and 10^{-3} Ω respectively. Clearly show the positions of the voltmeter and the ammeter. [JEE' 2004]

Q.15 In the figure shown the current through 2Ω resistor is



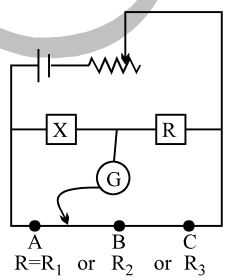
(A) 2 A (B) 0 A
(C) 4 A (D) 6 A

[JEE' 2005 (Scr)]

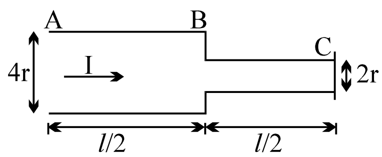
Q.16 An uncharged capacitor of capacitance 4μF, a battery of emf 12 volt and a resistor of 2.5 MΩ are connected in series. The time after which $v_c = 3v_R$ is (take ln2 = 0.693)
(A) 6.93 sec. (B) 13.86 sec. (C) 20.52 sec. (D) none of these
[JEE' 2005 (Scr)]

Q.17 A galvanometer has resistance 100Ω and it requires current 100μA for full scale deflection. A resistor 0.1Ω is connected to make it an ammeter. The smallest current required in the circuit to produce the full scale deflection is
(A) 1000.1 mA (B) 1.1 mA (C) 10.1 mA (D) 100.1 mA
[JEE' 2005 (Scr)]

Q.18 An unknown resistance X is to be determined using resistances R_1, R_2 or R_3. Their corresponding null points are A, B and C. Find which of the above will give the most accurate reading and why?
[JEE 2005]



Q.19 Consider a cylindrical element as shown in the figure. Current flowing the through element is I and resistivity of material of the cylinder is ρ. Choose the correct option out the following.



(A) Power loss in second half is four times the power loss in first half.
(B) Voltage drop in first half is twice of voltage drop in second half.
(C) Current density in both halves are equal.
(D) Electric field in both halves is equal. [JEE 2006]

ANSWER KEY

EXERCISE # I

Q.1 1Ω Q.2 3.5 A Q.3 I = 2.5 A, V = 3.5 Volts Q.4 $\frac{22}{35}\Omega$

Q.5 12A, –20W Q.6 $\sqrt{R_1R_2}$ Q.7 8/7 R Q.8 $\frac{3r}{5}$

Q.9 4Ω Q.10 1Ω Q.11 600Ω Q.12 1 V

Q.13 9Ω Q.14 46.67 cm Q.15 4 ohm Q.16 $\frac{10}{3}\ \Omega, 5\ \Omega$

Q.17 20 ohm Q.18 7.5 m, 8.75m, 6.25m Q.19 $R_1 = 0.0278\ \Omega$, $R_2 = 0.25\ \Omega$, $R_3 = 2.5\ \Omega$

EXERCISE # II

Q.1 (3/11)α Q.2 (a) $J_0A/3$; (b) $2J_0A/3$ Q.3 $\frac{R_2}{R_1} = \frac{3}{5}$

Q.4 (i) 10.52Ω ; (ii) 0.3125Ω Q.5 7/5 times the length of any side of the square

Q.6 (i) $\frac{(k-1)^2}{k}$; $\frac{k}{(k-1)}$ (ii) $\frac{\left((k-1)/k^2\right)V_0}{R^3}$ Q.7 $\frac{(2+\pi)\,a\,r}{8}$

Q.8 0.3Ω Q.9 4/9 kg/sec., 450 sec

Q.10 (i) $V_{ab} = -12$ V, (ii) 3 amp from b to a Q.11 $11+6\sqrt{2}$

Q.12 $R = \frac{\rho_0 L}{A}\left(1-\frac{1}{e}\right)$; $I = \frac{V_0 A}{\rho_0 L}\left(\frac{e}{e-1}\right)$; $V = \frac{V_0\,(e^{-x/L} - e^{-1})}{1-e^{-1}}$

Q.13 $\frac{\varepsilon}{r+R_0(f-f^2)}$; for I_{max} f = 0, 1 ; I_{min} f = 1/2 Q.14 7.2 m Q.15 (a) 5/7 R, (b) 9R/14

Q.17 $-\frac{22}{9}$ V Q.18 $\alpha_{eff} = \frac{5}{4}\alpha$ Q.19 1A Q.20 233.3Ω; 144V Q.21 (a) 6 m, (b) 1Ω

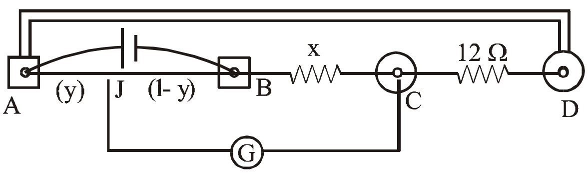
Q.22 (a) 1.01 W, (b) 0-5A, 0-10V, (c) 0.05 A

EXERCISE # III

Q.1 20/3 V Q.2 (i) D; (ii) $M^{-1}L^{-3}T^3A^2$; (iii) $\frac{V_1r_2 + V_2r_1}{r_1 + r_2}$, $\frac{r_1 r_2}{r_1 + r_2}$ Q.3 D

Q.4 A Q.5 A Q.6 D

Q.7 (a) No, (b)

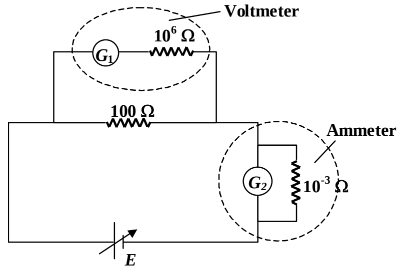


(c) 8 Ω Q.8 A Q.9 A

Q.10 Battery should be connected across A and B. Out put can be taken across the terminals A and C or B and C

Q.11 A Q.12 B Q.13 C

Q.14



Q.15 B Q.16 B Q.17 D

Q.18 This is true for $r_1 = r_2$; So R_2 given most accurate value Q.19 A

