04. Current Electricity

4.0 Basic Concepts :

Electric current :

1. Charge flows from higher potential to lower potential. Here charge means positive charge. Negative charge flows from lower potential to higher potential. Charge in motion constitutes current electricity.
2. A charge at rest produces electric field only and a moving charge produced both electric and magnetic field.
3. As charge is conserved, charge entering at one end per second of a conductor is equal to the charge leaving the other end per second.
4. The rate of flow of electric charge through any section of a conductor is called electric current.

   It is given by, $I = \dfrac{q}{t} = \dfrac{n.e}{t}$
5. If n particles each having a charge q across a given area in time 't', current associated with it is $I = \dfrac{nq}{t}$.
6. If a charge q is moving in a circle of radius 'r' with speed v, current associated with it is $I = \dfrac{qv}{2\pi r}$
7. If a charge q is moving in a circle of radius 'r' with frequency f, current associated with it is $I = qf$
8. Electric current is along the direction of motion of positive charge in solids, liquids and gases.

   In S.I. system, unit of current is ampere.
9. Current is the characteristic property of a given conductor. It is a fundamental quantity.
10. Electric current is a scalar Quantity. It does not obey parallelogram law of vectors.
11. A current of 1 ampere is that current which when following through each of two very long, straight conductors placed parallel to each other 1 m apart in free space produces a force of 2×10^{-7} N per metre length of each conductor. OR

    The current through a wire is called one ampere, if one coulomb of charge flows through the wire in one second. OR

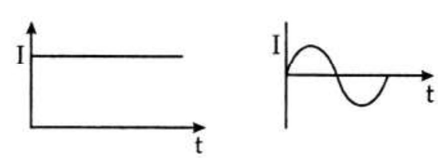
    The current flowing through the conductor is said to be 1 ampere if the electrons of about 6.25×10^{18} flow through the conductor per unit time.
12. Electrostatic unit of current is stat ampere.

    1 ampere = 3×10^{9} stat ampere

    Electromagnetic unit of current is abampere

    1 ab ampere = 10 ampere
13. The current, which is assumed to be flowing from positive (high potential) to negative (low potential) terminal of battery is called conventional current.

    It is always opposite to electronic current.
14. When current flows through a conductor, it remains uncharged.
15. For a given conductor current does not change with change in its cross section.
16. i) In conductors, current conduction take place due to electrons which was proved by Stewart and Tolman in 1917.
    ii) In semiconductors, current conduction take place due to electrons and holes.
    iii) In superconductors, current conduction take place due to coherent pair of electrons.
    iv) In liquid electrolyte, current conduction take place due to positive and negativ.e ions.
    v) In gases current conduction take place due positive ions and electrons.
17. If the magnitude and direction of current does not vary with time. It is known as direct current DC. If a current is periodic i.e. magnitude varies periodically and polarity reverses after each half cycle, it is known as alternating current (Ac).



Flow of current in a conductor:

1. There are two types of electrons in solids

i) The electrons in an atom which are more strongl y bound to the nucleus are known as bound electrons.

ii) The electrons which are loosely bound to the nucleus are known as free electrons. These electrons are free enough so as to move freely inside the material. But at room temperature they do not come out of the material.

2. In conductors there are large number of electrons called as conduction electrons. These electrons are always in the state of random motion.

i) In a metal fixed positive ions are present and a large number of free electrons will be moving randomly which collide with the lattice and follow a zig zag path.

ii) When no electric field is applied, the number of electrons passing in one direction is equal to the number of electrons passing in the opposite direction. So, the net current through any cross section is zero.

3. The average value of velocity of electron in the absence of external electric field is called average velocity of electrons. It is of the order of 10^4 m/s. The net flow of electrons through the conductor is zero in the absence of external field.

4. The velocity with which a free electron in a conductor gets drifted under the influence of the applied electric field, is called drift velocity. It is of the order of 10^{-4} m/s.

Drift velocity of electron $= v_d = \dfrac{J}{ne} = \dfrac{I}{nAe}$

5. When an electric field is applied, instead of straight line electrons drift opposite to the field. As a result there is a net transfer of electrons across a cross section resulting in current.

6. The current per unit area is called current density (J). $J = \dfrac{I}{A}$. It is a vector. It is directed along the direction of intensity of electric field. The laws of vector addition are not applicable for current density vector.

i) Its SI unit is ampere/m^2

ii) J is the characteristic property of a particular point inside the conductor and not of the whole conductor.

iii) Current is flux of current density.

7. Under the influence of external electric field, in conductors electrons will move opposite to direction of electric intensity.

In liquids and gases positive ions moves along the direction of electric field intensity and negative ions moves opposite to direction of electric field intensity.

The relation between current density, conductivity and electric intensity is,

$J = \sigma E$ also $E = \rho J$ where ρ is resistivity of conductor and σ is conductivity of conductor.

9. The drift velocity of electrons is also given by,

$$v_d = u + at = 0 + \frac{eE}{m}.t$$

$$v_d = \frac{e}{m}\frac{V}{l}.t \qquad \left(\because E = \frac{V}{l}\right)$$

where t is relaxation time,

10. The average time interval between two successive collisions of electrons with the vibrating atoms is called as relaxation time. It is of the order of 10^{-14} s.

11. Nature of electrical resistance:

$$v_d = \frac{I}{nAe} = \frac{e}{m}\frac{V}{l}t,$$

$$\text{Thus, } I = \frac{nAe^2}{m.l}V.t$$

$$R = \frac{V}{I} = \frac{m}{ne^2t}.\frac{l}{A}$$

$$\text{and resistivity} = \rho = \frac{RA}{l} = \frac{m}{ne^2t}$$

Thus, resistivity of a material of a conductor

i) is inversely proportional to the number of electrons per unit volume of the conductor.

ii) is inversely proportional to the relaxation time. (The relaxation time decreases with increase in temperature)

12. Explanation of Ohm's law:

$$E = \rho J = \rho\frac{I}{A} \text{ and } E = \frac{V}{l}$$

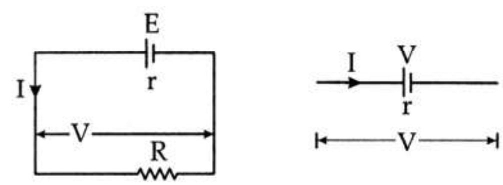
$$\therefore \frac{V}{l} = \frac{\rho I}{A}$$

$\therefore \quad V = I\dfrac{\rho l}{A}$

$\therefore \quad V = IR \qquad \because \quad R = \dfrac{\rho l}{A}$

Sources of e.m.f. :

1. A source which gives constant potential difference and hence flow of charge is called source of e.m.f. The sources of current are commonly known as sources of e.m.f. Thus, the cell is a source of e.m.f.
2. The amount of work done or energy spent by a cell in sending unit charge once through the complete circuit is called e.m.f. of a cell. OR
   E.m.f. of a cell is equal to the terminal potential difference of a cell when the cell is in open circuit (when no current is drawn from the cell).
   In S.I. system, unit of e.m.f. of a cell is volt and volt = joule / coulomb.
   Electrostatic unit of e.m.f. is stat volt.
   $$1 \text{ volt} = \frac{1}{300} \text{ stat volt}$$
3. The e.m.f. of a cell does not depend on
   i) quantity of electrolyte
   ii) distance between the electrodes
   iii) area of the electrodes.
4. The e.m.f. of a cell depend on
   i) nature of electrolytes
   ii) nature of electrodes.
5. Electromotive force is the characteristic property of the cell. The direction of current inside the cell is always from negative to positive electrode.
6. The amount of work done or energy spent by a cell in sending unit charge once through external resistance is called as terminal potential difference of a cell.
   The terminal potential difference of a cell is always less than e.m.f. of a cell. It is expressed in terms of volt.
   i) As the current drawn from the cell increases, terminal potential difference of a cell decreases but e.m.f. of a cell is always constant.
   ii) When no current is drawn from the cell then E=V
   Terminal P.D. of cell when cell being discharged is V = E – I r
   $$V = IR = \frac{ER}{R+r}$$
   Where I is circuit current, r = internal resistance of cell and R is external resistance.
   iii) Terminal P.D. of cell during charging is,
   $$V = E + Ir.$$
   iv) Terminal P.D. of cell is not fixed quantity. It depends on the external resistance.
   v) P.D. is less than e.m.f. during discharge and greater than e.m.f. during charging.



(a) Discharging cell $V = E - Ir$ (b) Charging a cell $V = E + Ir$

7. It the cell is short circuited the maximum current flows through the cell.
8. The direction of flow of current through the solution of the cell is from negative plate to positive plate and in external circuit, the direction of current is from positive plate to negative plate.
9. The resistance offered by electrolytic solution of a cell is called as internal resistance of cell. The internal resistance of ideal cell is zero.
10. Internal resistance of a cell is,
    i) Proportional to distance between the electrodes.
    ii) Proportional to concentration of electrolyte.
    iii) Inversely proportional to area of the electrodes.
    iv) Proportional to polarization.
    v) Proportional to concentration.
    vi) Inversely proportional to temperature of electrolyte.
11. Power transferred to the load is maximum when external resistance becomes equal to internal resistance.
12. **Lost volts :** It is the difference between e.m.f. and P.D. of a cell. It is used in driving the current between the terminals of cell.
    Loss volts = E – V = i r
13. **Back e.m.f. :** Due to the flow of current, the

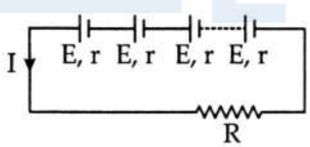
electrolyte decomposes into ions. These ions travel towards the opposite electrodes and produce e.m.f. in the opposite direction of the e.m.f. that maintains the current. This opposing e.m.f. is called back e.m.f. and the phenomenon is called electrolytic polarisation.

In some electrolyte cells hydrogen is liberated and formed as a layer or bubbles on cathode. This formation reduces the effective area of electrodes. As a result internal resistance decreases. As back e.m.f. increases gradually, the current may stop finally. To prevent polarisation, in voltaic cell, Lechlanche cell etc. Manganese dioxide is added which is used as depolariser.

14. The cell is a source of e.m.f.
    A device which converts chemical energy into electrical energy is called as cell.
15. **Capacity of a cell :** It is the ability to supply electric energy. It depends upon the size of the cell, nature of electrolytes and nature of electrodes (plates).
    It is expressed in ampere-hour.
    The capacity of a cell depends on rate of charging.
16. The term ampere-hour indicates, capacity of a cell for sending electric current through the circuit in one hour.

Combinations i.e. grouping of cells:

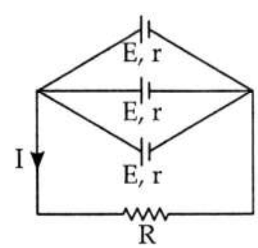
1. **Cells in series:** When 'n' identical cells each of e.m.f. E and internal resistance r, are connected in series so as to assist, then



i) net e.m.f. of combination = nE
ii) net internal resistance of cells = n . r
iii) net resistance of circuit = R + nr
iv) current through the circuit = $I = \frac{nE}{R + nr}$
v) If R < < nr, then $I = \frac{E}{r}$ = current due to single cell.
   Hence, their is no use of joining such cells in series.
vi) If R > > nr , then $I = \frac{nE}{R}$ = n times the current due to a single cell. Hence cells, whose total internal resistance is less than external resistance must be connected in series to obtain maximum current.
vi) If the e.m.f. of n cells and their internal resistances are different then
   a) $E = E_1 + E_2 + E_3 + ... + E_n$
   b) $r = r_1 + r_2 + r_3 + ... + r_n$
   c) $I = \frac{E}{R + r}$

2. **Cells in parallel:** When n identical cells each of e.m.f. E and internal resistance 'r' are connected in parallel then

i) net e.m.f. of combination= E
ii) net internal resistance of cells = $\frac{r}{n}$
iii) net resistance of circuit = $R + \frac{r}{n}$
iv) current through the circuit = $I = \frac{nE}{nR + r}$
v) If R << r/n then $I = n\frac{E}{r}$ = n times the current due to single cell. Hence cells, whose total internal resistance is much greater than the external resistance, must be connected in parallel to obtain maximum current.



vi) If $R >> \frac{r}{n}$ then $I = \frac{E}{r}$ = current due to single cell. Hence cells, whose total internal resistartce is much smaller than the external resistance are of no use of joining such cells in parallel.
vii) If the e.m.f. of n cells and their internal resistance are different then

a) $I = I_1 + I_2 + I_3 + ... + I_n$

b) $I = \dfrac{\left(\dfrac{E_1}{r_1}+\dfrac{E_2}{r_2}+.....+\dfrac{E_n}{r_n}\right)}{\left[1+R\left(\dfrac{1}{r_1}+\dfrac{1}{r_2}+.....+\dfrac{1}{r_n}\right)\right]}$ and

$$\frac{1}{r} = \frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}+.....+\frac{1}{r_n}$$

3. **Mixed grouping of cells:** When N cells each of e.m.f. E and internal resistance r are arranged in m rows, each row having n cells, then

i) net e.m.f. of combination = nE

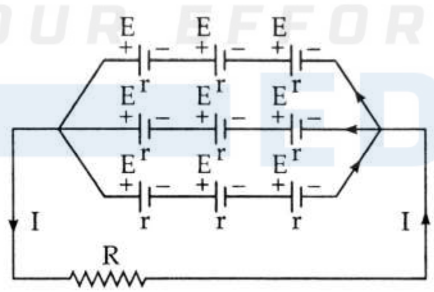
ii) net internal resistance of cells = $\dfrac{nr}{m}$

iii) net resistance of circuit = R + $\dfrac{nr}{m}$

iv) current through the circuit is,

$$I = \frac{mnE}{mR+nr} = \frac{NE}{nR+nr} \qquad \therefore \quad m \times n = N$$

Thus, the cells, whose total internal resistance is equal to the external resistance of the circuit then such cells should be mixed grouped in order to obtain large current.



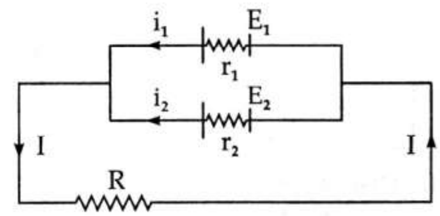
v) For maximum current R = nr/m, where nr/m is the internal resistance of the resultant battery.

vi) In mixed grouping of cells maximum current is obtained when the internal resistance of battery is equal to the external resistance. .

vii) This type of combination is used when more power is required in the circuit.

Note:

1. If two cells of e.m.f.s E_1 and E_2 and internal resistance r_1 and r_2 are connected in parallel, to an external resistance R.



i) Effective e.m.f. E = $\dfrac{E_1r_2+E_2r_1}{r_1+r_2}$

ii) Effective internal resistance r = $\dfrac{r_1r_2}{r_1+r_2}$

iii) $I = \dfrac{E}{R+r} = \dfrac{E_1r_2+E_2r_1}{r_1r_2+R(r_1+r_2)}$

iv) $I_1 = \dfrac{E_1-V}{r_1} = \dfrac{E_1-IR}{r_1}$

v) $I_2 = \dfrac{E_2-V}{r_2} = \dfrac{E_2-IR}{r_2}$

2. When two cells are arranged in series so as to oppose, then

i) net e.m.f. of combination = $E_1 - E_2$ ($E_1 > E_2$)

ii) net internal resistance of cell = $r_1 + r_2$

iii) net resistance of circuit = $R + r_1 + r_2$

iv) current through the circuit = $I = \dfrac{E_1-E_2}{R+r_1+r_2}$

3. **Wrongly connected cells:** If 'n' cells each of e.m.f. 'E' and internal resistance 'r' are connected in series and by mistake 'rn' cells are wrongly connected, to an external resistance 'R' then

i) Total e.m.f. of the combination, $E_1 = (n - 2m)$ E

ii) Total internal resistance = nr

iii) Total resistance of the circuit = R + nr

iv) Current through the circuit, $i = \dfrac{(n-2m)E}{R+nr}$

Important points to remember about cells :

1. When the cells is discharging,

$$I = \frac{E}{R+r} \text{ and } \frac{V}{E} = \frac{R}{R+r}$$

2. When the cells is charging,

$$I = \frac{V-E}{r} \qquad \Rightarrow V = E + 1\ r$$

3. When the cells is in open circuit,

   $R = \infty$ then $I = a$ and $V = E$

4. When the cell is short circuited $R = 0$

   $$I = \frac{E}{r} \text{ and } V = 0$$

   $\Rightarrow$ short circuit current of a cell is maximum

5. A cell neither creates nor destroys charge but maintains the flow of charge present in various parts of the circuit.
6. A standard cell means its e.m.f. is precisely specified.

   E.x.: Weston cadmium cell

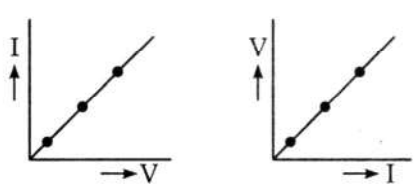
7. A cell is a source of constant e.m.f. and not of constant current.
8. The current inside a cell is always due to motion of both positive and negative ions while out side depends on the circuit element.
9. A fresh cell gives more current as compared to old one for the same load resistance.
10. The direction of current inside a cell is from negative to positive terminal.
11. While charging a cell, the direction of current is from positive to negative electrode.

    While drawing current form the cell, is direction is from negative to positive electrode inside the cell.

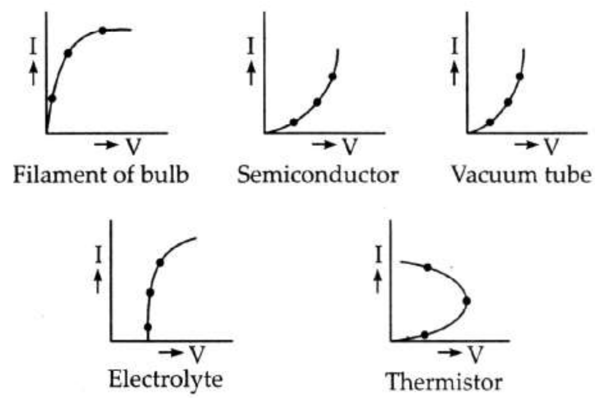
12. If the e.m.f.'s of primary and secondary cells are equal then current given by a secondary cell is more than that from primary cell.

Ohm's law:

1. The relation between current and potential difference was given by George Ohm in 1828. Ohm's law is applicable for metallic conductors.
2. **Statement:** If the physical state of the conductor remains unchanged then the current flowing through the conductor is directly proportional to potential difference between the ends of conductor Mathematically, $V \propto I$ or $V = I R$
3. Ohm's law is obeyed by metal alloys. They are called ohmic conductors.
4. Graph drawn between I-V for ohmic conductor is straight line passing through origin.



5. Slope of graph obtained by plotting V on Y-axis and I on X-axis gives resistance.
6. Ohm's law is not obeyed by vacuum tubes, Transistors, discharge tubes, electrolyte, thermistor. They are called non ohmic conductors. Graph drawn between' I-V for non ohmic conductors is a curve as shown.



7. Slope of V- I graph is not constant. Here this slope gives dynamic resistance

   $$\Rightarrow r = \frac{\Delta V}{\Delta I}$$

Resistance :

1. The property by virtue of which a conductor opposes the flow of charge in it is known as resistance.
2. It is measured as the ratio between potential difference between the ends of the conductor and current flowing in the conductor $\Rightarrow R = V/I$.
3. SI unit of resistance is Ohm.

   1 Ohm = 1 volt/lamp

4. Ohm is the resistance of a conductor through which a current of 1 ampere flows when the potential difference between its ends is 1 volt.
5. Dimensions of R – $[ML^2 T^{-3} I^{-2}]$
6. **Conductance:**

i) The reciprocal of resistance is known as conductance $\Rightarrow G = 1/R$

ii) SI unit of Gis siemen (S) (or ohm^{-1} or mho)

iii) Conductance decreases on increasing temperature.

Dependence of resistance :

1. The resistance of a body depends on its shape, size, material and temperature.
2. For good conductors resistance is very low and

for insulators or bad conductors it is high.

3. Resistance of a conductor is directly proportional to its length and inversely proportional to its area of cross section.

$$R \propto \frac{l}{A} \Rightarrow R = \rho\frac{l}{A}$$

Here ρ is known as resistivity or specific resistance,

$$R = \frac{\rho l}{\pi r^2}$$ wehre r is radilus of cross section.

4. Resistance does not depend on current and potential difference.
5. Though resistance' of a linear conductor is independent of applied voltage, for a given body it is not unique and depends on length and area of cross section. (i.e. how the potential difference is applied).

If l, b, h denote length, breadth and thickness of a slab, (l > b > h),

$$R_{max} = \frac{\rho l}{bh} \quad \text{and} \quad R_{min} = \frac{\rho h}{lb}$$

Variation of resistance with temperature

1. If R_0 and R, are resistance 0 °C and t°C, then $R_t = R_0(1 + \alpha t)$

Here α is temperature coefficient of resistance.

2. The temperature coefficient of resistance is equal to increase in resistance per unit original resistance at 0° C per unit rise in temperature.
3. If R_1 and R_2 are resistance at t_1 °C and t_2°C,

then $$\alpha = \frac{R_2 - R_1}{R_1 t_2 - R_2 t_1}$$

4. α is positive for most of metals in pure form.

α is negative for semiconductors, mica, carbon.

α is very small or nearly zero for constantan and manganin.

Constantan is an alloy of copper and nickel.

Manganin is an alloy of copper, manganese and nickel.

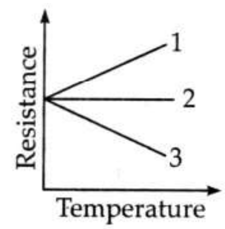
5. Variation of resistance with temperature as shown in the graph

1 - For metal conductor

2 - For manganin or constantan

3 - For semiconductor

6. Resistance of any conductor at absolute zero is zero.



Special resistors :

1. In resistance boxes, standard resistors manganin wires are used. Because the temperature coefficient of resistance is negligible.
2. In metre bridges or potentiometer, manganin or constantan wires are used. Because specific resistance is more and temperature coefficient of resistance is negligible.
3. Fuse wire is always connected in series in the circuit. Fuse wire is an alloy of lead and tin which has high resistance and low melting point.
4. In electric heater elements nichrome is used. Because its specific resistance is high, melting point is high and low temperature coefficient of resistance.

Thermistor :

1. It is a heat sensitive non ohmic device.
2. Semiconductor compounds like oxides of nickel, iron, cobalt, copper etc., are used in the preparation of thermistor. It is usually enclosed in a capsule enclosed with epoxy surface.
3. One type of thermistor has positive temperature coefficient of resistance. When it is placed in series with a battery and a galvanometer, the current in the circuit decreases on heating. So, galvanometer shows a fall in deflection. Here resistance of thermistor increases with rise of temperature.
4. Another type of thermistor has negative temperature coefficient of resistance. In this case resisatnce decreases with rise of temperature.
5. Thermistors with negative temperature coefficient can be used as resistance thermometers. These can measure temperatures of the order 10 K.
6. Thermistor with negative temperature coefficient are used to protect against the surges in circuits which may damage equipment like valves, heaters etc.

7. Thermistors can be used as thermostats.
8. A typical thermistor can detect small change in temperature of about 0.001°C. It is used to measure the temperature in the range of –100°C to 300°C.

Specific resistance or resistivity :

1. Specific resistance depends on nature of material and independent of dimensions of the given conductor.
2. Specific resistance depends on temperature of the material.
3. The variation of resistivity with temperature is given by $\rho = \rho_0(1 + \alpha\ t)$.

   Here a is temperature coefficient of resistivity.

   α is positive for metals and negative for Bi, Sb and semiconductors.
4. In general resistivity of an alloy is greater than that of constituent elements.

   e.g. : For manganin resistivity is more than the constituent metals.
5. In general addition of impurity increases the resistivity.
6. SI unit of specific resistance is ohm - metre
7. Its dimensions are $[M\ L^3 T^{-3}\ I^{-2}]$.
8. For silver and copper resistivity is less for nichrome, manganin constantan it is more.

   The general order is $\rho_{alloy} > \rho_{semiconduct} > or\ \rho_{conductor}$
9. The reciprocal of specific resistance is known as specific conductance or conductivity.

$$\sigma = \frac{1}{\rho}$$

10. If E is intensity of electric field and J is current density, $\rho = \dfrac{E}{J}$ and $\sigma = \dfrac{J}{E}$.

More about resistances:

1. In m is mass of conductor, V is its volume and' d' is the density,

   for $R = \dfrac{\rho l}{A}$

   we can write $R = \dfrac{\rho l^2}{Al} = \dfrac{\rho l^2}{V} \Rightarrow R = \dfrac{\rho l^2 d}{m}$

   $$\Rightarrow \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \left(\frac{l_1}{l_2}\right)^2 \times \frac{d_1}{d_2} \times \frac{m_2}{m_1}$$

   (for two different conductors or wires of different materials)
2. If two wires are made of different materials, ratio of their resistances is,

   $$\frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \frac{A_2}{A_1}$$

   $$\Rightarrow \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \left(\frac{r_2}{r_1}\right)^2$$

   (r_1 and r_2 are radii of cross section)
3. If two wires are made of same material with different masses and different lengths, ratio of their resistances is,

   $$\frac{R_1}{R_2} = \left(\frac{l_1}{l_2}\right)^2 \times \frac{m_2}{m_1}$$
4. If two wires are made of same material but have different dimensions then

   $$\frac{R_1}{R_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \frac{l_1}{l_2} \times \left(\frac{r_2}{r_1}\right)^2$$
5. If a wire of resistance R_1 is stretched from its initial length l_1 to final length l_2, its finai resistance is R_2, such that $\dfrac{R_1}{R_2} = \left(\dfrac{l_1}{l_2}\right)^2$

   In this case volume is constant.

   Here percentage change in resistance of the wire is,

   $$\left(\frac{l_2^2 - l_1^2}{l_1^2}\right) \times 100$$
6. If a wire of resistance R_1 is stretched from its initial radius of cross section r_1 to final radius of cross section r_2 its final resistance is R_2 such that

   $$\frac{R_1}{R_2} = \left(\frac{r_2}{r_1}\right)^4$$
7. If a wire of resistance R is stretched such that its final length is n times the initial· length, the new resistance is n^2 R.

   Here percentage change in resistance is $(n^2 - 1) \times 100$.
8. If a wire of resistance R is stretched such that its radius of cross section reduces to $(1/n)^{th}$, the new

resistance is n^4 R.

9. If a wire of resistance R is stretched such that its cross sectional area reduces to (1/n)th, the new resistance is n^2 R.

10. Percentage changes,

$$\frac{\Delta R}{R}\% = 2\frac{\Delta l}{l}\%,\ \frac{\Delta R}{R}\% = -4\frac{\Delta r}{r}\%,$$

$$\frac{\Delta R}{R}\% = -2\frac{\Delta A}{A}\%$$

11. If a wire of resistance R is bent at the middle and the two parts are kept one over the other, new resistance is R/4.

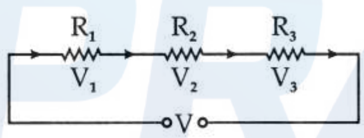
12. A cylindrical tube of length l has inner radius r_1 and outer radius r_2. The resistancebetween its ends faces is,

$$R - \frac{\rho l}{\pi(r_2^2 - r_1^2)}$$

Resistances in series:

1. Current in each resistance is same

$\Rightarrow I_1 : I_2 : I_3 = 1 : 1 : 1$



2. Potential difference across each resistance is different and is proportional to the resistance. $V_1 : V_2 : V_3 = R_1 : R_2 : R_3$ and $V_1 + V_2 + V_3 = V$

$$\Rightarrow\ V_1 = \frac{VR_1}{(R_1 + R_2 + R_3)},$$

$$V_2 = \frac{VR_2}{(R_1 + R_2 + R_3)}$$

$$V_3 = \frac{VR_3}{(R_1 + R_2 + R_3)}$$

3. Equivalent resistance of the arrangement is,

$R = R_1 + R_2 + R_3$

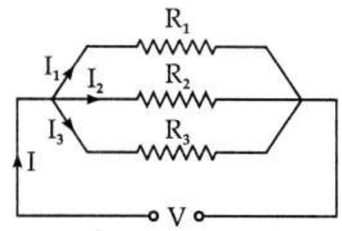
Effective resistance is greater than any individual resistance.

4. If n wires each of resistance R are connected in series, effective resistance is nR.

5. Effective conductance G is given by

$$\frac{1}{G_1} + \frac{1}{G_2} + \frac{1}{G_3} + ...$$

Resistance in parallel:



1. Potential difference across each resistance is same

$\Rightarrow V_1 : V_2 : V_3 = 1 : 1 : 1$

2. Currents in the resistors are in the rate of reciprocals of the resistances.

$$\Rightarrow I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3} \text{ and } I = I_1 + I_2 + I_3$$

3. Equivalent resistance of the arrangement is R such that $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Equivalent conductance $G = G_1 + G_2 + G_3 + ...$

4. Effective resistance is less than any individual resistance.

5. If two resistors are in parallel,

$$R_P = \frac{R_1R_1}{R_1 + R_2} \text{ and } I_1 = \frac{IR_2}{(R_1 + R_2)},\ I_2 = \frac{IR_1}{(R_1 + R_2)}$$

6. If n wires each of resistance R are connected in parallel equivalent resistance is R/n.

If those wires are first connected in series and then in parallel, ratio of the equivalent resistances in these two cases is,

$$\frac{R_s}{R_P} = n^2$$

7. A wire of resistance R is cut into n identical pieces and those are connected in parallel.

Then equivalent resistance is R/n^2.

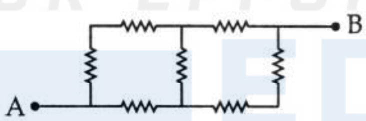
8. Two resistances R_1 and R_2 are first connected in series and then in parallel, if R_s and R_p are effective resistances in these two cases, then they are given by

$$R_1 \text{ or } R_2 = \left(\frac{R_s \pm \sqrt{R_s^2 - 4R_sR_p}}{2}\right)$$

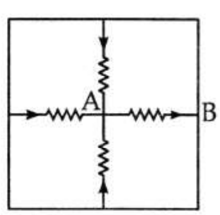
9. If n wires of equal resistances are connected in different combinations, different possible resistances one can obtain is (2n – 1).
If those wires are of unequal resistances the different possible resistances would be 2n (n > 2).

Typical circuits :

1. If a wire of resistance R is bent in the form of a regular polygon of n sides, effective resistance between any two adjacent sides is $\frac{(n-1)R}{n^2}$
2. If n wires each of resistance R are connected to form a closed polygon, effective resistance between any two adjacent side is $\left(\frac{n-1}{n}\right)$ R
3. If 12 wires each of resistance R are connected to form a cube, effective resistance between the ends of longest diagonal is 5 R/6.
Effective resistance between the side ends is 7 R/12 Effective resistance between the ends of face diagonal is 3 R/4.
Effective resistance between vacant edge of cube is 7 R/5.
4. If seven resistances each R are connected as shown, equivalent resistance between A and B is 7 R/5

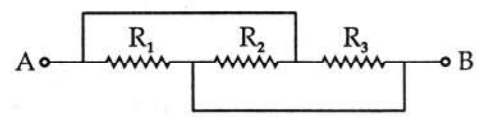


5. If four resistances each R are connected as shown, equivalent resistances between A and B is R/4



6. If three resistances R_1, R_2, R_3 are connected as shown effective resistances between A and B is

$$\frac{R_1\ R_2\ R_3}{R_1R_2 + R_2R_3 + R_3R_1}$$



4.1 Kirchhoff's laws

1. Kirchhoff's laws are used to calculate current, potential difference and resistances in complicated circuits. Kirchhoff's laws deals with conservation of energy.
2. **Kirchhoff's first law:**
(Kirchhoff's current law, junction theorem)
i) Kirchhoff's current law states that, the algebraic sum of the currents at the junction point in any electric circuit is always equal to zero
i.e. $\Sigma I = 0$.
ii) Sign conventions : The currents flowing' towards junction point are taken as positive and the currents flowing away from the junction point are considered as negative.
3. Kirchhoff's current law deals with the conservation of charge.
4. **Kirchhoff's voltage law:**
(Kirchhoff's second law, loop theorem, mesh theorem)
i) Kirchhoff's second law states that if the circuit is traversed in the same direction then algebraic sum of the potential differences across the resistance and e.m.f.s of the cell is equal to zero.
i.e. $\Sigma\ IR + \Sigma\ E = 0$
ii) Sign conventions:
a) If the closed circuit is traversed in the direction of current then the p.d. across the resistance is taken as negative and in opposite direction of current it is taken as positive.
b) If the cell is traversed from positive terminal to the negative terminal then its e.m.f. is taken as negative. If the cell is traversed from negative terminal to the positive terminal then its emf is taken as positive.
5. Kirchhoff's voltage law deals with the conservation of energy.
6. In steady state, the branch of the circuit containing a capacitor acts as an open circuit. In steady state, the inductor acts as a conductor having no resistance.

7. When current I flows through a cell of e.m.f. E and internal resistance r, the p.d. across its two terminals is given by,

i) $V = E - Ir$, if the current flows through the cell from its negative to positive terminal.

ii) $V = E + Ir$, if the current flows through the cell from its positive to negative terminal.

8. In applying kirchhoff's laws to electrical networks, the direction of current may be arbitrarily chosen. If the assumed direction of current is not the actual direction, then after applying the loop or mesh rule, we get – ve sign to that current. If the assumed direction is same as actual direction, we get +ve sign.

4.2 Wheatsone's network

1. **Principle:** There is no flow of electric current between any two equipotential points of an electric circuit.
   It was designed by Charles Wheatstone in 1843.
2. It is used to determine unknown resistance.
3. **Construction:** Different forms of network are as shown in figures.

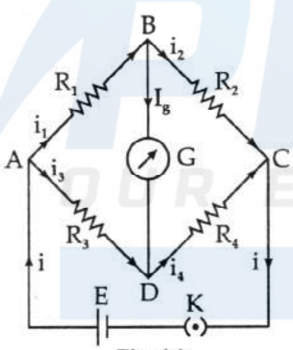


Fig. (a)

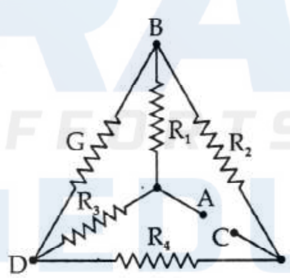


Fig. (b)

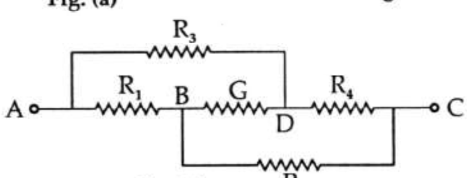


Fig. (c)

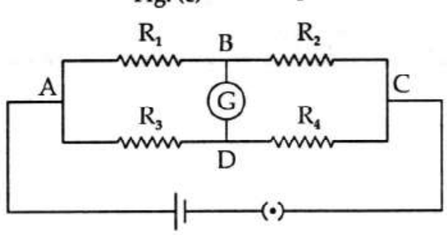


Fig. (d)

4. For balanced bridge (i.e. null condition or neutral condition or condition of equipotentiality),

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

5. For balanced bridge, $I_g = 0$, $V_B = V_D$, $V_{BD} = 0$.
6. For balanced bridge, R_1 and R_2 are in series (R_{S1}) R_3 and R_4 are in series (R_{S2}), Now R_{S1} and R_{S2} are in parallel. Therefore equivalent resistance between point A and point C is,

$$R_{AC} = \frac{R_{S1}R_{S2}}{R_{S1}+R_{S2}} = \frac{(R_1+R_2)(R_3+R_4)}{(R_1+R_2)+(R_3+R_4)}$$

7. In Wheatstone's network, if $R_1 = R_2 = R_3 = R_4 = R$ (suppose) whatever may be G then equivalent resistance between point A and point C is, $R_{AC} = R$.
8. The sensitivity of Wheatstone's network depends on resistance. The sensitivity of Wheatstone's network is maximum if arm ratio of network is one i.e. (i) $R_1 = R_2 = R_3 = R_4$ or (ii) $R_1 = R_2$ and $R_3 = R_4$.

   If $R_3 > \frac{R_2R_4}{R_1}$ then current flows from B to D

   and

   if $R_3 > \frac{R_2R_4}{R_1}$ then it flows from D to B.

10. For unbalanced bridge, .
   The potential difference between points B and D in an unbalanced Bridge is given by

$$V_{BD} = V_B - V_D = \frac{I(R_2R_3 - R_1R_4)}{(R_1+R_2+R_3+R_4)}$$

or $$V_{BD} = V_B - V_D = \frac{E(R_2R_3 - R_1R_4)}{(R_1+R_2)(R_3+R_4)}$$

ii) For the unbalanced network, resistance between A and C is,

$$R_{AC} = \frac{R_1R_2\ (R_3+R_4) + R_3R_4\ (R_1+R_2) + G\ (R_1+R_2)(R_3+R_4)}{G\,(R_1+R_2+R_3+R_4) + (R_1+R_3)(R_2+R_4)}$$

iii) For the unbalanced network, current through the galvanometer is

$$I_g = \frac{E(R_2R_3 - R_1R_4)}{R_1R_2\ (R_3+R_4) + R_3R_4\ (R_1+R_2) + G\,(R_1+R_2)(R_3+R_4)}$$

11. The metre bridge and post-office box are the applications of Wheatstone's network.

4.3 Metre bridge or Slide wire bridge

1. Metre bridge is modification of Wheatsone's network. It was designed by Wheatsone in 1843.
2. An electrical device in which a potential is applied across resistance wire of uniform cross sectional area and of length 1m, is called metre bridge.
3. Wire made of manganin or constantan is used.
4. Metre bridge is used,
   i) To determine unknown resistance
   ii) To verify laws of resistances in series and in parallel.
   iii) To compare the specific resistances of the material.
5. The unknown resistance of wire by metre bridge is given by,

$$X = \frac{l_x}{l_r} R$$

6. In metre bridge experiment, null deflection method is used to determine unknown resistance.
7. In Kelvin's method of metre bridge, equal deflection method is used to determine unknown resistance of galvanometer.
8. The resistance of galvanometer by Kelvin's method by metre bridge is given by,

$$G = \frac{l_g}{l_r} R.$$

9. X_1 and X_2 are two unknown resistances when they are used separately in the left gap of the metre bridge for the same resistance R in the - right gap balancing lengths are l_1 and l_2 then

$$\frac{X_1}{R} = \frac{l_1}{100 - l_1} \text{ and } \frac{X_2}{R} = \frac{l_2}{100 - l_2}$$

Now the two unknown resistances are connected in series in the left gap and balancing length is Is

$$\Rightarrow \left(\frac{X_1 + X_2}{R}\right) = \left(\frac{l_s}{100 - l_s}\right)$$

$$\Rightarrow \left(\frac{l_s}{100 - l_s}\right) = \left(\frac{l_1}{100 - l_1}\right) + \left(\frac{l_2}{100 - l_2}\right)$$

If the two unknown resistances are connected in parallel in the left gap and balancing length is Ip

$$\Rightarrow \left(\frac{X_p}{R}\right) = \left(\frac{l_p}{100 - l_p}\right) \text{ or}$$

$$\left(\frac{R}{X_p}\right) = \left(\frac{l_p}{100 - l_p}\right)$$

$$\Rightarrow \left(\frac{l_p}{100 - l_p}\right) = \left(\frac{100 - l_1}{l_1}\right) + \left(\frac{100 - l_2}{l_2}\right)$$

10. In a metre bridge if the unknown resistance wire in the left gap is heated, balancing length shifts towards right.
11. **Precautions:**

i) The resistance wire must be of uniform cross sectional area and of length of about 1m.

ii) The position of unknown resistance and known resistance are interchanged to eliminate contact resistance.

iii) The value of known resistance is so selected that the null point is obtained at the middle of the wire.

4.4 Potentiometer

1. The ideal apparatus of infinite resistance based on null deflection method and used to measure unknown potential difference is known as potentiometer.
2. An electrical device in which a potential is applied across a resistance wire of uniform cross sectional area and of length of about 4m to 10m is called as potentiometer.
3. Potentiometer is used

i) to measure p.d. between two points.

ii) to measure current accurately.

iii) to compare e.m.f.'s of two cells.

iv) to determine internal resistance of a cell.

v) to calibrate ammeter.

vi) to calibrate voltmeter.

4. The potential applied across the potentiometer wire is directly proportional to its length', is principle of working of potentiometer.
5. The current supplied by main battery of potentiometer circuit is,

$$I = \frac{E}{R + r + R_h}$$

6. **Potential gradient (X) :**

i) The fall of potential per unit length of potentiometer wire is defined as potential gradient X = V/L.

ii) Potential gradient directly depends upon

a) The resistance per unit length of potentiometer wire ρ ($\because \rho = R/L$).

b) The radius of cross section of potentiometer wire.

c) The specific resistance of the material of potentiometer wire.

d) The current flowing through potentiometer wire.

iii) Potential gradient indirectly depends on

a) The e.m.f. of battery in the primary circuit (E).

b) The resistance of rheostat in the primary circuit (R_h)

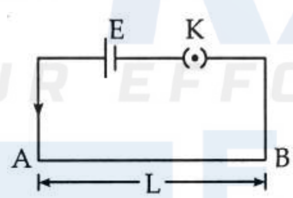
c) The total resistance of potentiometer wire R and its total length L ($\because R = \rho L$)

iv) The potential gradient or potential difference per unit length of potentiometer is, $I\rho = V/L$.

v) S. I. unit of potential gradient is, V/m.

7. Formulae for potential gradient:

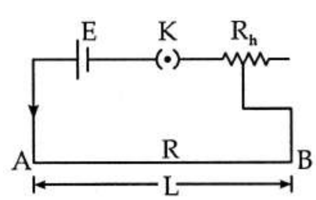
i) When no resistance other than the potentiometer wire is connected in potentiometer circuit.



$$X = \frac{E}{L}$$

here E = e.m.f. of the battery used in the primary circuit, L = length of potentiometer wire

ii) When an additional resistance is connected in the circuit



$$x = \frac{ER}{(R + R_h + r)L}$$

here R = Resistance of potentiometer wire,
R_h = Resistance of rheostat or resistance, r = Internal resistance of the battery.

iii) When the current flowing in the primary circuit is I, then $X = I\rho$ where $\rho = R/L$, ρ = resistance per unit length of potentiometer wire.

iv) When potential difference V is constant.

Then $\frac{x_1}{x_2} = \frac{L_2}{L_1}$

v) When two wires of lengths L_1 and L_2 and resistance R_1 and R_2 are joined together to form the potentiometer wire, then

$$\frac{x_1}{x_2} = \frac{R_1}{L_1}\frac{L_2}{L_1}$$

vi) When specific resistance (S) of potentiometer wire is given, then

$$X = \frac{IS}{A} = \frac{IS}{\pi r^2}$$

where A = area of cross section of potentiometer wire, r = radius of potentiometer wire.

8. The potential difference across the potentiometer wire of length L is given by, $V = I\rho L$

9. The unknown e.m.f. of cell by potentiometer is given by, $E_1 = I\rho l_1$

10. The comparison of e.m.f. of two cells by potentiometer is given by,

i) $\frac{E_1}{E_2} = \frac{l_1}{l_2}$ (By individual method)

ii) $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_2 - l_2}$ (By sum and difference method)

11. Internal resistance of cell by potentiometer is given by,

i) $r_1 = R_1\left(\frac{l_1 - l_2}{l_2}\right)$ ii) $r_1 = R_1\left(\frac{E_1}{V_1} - 1\right)$

12. A resistance R_1 is connected in parallel across the cell in secondary circuit for which the balancing length is l_1. If resistance R_2 is connected balancing length is l_2. If r is internal resistance of cell in secondary circuit,

13. When the same cell is used in secondary circuit of potentiometer by changing potential gradient

of the wire, then e.m.f. of that cell is,

$E = Xl = X^1 l^1$

X, X^1 are initial and final potential gradients,

l, l_1 are corresponding balancing lengths.

In this case potential gradient can be changed by changing R_h or by changing L or by changing potentiometer wire or by changing E.

14. If R_1 and R_2 are resistances connected in series and same current is flowing through the arrangement, if the potential differences across R_1 and R_2 are balanced for length l_1 and l_2 then

$$\frac{R_1}{R_2} = \frac{l_1}{l_2}$$

15. When the null point is obtained on the potentiometer wire then the current flowing through the wire is the current supplied by main battery of the circuit.

16. If the e.m.f. of main battery of potentiometer is less than e.m.f.s of other cells connected in the circuit, then null point is obtained beyond the length of potentiometer wire.

17. Sensitivity of potentiometer:

i) A potentiometer is said to be more sensitive if it measures a small potential difference more accurately.

ii) The sensitivity of potentiometer is estimated by its potential gradient.

iii) The sensitivity is inversely proportional to the potential gradient i.e. lower the potential gradient higher will be the sensitivity and vice versa.

iv) In order to increase the sensitivity of potentiometer

a) The resistance in primary circuit will have to be increased and current will have to be decreased.

b) The length of potentiometer wire will have to be increased.

18. Potentiometer is ideal instrument for measurement of e.m.f. and potential difference, because it does not disturb the current flowing through the circuit.

19. Potentiometer is not suitable for measurement of large potential because it requires a driving cell whose e.m.f. should be greater than the potential which is to be measured.

20. The specific resistance of potentiometer wire must be high but its temperature coefficient of resistance (a) must be low.

21. Precautions of potentiometer:

i) The e.m.f. of driving (main battery) cell should be greater than e.m.f's of other cells connected in the potentiometer circuit.

ii) The positive or negative terminal of driving cell is connected to that terminal of potentiometer at which positive or negative terminal of the cell of unknown e.m.f. is connected.

iii) The resistance wire must be of uniform cross sectional area.

iv) The resistance of potentiometer wire should be large.

22. Advantages of potentiometer:

i) It is used to measure e.m.f. of a cell

ii) It is used to measure very low potential difference

iii) It is more sensitive and accurate compared to voltmeter

iv) It is used for the calibration of readings of ammeter and voltmeter.

23. Disadvantages of potentiometer:

i) It is not portable.

ii) It does not give direct readings.

❍❍❍

MULTIPLE CHOICE QUESTIONS

4.0 Basic concept

Electric Current

1. The current, which is assumed to be flowing in a circuit from positive terminal to negative, is called
a) electronic current b) conventional current
c) alternating current d) pulsating current
2. The carriers of electricity, in a solid conductor, are
a) protons b) electrons
c) positive ions d) negative ions
3. The flow of positive charge, in one direction, is equivalent to the flow of an equal
a) negative charge in the same direction
b) negative charge in the opposite direction
c) positive charge in the same direction
d) positive charge in the opposite direction
3. No current flows between two charged bodies when connected, if they have the same
a) capacity b) potential
c) charge d) none of these
4. When electric field (E) is applied on the ends of a conductor; the free electrons start moving in direction
a) similar to E b) opposite to E
c) perpendicular to E d) cannot be predicted
5. The charge carriers, in liquids, are
a) anions b) cations
c) electrons d) both 'a' and 'b'
6. In gases, the carriers of electricity are
a) ions b) protons
c) neutrons d) electrons
7. The charge carriers in semiconductor are
a) electrons b) holes
c) positive ions d) both 'a' and 'b'
8. The charge carriers in a superconductor are
a) holes
b) free electrons
c) coherent pair of electrons
d) both 'a' and 'b'
9. The rate of flow of electric charge is
a) electric current b) voltage
c) power d) resistance
10. The electric current is a
a) scalar quantity b) vector quantity
c) unitless d) none of these
11. If an electron has no initial velocity in a direction different from that of an electric field, the path of electron is
a) parabola b) circle
c) ellipse d) straight line
13. If an electric current is passed through the nerve, the man
a) is excited
b) begins to weep
c) begins to laugh
d) becomes insensitive to pain
14. In vacuum tubes, the flow of electricity is due to the electrons coming out of
a) ions b) cathode
c) anode d) filament
15. In S. I. system, unit of current is
a) ampere b) stat ampere
c) coulomb c) henry
16. If the electronic charge is 1.6×10^{-19} C, then the number of electrons passing through a section of wire per second, when the wire carries a current of 1 A, is
a) 0.625×10^{19} b) 0.625×10^{17}
c) 1.6×10^{19} d) 1.6×10^{17}
17. A conductor carries a current of 300 mA. The number of electrons passing through it in 1 minute are about
a) 1.125×10^{17} b) 1.125×10^{20}
c) 1.125×10^{23} d) 1.125×10^{25}
18. A flow of 10^7 electrons per second in a conducting wire constitutes a current of
a) 1.6×10^{-26} A b) 1.6×10^{-12} A
c) 1.6×10^{12} A d) 1.6×10^{26} A
19. In a region, 10^{19} α–particles and 10^{19} protons moves to the left, while 10^{19} electrons moves to the right per second. The current is
a) 3.2 A towards left b) 6.4 A towards left
c) 9.6 A towards left d) 6.4 A towards right
20. An electron of charge 'e' is revolving in a circular orbit of radius r around a nucleus with speed v. The equivalent current is
a) $2e\pi rv$ b) evr
c) $\frac{ev}{2\pi r}$ d) zero

21. An electron moves in a circle of radius 10 cm with a constant speed of 4×10^{6} m/s. The electric current at a point on the circle is, ($e = 1.6 \times 10^{-19}$ C)
a) 2×10^{-12} A b) 1.019×10^{-12} A
c) 1×10^{-13} A d) 1×10^{-14} A

22. In 10 minutes, 3000 coulomb of free electrons enter one end of a conductor and 3000 leave the other end. The current is
a) zero b) 5 A
c) 10 A d) 30 A

23. A steady current is passing through a linear conductor of non uniform cross section. The net quantity of charge crossing any cross section per second is
a) independent of the area of cross section
b) directly proportional to area of cross section
c) directly proportional to length of cross section
d) inversely proportional to length of cross section

24. An electron carrying a charge of 1.6×10^{-19} C revolves in a circle at 10^{16} revolutions per second. The equivalent current is
a) 1.6×10^{-2} A b) 1.6×10^{-3} A
c) 1.6×10^{-4} A d) 1.9×10^{-3} A

Flow of current in a conductor

25. In metallic conductor, the motion of free electrons in the absence of electric field is
a) random b) unidirectional
c) bidirectional d) circular

26. In the absence of electric field across the conductor there is
a) net flow of charge in one direction
b) net flow of charge in two directions
c) no net flow of charge in any direction 36.
d) none of these

27. The average velocity of electrons in a conductor in the absence of electric field is
a) 10^{2} m/s b) 10^{-2} m/s
c) 10^{4} m/s d) 10^{-4} m/s

28. The direction of conventional current is in the
a) opposite direction of flow of electrons
b) in the same direction of field
c) in the same direction of flow of positive charge
d) all of these

29. A charge of magnitude q flows through the conductor in time 't'. The current through the conductor is
a) $I = q/t$ b) $I = qt$
c) $I = t/q$ d) $1 = q^{2}t$

30. The velocity with which a free electron in a conductor gets drifted under the influence of the applied electric field is,
a) average velocity b) drift velocity
c) thermal velocity d) all of these

31. The drift velocity of electrons in a conductor under the influence of electric field is
a) 10^{2} m/s b) 10^{-2} m/s
c) 10^{4} m/s d) 10^{-4} m/s

32. If A is the area of cross section of conductor, e be the charge on the electrons, n be the number of electrons per unit volume and J be the current density then drift velocity of electrons is
a) $v_d = J/ne$ b) $v_d = J.ne$
c) $v_d = ne/J$ d) $v_d = {}^{2}\ ne$

33. If A is the area of cross section of conductor, v_d is the drift velocity of electrons and n is the number of electrons per unit volume, then current density. through conductor is
a) $ne\, v_d$ b) $\dfrac{neA}{v_d}$
c) $\dfrac{nev_d}{A}$ d) $\left(\dfrac{n}{e}\right)Av_d$

34. Under the action of electric field, a material is said to be a conductor of electricity if there is flow of
a) same type of charge in or opposite direction of field
b) opposite type of charge in the same direction of field
c) no flow of charge
d) none of these

35. In conductors, current conduction take place due to
a) electrons moving in the direction of field
b) electrons moving opposite to the direction of field
c) positive ions moving in the direction of field
d) none of these

36. The direction of conventional current flowing through a metal due to applied potential difference or electric field is
a) same as the direction of field
b) from high potential end to low potential end

c) from low potential end to high potential end
d) both 'a' and 'b'

37. A conductor of length I and area of cross section A has n number of electrons per unit volume of the conductor. The total charge carried by the conductor is

a) $nAle$ b) $\frac{e}{nAl}$
c) $\frac{nAl}{e}$ d) n . e

38. A conductor of length l and area of cross–section A has n number of electrons per unit volume of the conductor. The current flowing through conductor in time t is given by

a) $I = \frac{nAle}{t}$ b) $I = nA\,l$
c) $I = \frac{e}{nA/t}$ d) $I = \frac{ne}{t}$

39. When a current I is set up in a wire of radius r, the drift velocity is v_d, If the same current is set up through a wire of radius 2r, the drift speed will be
a) 0.25 v_d b) 0.5 v_d
c) 2 v_d d) 4 v_d

40. There is a current of 0.21 A in a copper wire of area of cross section 10^{-6} m^2. If the number of electrons per m^3 is 8.4×10^{28} then the drift velocity is ($e = 1.6 \times 10^{-19}$ C)
a) 1.562×10^{-5} m/s b) 2×10^{-5} m/s
c) 0.64×10^{5} m/s d) 1×10^{5} m/s

41. The speed at which current travels, in a conductor, is nearly
a) 300 m/s b) 3×10^{5} m/s
c) 3×10^{6} m/s d) 3×10^{8} m/s

42. An electron in the hydrogen atom circles around the proton with a speed of 2.18×10^{6} m/s in an orbit of radius 0.53 A. The equivalent current is
a) 1.048×10^{-2} A b) 1.048×10^{-3} A
c) 1.048×10^{-4} A d) 1.058×10^{-4} A

43. A potential difference is applied across the ends of a metallic wire. If the potential difference is doubled, the drift velocity will be
a) doubled b) halved
c) quadrupled d) unchanged

44. In your city electricity cost 40 paise per kWh. You pay for
a) electric charge b) electric power
c) electric energy d) electric current

45. The relation between current density, conductivity and electric intensity is
a) $J = \sigma E$ b) $J = \sigma^2 E$
c) $J = \frac{E}{\sigma}$ d) $J = \frac{\sigma}{E}$

46. The drift velocity of electrons is given by

a) $v_d = \frac{e}{m}\frac{V}{l}\,t$ b) $v_d = \frac{eVt}{l}$
c) $v_d = \frac{e}{m}\,t$ d) $v_d = \frac{V}{l}\frac{m}{e}\,t$

47. The average time interval between two successive collisions of electrons with the vibrating atom is
a) periodic time b) relaxation time
c) mean time d) none of these

48. Resistivity of a material of conductor in terms of relaxation time is given by

a) $\rho = \frac{m}{ne^2t}$ b) $\rho = mne^2t$
c) $\rho = \frac{ne^2t}{m}$ d) $\rho = ne^2t$

49. Resistivity of a material of a conductor is inversely proportional to
a) number of electrons per unit volume of the conductor
b) relaxation time
c) both 'a' and 'b'
d) neither 'a' nor 'b'

50. The relaxation time
a) decreases with increase in temperature
b) increases with increase in temperature
c) decreases with decrease in temperature
d) increases with decrease in temperature

51. In the absence of electric field, the mean velocity of free electrons in a conductor at absolute temperature T is
a) zero
d) independent of temperature
c) proportional to Jf
d) proportional to T

52. The velocity of charge carriers of current (about

1ampere) in a metal under normal conditions is of the order of

a) a fraction of mm/s
b) velocity of light
c) several thousand metres/second
d) A few hundred metres per second.

53. For ohmic conductor, the drift velocity vd and the electric field applied across it are related as

a) $v_d \propto \sqrt{E}$ b) $v_d \propto E$
c) $v_d \propto E^{3/2}$ d) $v_d \propto E^2$

54. An electron is revolving n times per second. The charge passing in t second is

a) net b) $\frac{ne}{t}$
c) $\frac{nt}{e}$ d) $\frac{et}{n}$

55. If n, e, t and m represent electron density, charge, relaxation time and mass of an electron respectively, then the resistance of a wire of length l and cross sectional area A is

a) $\frac{ml}{ne^2tA}$ b) $\frac{2ntA}{ne^2l}$
c) $\frac{ne^2t}{2m}.\frac{A}{l}$ d) $\frac{ne^2m}{2t}.\frac{l}{A}$

56. The quantity in electricity analogous to friction in linear mechanical motion is

a) resistance b) potential
c) charge d) inductance

57. When a potential difference (V) is applied across a conductor at temperature T, the drift velocity of electrons is proportional to

a) V^{-1} b) V^2
c) $\sqrt{V}$ d) V

58. The quantity in electricity analogous to temperature is

a) resistance b) potential
c) charge d) inductance

59. Increase in which property of free electrons causes increase in the resistance of a conductor with rise in temperature?

a) Number density b) Relaxation time
c) Mass d) None of these

60. Resistance of a conductor increases with the rise of temperature, because

a) relaxation time decreases
b) relaxation time increases
c) electron density increases
d) electron density decreases

61. A current of 5A is passing through a metallic wire of area of cross section 4×10^{-6} m^2. If the density of the charge carriers in the wire is 5×10^{26} /m^3, then the drift speed of the electrons will be

a) 1.5625×10^{-2} m/s b) 1.5625×10^{-3} m/s
c) 1.5625×10^{3} m/s d) 1.5625×10^{-4} m/s

Sources of e.m.f.

62. A source which gives constant potential difference and hence flow of charge is

a) source of e.m.f. b) source of light
c) source of heat d) none of these

63. The energy spent by the cell in circulating unit charge once through the complete circuit is

a) e.m.f of cell
b) terminal potential difference of cell
c) current capacity
d) force

64. The potential difference across the terminals of the cell in open circuit is called as

a) current b) pot. diff. of cell
c) e.m.f. of cell d) resistance

65. The e.m.f. of a cell is always

a) equal to terminal pot. diff. of a cell
b) greater than pot. diff. of a cell
c) less than pot. diff. of a cell
d) internal resistance of a cell

66. In S.L system, unit of electromotive force of a cell is

a) newton b) dyne
c) volt d) ampere

67. The e.m.f. of a cell is independent of

a) quantity of electrolyte
b) distance between the electrodes
c) area of the electrodes
d) all of these

68. The e.m.f. of a cell depends on

a) nature of plates
b) nature of electrolytes
c) both 'a' and 'b'
d) neither 'a' nor 'b'

69. What determines the e.m.f. between the two metals placed in an electrolyte?

a) Quantity of electrolyte
b) Strength of electrolyte
c) Distance between the metal plates
d) Position of metals in electrochemical series

70. The e.m.f. of a cell is a
a) unit vector b) zero vector
c) scalar quantity d) vector quantity

71. The amount of work done by the cell in sending a unit charge once through the external resistance of the circuit is
a) current
b) resistance
c) e.m.f. of a cell
d) terminal potential difference of a cell

72. As the current drawn from the cell increases, terminal potential difference of a cell is
a) constant b) decreases
c) increases d) none of these

73. The resistance offered by electrolytic solution of a cell is
a) impedance
b) reactance
c) internal resistance of cell
d) admittance

74. The internal resistance of an ideal cell is
a) zero b) 0.5 Ω
c) 1 Ω d) infinity

75. Internal resistance of a cell is proportional to
a) distance between the electrodes
b) concentration of electrolyte
c) polarization
d) all of these

76. A device which converts chemical energy into electrical energy is called
a) electrochemical cell
b) photo cell
c) atomic cell
d) none of these

77. An arrangement, in which chemical.reaction can be proceeded at a steady rate so as to convert chemical energy into electrical energy, is called
a) photo cell b) atomic cell
c) electric generator d) electrochemical cell

78. The electric cell is a device to obtain electric energy from
a) electrons b) electric charge
c) chemical energy d) electric force

79. Within the electric cell, the charge is transported by
a) free electrons b) positive ions
c) negative ions d) both 'b' and' c'

80. First electrochemical cell was designed by
a) Galvani b) Faraday
c) Leclanche d) Edison

81. The ability of a cell to supply electric energy is called as
a) resistance of a cell
b) capacity of a cell
c) terminal pot. diff. of a cell
d) all of these

82. The current capacity of a cell is measured in terms of
a) ampere b) ampere hour
c) watt d) watt hour

83. The current capacity of a charged secondary cell depends upon
a) temperature b) rate of charging
c) rate of discharging d) both 'a' and 'b'

84. A certain electric circuit with a resistance R is supplied power simultaneously from n identical storage batteries. For what internal resistance of the storage batteries will the current in the circuit be the same when they are connected in series and in parallel ?
a) $r = R$ b) $r = 2R$
c) $r = R^2$ d) $r = \frac{R}{2}$

85. Two cells each of e.m.f. E and internal resistance are connected in parallel across a resistor R. The power delivered to the resistor is maximum if
a) $R = \frac{r}{2}$ b) $R = r$
c) $R = 2r$ d) $R = 0$

Ohm's law, resistance and specific resistance

86. The relation between current and potential difference is given by
a) Ohm's law b) Coulomb's law
c) Kirchhoff's law d) Newton's law

87. Ohm's law is true for
a) metallic conductor
b) non metallic conductor

c) both 'a' and 'b'
d) none of these

88. The V – I graph for a conductor makes angle e with y–axis. Here V denotes voltage and I denotes current. The resistance of the conductor is given by
a) sin θ b) cos θ
c) tan θ d) cot θ

89. Ohm's law is applicable to
a) metals b) electrolytes
c) both 'a' and 'b' d) none of these

90. Ohm's law is valid, when the temperature of the conductor is
a) constant b) very high
c) very low d) varying

91. When the potential difference applied across a solid conductor is increased, the rate of flow of electrons
a) decreases b) increases
c) remains same d) decreases sharply

92. In case of liquids, the Ohm's law is
a) fully obeyed b) partially obeyed
c) never obeyed d) sometimes obeyed

93. For the validity of Ohm's law, which of the following quantity is constant?
a) Length
b) Temperature
c) Area of cross–section
d) All of these

94. 'If the physical state of the conductor remains unchanged then the current through the conductor is directly proportional to potential difference between the ends of a conductor.
This is the statement of
a) Ohm's law b) Laplace's law
c) Lenz's law d) Kirchhoff's law

95. Ohm's law is not applicable for
a) vacuum tube devices
b) semiconductors
c) metals
d) both 'a' and 'b'

96. In a closed circuit, the e.m.f. and internal resistance of the generator are E and r respectively. If the external resistance in the circuit is R, then Ohm's law has the form
a) $I = \frac{E}{Rr}$ b) $I = \frac{E}{R}$
c) $I = \frac{E}{r}$ d) $I = \frac{E}{(R+r)}$

97. Which of the following is mathematical equation of Ohm's law?
a) V = IR b) I = GV
c) V = 12R d) both 'a' and 'b'

98. An external resistance R is connected to a cell of internal resistance r. The current in the circuit is maximum when
a) R < r b) R > r
c) R = r d) R = 2r

99. Ohm is the S. I. unit of
a) resistance b) conductance
c) resistivity d) capacitance

100. The reciprocal of resistance is
a) resistivity b) conductance
c) capacitance d) inductance

101. If a potential difference of Ivolt applied across the conductor causes a current of 1 ampere to flow through it, then the resistance of a conductor is a
a) ohm b) siemen
c) farad d) henry

102. S.I. unit of conductance is
a) ohm b) mho
c) siemen d) both 'b' and 'c'

103. The resistance of a conductor depends on its
a) length b) area of cross section
c) temperature d) all of these

104. The reciprocal of conductivity is called as
a) resistivity b) specific resistance
c) both 'a' and 'b' d) none of these

105. A conductor of length I and area of cross–section A has a resistance R then its specific resistance is
a) $\rho = \frac{RA}{l}$ b) $\rho = RAl$
c) $\rho = \frac{l}{RA}$ d) $\rho = \frac{R^2A}{l}$

106. The resistance of the material of unit length and unit area of cross section is
a) specific resistance b) conductance

c) inductance d) capacitance

107. The S. I. unit of specific resistance is

a) Ω cm b) Ω m

c) Ω/m d) Ω/cm

108. If the length and area of cross section of a conductor are doubled, its resistance will be

a) halved b) unchanged

c) doubled d) none of these

109. The specific resistance of all metals is most affected by

a) temperature

b) pressure

c) degree of illumination

d) applied magnetic field

110. If 'n' is the number of free electrons in a metallic wire, then the resistance is proportional to

a) $1/n^2$ b) $1/n$

c) n^2 d) n

111. The example of an ohmic conductor is

a) diode b) germanium

c) tungsten wire d) torch bulb

112. The example of a non–ohmic resistance is

a) diode b) copper wire

c) filament lamp d) carbon resistance

113. A metal wire of cross–sectional area Lmm/ contains 5×10^{22} electrons per cm^2. If the electrons move along the wire with average drift velocity 1 mm/s, then the current in the wire is ($e = 1.6 \times 10^{-19}$ C)

a) 8 A b) 4 A

c) 2 A d) 1A

114. A nichrome wire of length 100 cm and area of cross–section 0.5 mm– has a resistance of 2.2 Ω. The resistivity of nichrome is

a) 110 Ω m b) 0.11 Ω m

c) 121 Ω m d) 11×10^{-7} Ω m

115. If a wire of resistance 25 Ω is uniformly stretched until its length becomes three times its original length then its new resistance is

a) 100 Ω b) 225 Ω

c) 2.25 Ω d) 122.5 Ω

116. The resistance of a wire is RΩ. The wire is stretched to double its length. Now the resistance of the wire will become

a) 0.25 R b) 0.5 R

c) 2 R d) 4 R

117. If a certain piece of copper is to be shaped into a conductor of minimum resistance, its length L and cross–sectional area A shall be respectively

a) L and A b) 2L and $\frac{A}{2}$

c) $\frac{L}{2}$ and A d) $\frac{L}{3}$ and 4A

118. A wire of 50 cm long and 1 mm– in cross section carries a current of 4 A when connected to 2 V battery. The resistivity of the wire is

a) 5×10^{-6} Ωm b) 2×10^{-6} Ωm

c) 4×10^{-6} Ωm d) 1×10^{-6} Ωm

119. Two wires of the same metal have same length, but their cross–sections are in the ratio 3 : 1. They are joined in series. The resistance of thicker wire is 10 Ω. The total resistance of the combination will be

a) 2.5 Ω b) 40/3 Ω

c) 40 Ω d) 100 Ω

120. A metallic wire carries a current of 100 A, its area of cross section is 1 cm^2. If the resistivity of the copper is 1.7×10^{-8} Ωm, then the electric field strength in the copper will be

a) 1.7×10^{-2} V/m

b) 2.7×10^{-2} V/m

c) 1.7×10^{-3} V/m

d) 2.7×10^{-3} V/m

121. A wire 1m long has a resistance of 1 Ω. If it is uniformly stretched, so that its length increases by 25 % then its resistance will increase by

a) 25 % b) 50 %

c) 56.25 % d) 77.33 %

122. In an electric circuit, potential difference across a lamp is 20 V and current through the lamp is 0.5 A. The resistance of the lamp is

a) 10 Ω b) 20 Ω

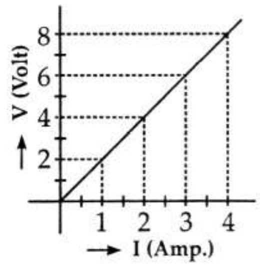
c) 30 Ω d) 40 Ω

123. A cell of e.m.f. 2 V and internal resistance 2 Ω and an external resistance 18 Ω forms dosed circuit. The current through the circuit is

a) 0.1 A b) 1 A

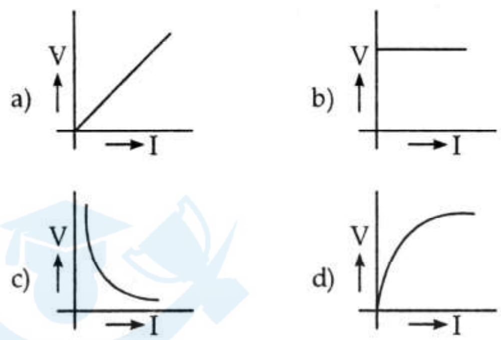
c) 10 A d) 100 A

124. Variation of current and voltage in a conductor is shown in the adjoining figure. The resistance of the conductor is



a) 4 Ω b) 2 Ω
c) 1 Ω d) 0.5 Ω

125. Which of the following adjoining graphs represents an ohmic resistance?



126. The external diameter of 5 m long hollow tube is 0.1 m and thickness of its wall is 0.005 m. If $\rho = 1.7 \times 10^{-8}\ \Omega$ m, its resistance will be
a) $5.7 \times 10^{-5}\ \Omega$ b) $2.7 \times 10^{-5}\ \Omega$
c) $2 \times 10^{-5}\ \Omega$ d) $5 \times 10^{-5}\ \Omega$

127. The temperature coefficient Of resistance is positive for
a) carbon b) silicon
c) germanium d) aluminium

128. Which of the following has negative temperature coefficient of resistance?
a) Tungsten b) Carbon
c) Nichrome d) Platinum

129. At a temperature of 0° K, the germanium behaves as
a) conductor b) super conductor
c) insulator d) ferromagnetic

130. When the temperature of a metallic conductor is increased, its resistance
a) always decreases
b) always increases
c) may increases or decreases
d) remains constant

131. Thermistors are alloys of
a) insulators
b) semiconductor materials
c) conductor materials
d) none of these

132. Thermistor is
a) an ohmic device b) a non ohmic device
c) both 'a' and 'b' d) none of these

133. If temperature is increased, then relaxation time of electrons in metals will
a) increase b) decrease
c) fluctuate d) remain constant

134. Thermistors are usually, prepared from
a) metals b) nonmetals
c) oxides of metals d) oxides of non metals

135. A typical thermistor can easily measure a change in temperature of the order of
a) 10^{3} °C b) 10^{2} °C
c) 10^{-2} °C d) 10^{-3} °C

4.1 Kirchhoff's laws :

136. The algebraic sum of currents at junction point in any electric circuit is equal to
a) zero b) infinity
c) both a and b d) none of these

137. The mathematical equation of Kirchhoff's current law is
a) $\Sigma I = 0$ b) $\Sigma IR = 0$
c) $\Sigma E + \Sigma IR = 0$ d) $\Sigma E = 0$

138. $\Sigma IR = \Sigma E$ is the mathematical equation of
a) Kirchhoff's current law
b) Kirchhoff's voltage law
c) Newton's law
d) Ohm's law

139. Kirchhoff's first law, deals with the conservation of
a) charge b) energy
c) momentum d) all of these

140. Kirchhoff's second law is based on the law of conservation of
a) charge b) energy
c) momentum d) current

141. Kirchhoff's laws are related to the law of conservation of
a) mass b) momentum
c) energy d) all of these

142. Kirchhoff's law are used to calculate the current

in

a) simple circuits b) complicated circuits

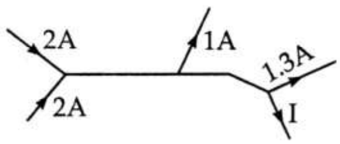
c) parallel circuit d) none of these

143. A steady current passes through a linear conductor of uniform cross section. Any given segment of the conductor will have a net

a) negative charge b) positive charge

c) zero charge d) none of these

144. The adjoining figure shows currents in a part of an electric circuit. Then current I is



a) 1.7 A b) 3.7 A

c) 1.3 A d) 1 A

145. Sign conventions used to apply Kirchhoff's current law are

a) entering and leaving currents are positive

b) entering and leaving currents are negative

c) entering currents are positive and leaving currents are negative

d) all of these

146. Twelve wires, each of resistance 6 Ω are connected to form a cube. The effective resistance between two diagonally opposite corners of the cube is

a) 6 Ω b) 12 Ω

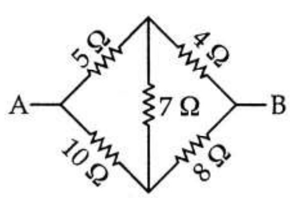
c) 5 Ω d) 10 Ω

147. There are n similar resistors, which when connected in parallel, have the total resistance R. When these resistance are connected in series the total resistance will be

a) n^2R b) nR

c) $\frac{R}{n}$ d) $\frac{R}{n^2}$

148. Five resistances are connected as shown in A figure. The effective resistance between A and B is



a) $\frac{10}{3}$ Ω b) $\frac{20}{3}$ Ω

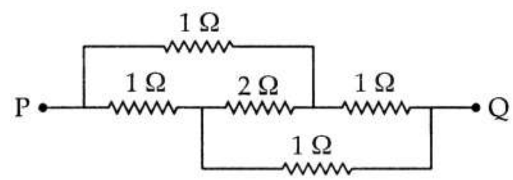
c) 15 Ω d) 6 Ω

149. Two resistors when connected in series have an equivalent resistance of 9 Ω and when connected in parallel have an equivalent resistance of 2 Ω. The value of two resistors are

a) 2 Ω and 9 Ω b) 3 Ω and 6 Ω

c) 3 Ω and 9 Ω d) 2 Ω and 6 Ω

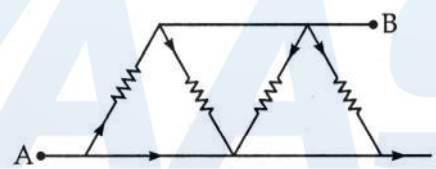
150. The equivalent resistance across P and Q in the given electric circuit will be



a) 1 Ω b) 2 Ω

c) 3 Ω d) 5 Ω

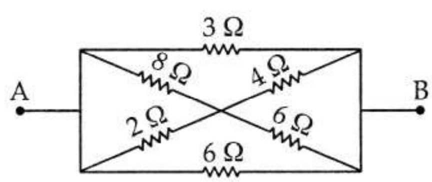
151. In the diagram below each resistance is of 1 Ω. The total resistance between A and B is



a) 3/8 Ω b) 3/5 Ω

c) 2/8 Ω d) 5/7 Ω

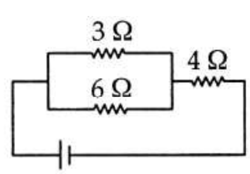
152. In the adjoining figure, the equivalent resistance between A and B is



a) 17/24 Ω b) 4/3 Ω

c) 29 Ω d) 24/17 Ω

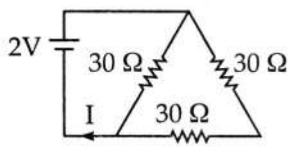
153. If the current through the 3 Ω resistor is 0.8 A, then potential drop across 4 Ω resistor is



a) 9.6V b) 4.8V
c) 2.6V d) 1.2V

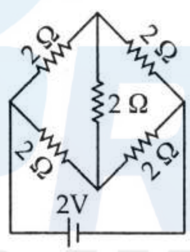
154. Resistance of 1 Ω, 2 Ω and 3 Ω are connected in the form of a triangle. If a 1.5V cell of negligible internal resistance is connected across the 3 Ω resistor, the current flowing through this resistance will be
a) 0.25 A b) 0.5 A
c) 1.0 A d) 1.5 A

155. The magnitude of current I in the following circuit is



a) 1/45A b) 1/15A
c) 1/10A d) 1/5A

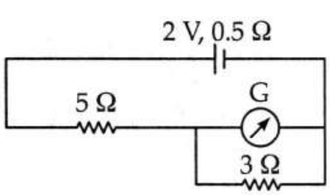
156. In the circuit shown below the current flowing from the battery is



a) 0.5A b) 1 A
c) 2 A d) 2.25A

157. A cell supplies a current of 0.9 A through a 2 Ω resistor. The same cell supplies a current of 0.3A through a 7 Ω resistor. The internal resistance of the cell is
a) 0.1 Ω b) 0.3 Ω
c) 0.5 Ω d) 0.7 Ω

158. If the resistance of the galvanometer G is 15 Ω, then current through the galvanometer will be

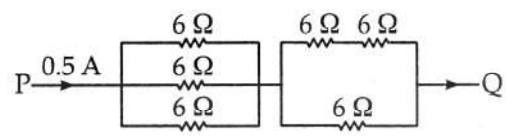


a) 1/3 A b) 1/8 A
c) 1/17 A d) 1/24 A

159. Two cells of 1.5 V and 2 V, having internal resistances of 1 Ω and 2 Ω respectively, are connected in parallel so as to read the current in the same direction through an external resistance of 5 Ω. The current in the external resistance will be

a) $\frac{5}{17}$ A b) $\frac{17}{5}$ A
c) $\frac{5}{12}$ A d) $\frac{12}{5}$ A

160. Resistances of 6 Ω each are connected in the manner shown in the following figure. The potential difference $V_p - V_q$ is



a) 13.6 V b) 6 V
c) 3 V d) 17.2V

4.2 Wheatstone's network

161. Wheatstone's bridge is an arrangement used for measuring
a) e.m.f. of a cell b) unknown resistance
c) unknown current d) potential difference

162. On sending the current in the bridge, the bridge is said to be balanced, if
a) there is no deflection in the galvanometer
b) there is a deflection in the galvanometer
c) partially deflection in the galvanometer
d) none of these

163. The sensitivity of Wheatstone's network depends upon the value of
a) current b) resistance
c) voltage d) all of these

164. The Wheatstone's bridge is maximum sensitive, when all the four resistances are in
a) different order
b) same order
c) partially same order
d) partially different order

165. The Wheatstone's bridge is most sensitive when the arm ratio is equal to
a) 0 b) 1

c) 10 d) infinity

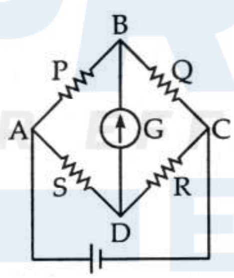
166. Post office box is an arrangement of finding resistance of a conductor and it makes use of
a) Ampere's law
b) Wheatstone's network principle
c) Potentiometer principle
d) Flemings rule

167. Four resistances 10, 10,10 and 15 Ω are connected so as to form Wheatstone's bridge. The resistance connected across 15 Ω resistance to balance the bridge is
a) 10 Ω b) 20 Ω
c) 30 Ω d) 40 Ω

168. Wheatstone's bridge is most sensitive when
a) $R_1 = R_2$ and $R_3 = R_4$
b) $R_1 = R_2 = R_3 = R_4$
c) $R_1 + R_2 = R_3 + R_4$
d) $R_1 - R_2 = R_3 - R_4$

169. Slide wire bridge or metre bridge is an application of
a) potentiometer b) Wheatstone's bridge
c) voltmeter d) both 'a' and 'c'

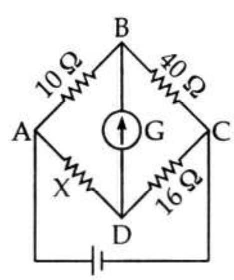
170. A Wheatstone's bridge is shown in figure. The condition for balancing the bridge is



a) $\frac{P}{Q}=\frac{R}{S}$ b) $\frac{P}{S}=\frac{R}{Q}$

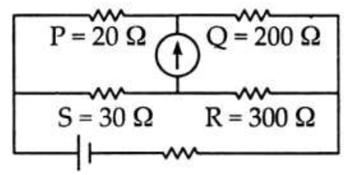
c) $\frac{P}{R}=\frac{S}{Q}$ d) $\frac{P}{Q}=\frac{S}{R}$

171. A Wheatstone's bridge shown in figure, is to be balanced. The value of must be



a) 4 Ω b) 8 Ω
c) 160 Ω d) 32 Ω

172. Figure below shows a balanced Wheatstone's network. If it is distributed by changing P to 22 Ω then which of the following steps will bring the bridge to balance again ?



a) increasing 5 by 3 Ω
b) increasing Q by 20 Ω
c) increasing R by 50 Ω
d) both 'a' and 'b'

4.3 Metre bridge

173. Which of the following instrument is generally used with a galvanometer to show nil reading?
a) an ammeter b) a voltmeter
c) a voltameter d) a metre bridge

174. In a metre bridge experiment l_x and l_r are the balancing lengths and R is known resistance then unknown resistance is given by
a) $X = \frac{l_x}{l_r}.R$ b) $X = \frac{R}{l_x.l_r}$
c) $X = l_x \cdot l_r \cdot R$ d) $X = l_x^2 R$

175. Kelvin's method of determination of resistance of galvanometer by metre bridge is
a) equal deflection method
b) null deflection method
c) equal distance method
d) all of these

176. Which of the following statement is not correct in metre bridge experiment?
a) the resistance wire must be of uniform cross sectional area.
b) the readings should be taken at the middle of wire.
c) the readings should be taken by interchanging the positions of known and unknown resistance.
d) the jockey should be changed.

177. In the measurement of resistance by a metre bridge, the known and unknown resistance are interchanged to eliminate

a) end errors
b) index error
c) random error
d) error due to thermoelectric effect

178. In a metre bridge experiment, unknown resistance X and known resistance of 60 Ω is connected in left and right gap of a metre bridge respectively. If the null point is obtained at 40cm from the left end then the unknown resistance is
a) 20 Ω b) 40 Ω
c) 60 Ω d) 80 Ω

179. Metre bridge is the modification of
a) Wheatstone's network
b) galvanometer
c) potentiometer
d) speedometer

180. Metre bridge is used to
a) determine unknown resistance
b) measure current
c) measure P. D.
d) all of these

181. For the accurate measurement of resistance by metre bridge, the null point should be obtained
a) towards left end
b) towards right end
c) at the middle of wire
d) all of these

182. To find resistance of galvanometer by Kelvin's method by metre bridge, usually galvanometer is connected
a) in left gap
b) between jockey and. centre of middle copper strip
c) in series with the cell across the metre bridge wire
d) none of these

183. To find resistance of galvanometer by Kelvin's method using metre bridge, the null point is observed in such a way that
a) the pointer of galvanometer should be at zero
b) the pointer of galvanometer should be towards the right of zero
c) there should not be any change in the deflection of galvanometer
d) all of these

184. In a balanced metre bridge, the segment of wire opposite to a resistance of 70 Ω is 70 cm. The unknown resistance is
a) 30 Ω b) 60 Ω
c) 90 Ω d) 15 Ω

185. A metre bridge is balanced by putting 20 Ω resistance in the left gap and 40 Ω in the right gap. If 40 Ω resistance is now shunted with 40 Ω resistance. The shift in the null point towards right is nearly
a) 16.67 cm b) 50 cm
c) 25 cm d) 70.67 cm

186. With resistances P and Q in the left and the right gap respectively of a metre bridge, the null point divides the wire in the ratio 3 : 4. When P and Q are increased by 20 Ω each, the null point divides the wire in the ratio 5 : 6. The values of P and Q are
a) 30 Ω , 40 Ω b) 20 Ω , 40 Ω
c) 30 Ω , 80 Ω d) 20 Ω , 20 Ω

187. In a Wheatstone's network the positions of the battery and the galvanometer are interchanged. The balance condition
a) remains unaltered
b) alters
c) mayor may not altered depending on the resistance of the galvanometer and the battery
d) none of these

188. If the balancing point is obtained at 35th cm on a metre bridge, then the ratio of resistances in the gaps is
a) 13 : 7 b) 11 : 9
c) 7 : 13 d) 2 : 3

4.4 Potentiometer

189. In a potentiometer, potential difference across the potentiometer wire is directly proportional to its
a) length b) area
c) resistance d) all of these

190. If the length of potentiometer wire is increased, then the accuracy in the determination of null point
a) decreases b) increases
c) remains unaffected d) none of these

191. In a potentiometer circuit, all the +ve terminals should be connected at
a) one point b) different points
c) alternate points d) either 'b' or 'c'

192. The best instrument for the accurate measurement of the e.m.f. of a cell is

a) voltmeter b) ammeter
c) potentiometer d) Wheatstone's bridge

193. A potentiometer is an ideal instrument for measuring potential difference or e.m.f. because
a) it has a long wire
b) it uses a sensitive galvanometer
c) it does not disturb the potential difference it measures
d) both 'a' and 'b'

194. The e.m.f. of two cells can be compared by
a) potentiometer b) ammeter
c) luxmeter d) speedometer

195. The balancing lengths for the cells of e.m.f. E_1 and E_2 are l_1 and l_2 respectively. If they are connected separately then
a) $\frac{E_1}{E_2} = \frac{l_1}{l_2}$ b) $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_2 - l_2}$
c) $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_2}$ d) $\frac{E_1}{E_2} = \frac{l_1 - l_2}{l_2}$

196. The equation, $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_2 - l_2}$ is used to compare e.m.f. of two cells by
a) individual method
b) sum and difference method
c) null deflection method
d) equal deflection method

197. The internal resistance of the cell can be determined by,
a) ohm meter b) galvanometer
c) voltmeter d) potentiometer

198. The unit of potential gradient is
a) volt cm b) ohm cm
c) volt/cm d) volt/ampere

199. In comparing e.m.f. of two cells by a potentiometer balance point is obtained on 5th wire, the current flowing through the wire is taken
a) from both cells
b) from one cell
c) from the main battery of circuit
d) none of these

200. The sensitivity of the potentiometer can be increased by
a) increasing the length of the wire
b) increasing the e.m.f. of the cell
c) decreasing the length of the wire
d) none of these

201. The null point of a potentiometer wire will shift beyond the potentiometer wire if
a) e.m.f. of driving cell is low
b) e.m.f. of accumulator is high
c) length of wire is small
d) length of wire is large

202. When null point is obtained in the potentiometer the current is drawn from
a) cell only
b) main battery only
c) both the cell and main battery
d) neither cell nor main battery

203. Potentiometer was first invented by
a) Ampere b) Newton
c) Poggendorf d) Millikan

204. In the construction of potentiometer, the length of wire used is
a) equal to one metre
b) less than one metre
c) greater than 1m upto 10 m
d) all of these

205. A potentiometer is more sensitive when
a) its wire is of small length
b) its wire is of large length
c) applied P.D. is large
d) potential gradient along the wire is very low

206. Instead of voltmeter, potentiometer is always used to measure e.m.f. of cell, because at the null point, the potentiometer
a) does not draw current from balanced cell
b) draw current from driven cell
c) ends its current through driven cell
d) none of these

207. The potentiometer wire of resistance R is connected in series with a cell of e.m.f. E and of internal resistance r along with external resistance R_h. The current flowing through the potentiometer wire is
a) $I = \frac{E}{R + r + R_h}$ b) $I = \frac{E}{R + r}$
c) $I = \frac{RE}{R_h + r}$ d) $I = \frac{E}{R}$

208. Potentiometer is used to

a) measure e.m.f. of cell
b) compare e.m.f. of two cells
c) determine internal resistance of cell
d) all of these

209. The internal resistance of a cell by potentiometer is given by

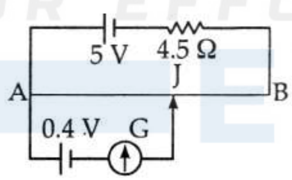
a) $r_1 = R_1\left(\dfrac{l_1 - l_2}{l_2}\right)$ b) $r_1 = R_1\left(\dfrac{E_1 - V_1}{V_1}\right)$

c) both 'a' and 'b' d) neither 'a' nor 'b'

210. In a potentiometer experiment, for measuring internal resistance of a cell, the balance point has been obtained on fourth wire. The balance point can be shifted to fifth wire by
a) decreasing the current due to auxiliary battery
b) increasing the current due to auxiliary battery
c) putting a suitable resistance in series to the cell
d) putting a shunt resistance in parallel to the cell

211. The current, in a potentiometer wire of 100 cm length, is adjusted to give a null point at 50 cm with a standard cell of e.m.f. 1.018V. The e.m.f. of a cell which gives null point at 60 cm is
a) 1.221 V b) 2.22 V
c) 3.22 V d) 4.22 V

212. In figure, the potentiometer wire AB has a resistance of 5 Ω and length 10m. The balancing length AJ for the cell of e.m.f. of 0.4 V is



a) 2.52 m b) 3.52 m
c) 1.52 m d) 4.52 m

213. The wire of potentiometer has resistance 4 Ω and length 1 m. It is connected to a cell of e.m.f. 2 V and internal resistance 1 Ω. The current flowing through the potentiometer wire is
a) 0.1 A b) 0.2 A
c) 0.4 A d) 0.8 A

214. A potentiometer has a uniform wire of length 10 m and resistance 5 Ω. The potentiometer is connected to an external battery of e.m.f. 10V and negligible internal resistance and an external resistance of 995 Ω in series. The potential gradient along the wire is
a) 1 mV/m b) 5 mV/m
c) 0.1 mV/m d) 4 mV/cm

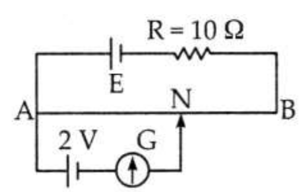
215. A voltmeter has a resistance of 50 Ω is connected across a cell of e.m.f. 2 V and internal resistance 10 Ω. The reading of voltmeter is
a) 1.667 V b) 16.7 V
c) 167 V d) 0.167 V

216. With a potentiometer null points were obtained at 140 cm and 180 cm with cell of e.m.f. 1.1 V and one of unknown e.m.f. respectively. The unknown e.m.f. is
a) 0.1 V b) 1.21 V
c) 1.414 V d) 1.8 V

217. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of 5 Ω the balance point is found at 40 cm of the wire from the same end. The internal resistance of the cell is
a) 5.2 Ω b) 4 Ω
c) 1.5 Ω d) 1 Ω

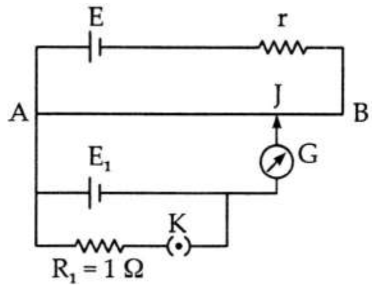
218. The potential gradient along the length of a uniform wire is 5 V/m. There are two points on the same wire at a distance of 20 cm and 40 cm from initial end of the wire. The potential difference between these points is
a) 1 V b) 2 V
c) 3 V d) 4 V

219. In figure AB is a potentiometer wire of length 10m and resistance 1 Ω. The balancing length for 2 V potential drop is 8 m. The e.m.f. of the battery E is



a) 12.5 V b) 22.5 V
c) 27.5 V d) 15.5 V

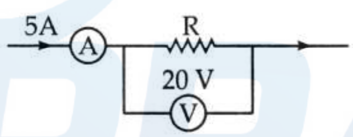
220. In figure AB is a potentiometer wire of length 10m and resistance 2Ω. With key K open, the balancing length is 5.5m. However on closing key K the balancing length reduces to 5m. The internal resistance of the cell E_1 is



a) 0.01 Ω b) 0.1 Ω
c) 0.2 Ω d) 1 Ω

221. A platinum wire has resistance of 10 Ω at 0°C and 20 Ω at 273° C, the value of temperature coefficient of platinum is
a) 273 per degree C b) 273 per degree K
c) $\frac{1}{273}$ per degree C d) $\frac{1}{273}$ per degree K

222. In the adjacent circuit the ammeter reads 5.0 A and voltmeter reads 20 V.The value of resistance R is



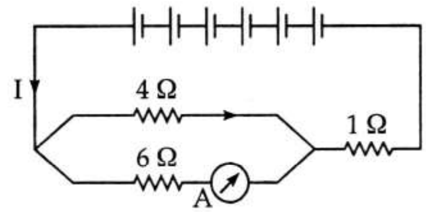
a) 4 Ω b) 100 Ω
c) 0.25 Ω d) 0.5 Ω

223. Following are the readings of potential and current through a specimen when it is connected to a source of variable potential:
Voltage: 0.2 V, 0.4 V, 0.6 V,0.8 V, 1V·
Current: 3 mA,5 mA, 9 mA, 13 mA, 17mA

224. From the observations, the specimen
a) obeys Ohm's law and is a conductor
b) obeys Ohm's law and is an insulator
c) does not obey Ohm's law and is a semiconductor
d) obeys Ohm's law and can be conductor or semiconductor

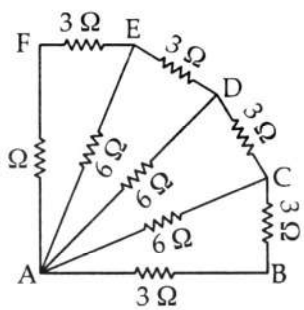
225. In a potentiometer experiment the balancing length is 8 m, when the two cells E_1 and E_2 are joined in series. When the two cells are connected in opposition the balancing length is 4m. The ratio of the e.m.f. of two cells (E_1 / E_2) is
a) 1 : 2 b) 2 : 1
c) 1 : 3 d) 3 : 1

225. Six cells each of e.m.f. 2 V and internal resistance 0.10 are connected to three resistances as shown in figure. The reading of a low resistance ammeter A in the circuit is,



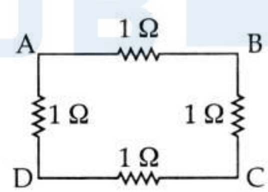
a) 2.1 A b) 3.0 A
c) 1.2 A d) 1.5 A

226. Find the equivalent resistance of the network given in the figure,



a) 4 Ω b) $\frac{2}{3}$ Ω
c) 2 Ω d) 1 Ω

227. Four identical resistances are joined as shown in the figure. The equivalent resistance between points A and B is R_1 and that between A and C is R_2 then ratio R_1/R_2 is



a) 1 : 1 b) 4 : 3
c) 3 : 4 d) 1 : 2

228. The length and radius of a wire is l and r respectively. Its resistance is R. After hammering the radius of the wire is made (r/2) then the new resistance will be
a) 4 R b) 8 R
c) 12 R d) 16 R

229. A copper wire of length 1m and radius 1 mm is joined in series with an iron wire of length 2 m and radius 3 mm and a current is passed through

the wires. The ratio of the current density in copper and iron wires is

a) 3/1 b) 1/3
c) 9/1 d) 1/9

230. The internal resistance of a primary cell is 4 Ω. It generates a current of 0.2 A in an external circuit of 21 Ω. The rate at which electric energy is consumed in providing the current is

a) 1 J/s b) 2 J/s
c) 1.5 J/s d) 2.5 J/s

231. A capacitor of 10 μF has a potential difference of 40 V across it. If it is discharged in 0.2 s, the average current during discharge is

a) 1 mA b) 2 mA
c) 3 mA d) 4 mA

232. The resistance of a conductor is 5 Ω at 50°C and 6 Ω at 100°C. The resistance at 0°C is

a) 2 Ω b) 4 Ω
c) 2.5 Ω d) 4.5 Ω

233. An electrical cable of copper has just one wire of radius 9 mm. It's resistance is 5 Ω. This single copper wire of cable is replaced by 6 different well insulated copper wires, each of radius 3 mm. The total resistance of the cable will now be equal to

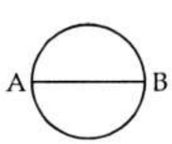
a) 7.5 Ω b) 5.5 Ω
c) 6 Ω d) 8 Ω

234. A copper wire of length l and radius r is nickel coated till its final radius is 2r. If the resistivities of copper and nickel are ρ_c and ρ_n, then the equivalent resistance of wire is

a) $\dfrac{l}{\pi r^2\left[\dfrac{1}{\rho_c}+\dfrac{3}{\rho_n}\right]}$ b) $\dfrac{l}{\pi r^2\left[\dfrac{1}{\rho_c}-\dfrac{3}{\rho_n}\right]}$

c) $\dfrac{2l}{\pi r^2\left[\dfrac{1}{\rho_c}-\dfrac{3}{\rho_n}\right]}$ d) $\dfrac{2l}{\pi r^2\left[\dfrac{1}{\rho_c}+\dfrac{3}{\rho_n}\right]}$

235. In the figure given below find the resistance between points A and B. Both the circle and the diameter are made of uniform wire of resistance r Ω per meter. The length AB is 2 metre.



a) 0.88 r b) 0.68 r
c) r d) 2 r

236. The resistance of a wire of iron is 10 Ω and temperature coefficient of resistance is 5×10^{-3}/°C. At 20°C it carries 30 mA of current. Keeping constant potential difference between its ends, the temperature of the wire is raised to 120°C. The current in milliamperes that flows in the wire is

a) 10 mA b) 20 mA
c) 5 mA d) 15 mA

237. Drift velocity of electrons in a conductor bearing potential difference V across its terminals is v. If the length of wire is stretched to three times and same potential difference V is applied, then the drift velocity will become

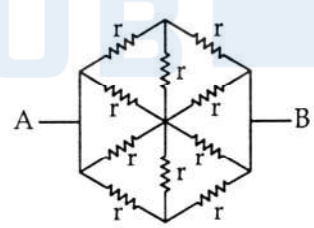
a) $\dfrac{v}{3}$ b) $\dfrac{v}{2}$

c) $\dfrac{v}{6}$ d) v

238. 100 cells each of e.m.f. 5 V and iriternal resistance 10 are to be arranged so as to produce maximum current in a 25 Ω resistance. Each row is to contain equal number of cells. The number of rows will be

a) 2 b) 3
c) 50 d) 40

239. The effective resistance between points A and B of a hexagonal circuit as A shown in figure is,



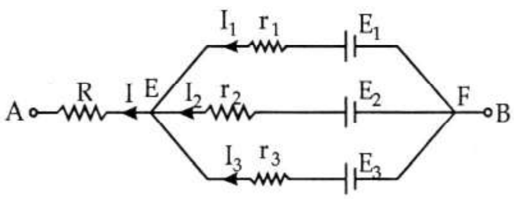
a) r b) 2 r
c) 3r d) 0.5 r

240. Twelve wires, each of resistance 10 are connected to from a skeleton cube. Battery of 10 V and negligible internal resistance is connected across diagonally opposite corners of the cube. Determine the equivalent resistance of the network and current supplied by the battery.

a) $\dfrac{5}{6}\Omega$ and 12 A b) $\dfrac{6}{5}\Omega$ and 12 A

c) $\frac{5}{6}\Omega$ and 4 A   d) $\frac{6}{5}\Omega$ and 4 A

241. In the circuit shown in figure,
$E_i = 3V$, $E_2 = 2V$, $E_3 = 1V$ and
$R = r_1 = r_2 = r_3 = 1\ \Omega$. The potential difference between points A and B will be



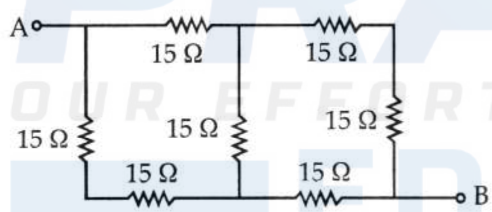
a) 1 V   b) 2 V
c) 3 V   d) 4 V

242. Twelve equal wires each of resistance r Ω form a cube. The effective resistance between the corners of the same edge of the cube is

a) $\frac{7}{12}r$ b) $\frac{12}{7}r$

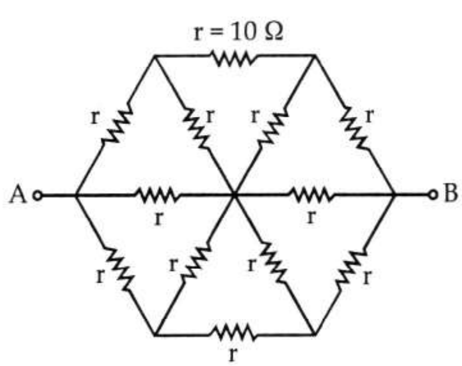
c) $\frac{5}{7}r$ d) $\frac{12}{5}r$

243. The equivalent resistance between the terminals A and B in the network shown in the figure is



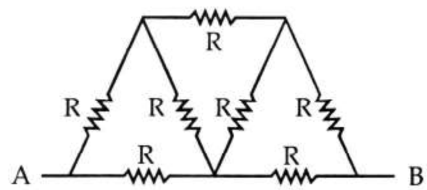
a) 7Ω b) 14Ω
c) $15\ \Omega$ d) $21\ \Omega$

244. 12 resistors each of 10 Ω are connected as shown in the figure. The effective resistance between A and B is



a) 4Ω b) 8Ω
c) $2\ \Omega$ d) $6\ \Omega$

245. In the network shown in figure each resistance is 1 Ω. The effective resistance between A and B is



a) $\frac{8}{7}\ \Omega$ b) $\frac{7}{8}\ \Omega$

c) $1\ \Omega$ d) $2\ \Omega$

Examples for practice

246. The length of wire of diameter 05 mm needed to produce a coil of resistance 10 Ω and specific resistance $4.4 \times 10^{-7}\ \Omega$ m is
a) 4.45 m   b) 5.55 m
c) 5.45 m   d) 1.45 m

247. The resistance of a wire of length 40 m and radius 0.25 mm is 10 Ω. The conductivity of the material of the wire is
a) 1×10^7 mho/m   b) 2×10^{-7} mho/m
c) 2×10^7 mho/m   d) 1×10^{-7} mho/m

248. A wire of resistance 12 Ω is stretched uniformly till its length becomes three times original length. The change in resistance of wire is
a) 96 Ω b) 108 Ω
c) 150 Ω d) 208 Ω

249. A wire of resistance 16 Ω is bent in to a circle and a cell of e.m.f. 2 V and internal resistance 1 Ω is connected between two points of wire, a quarter circumference apart. The current in each segment of wire is

a) $\frac{8}{1}A, \frac{3}{8}A$ b) $\frac{1}{8}A, \frac{8}{3}A$

c) $\frac{8}{1}A, \frac{8}{3}A$ d) $\frac{1}{8}A, \frac{3}{8}A$

250. Two cells of e.m.f. 2.5 V and 2.0 V having internal resistance of 1 Ω and 2 Ω respectively are connected in parallel with similar poles connected together so as to send the current in the same

direction through an external resistance of 2 Ω. The current in the external resistance is

a) 0.87 A b) 1.29 A
c) 1.00 A d) 2.29 A

251. Two cells of e.m.f. E_1 and E_2, $E_1 > E_2$ having an internal resistance of 1 Ω each form a closed circuit with an ammeter and a resistance. When the polarity of E_2 is reversed, the current changes from 130 mA to 20 mA. If the combined resistance of ammeter and resistance is 18 Ω then the value of E_1 and E_2 will be

a) 2.5 V, 1.1 V b) 1.5 V, 2.2 V
c) 1.5 V, 1.1 V d) 2.5 V, 2.

252. Four. resistances 1 Ω, 2 Ω, 2 Ω, and 4 Ω are connected so as to form a Wheatstone's network. The cell of e.m.f. 2 V is connected between its opposite points. The total current of bridge is

a) 1 A b) 0.5 A
c) 2 A d) 1.5 A

253. Four resistances 3 Ω, 6 Ω, 4 Ω, and 12 Ω are connected so as to form Wheatstone's network. Shunt needed across 12 Ω resistor to balance the bridge is

a) 12 Ω b) 24 Ω
c) 42 Ω d) 48 Ω

254. Two equal resistances are introduced in two gaps of a metre bridge. The shift in the null point if an equal resistance is connected in series with resistance in left gap is

a) 16.6 cm b) 16.6 m
c) 16.6 mm d) 66.6 cm

255. With an unknown resistance X in the left gap and a resistance R in the right gap of a meter bridge, the neutral point is obtained at a distance of 75 cm from the left end. The shift of null point if the unknown resistance is shunted by an equal resistance X and keeping same resistance in right gap is

a) 25 cm towards right
b) 25 cm towards left
c) 15 cm towards right
d) 15 cm towards left

256. Two coils are connected in series in one gap of the Wheatstone's meter bridge and null point is obtained at the centre of the wire with a resistance of 100 Ω in the other gap. When the two coils are connected in parallel in the same gap, the unknown resistance is to be changed by 84 Ω to obtain the null point at the centre again. The resistance of the two coils will be

a) 30 Ω and 80 Ω b) 80 Ω and 30 Ω
c) 20 Ω and 80 Ω d) 50 Ω and 50 Ω

257. With resistances P and Q in the left gap and right gap respectively, of a meter bridge. The null point is obtained at 60 cm from left end. When Q is increased by 10 Ω the null point is obtained at 40 cm from left end. The values of P and Q are

a) 12 Ω, 8 Ω b) 8 Ω, 12 Ω
c) 8 Ω, 8 Ω d) 12 Ω, 12 Ω

258. Two resistances prepared from the wire of the same material having diameters in the ratio 3 : 1 and length in the ratio 3 : 1 are connected in the left and right gap of Wheatstone's metre bridge. The distance of null point from the left end of the wire is

a) 55 cm b) 25 cm
c) 35 cm d) 52 em

259. Equal lengths of wires A and B are connected in the left and the right gap respectively of a meter bridge. The null point is obtained at 0.4 m from the left end of the wire. If the diameters of the wires A and B are in the ratio 2 : 3. Then the ratio of specific resistances of the materials of the wires will be

a) 8 : 27 b) 8 : 15
c) 27 : 8 d) 15 : 8

260. A potentiometer wire is 500 cm long and potential difference of 4 V is maintained between the ends of the wire. The e.m.f. of the cell which balances against the length of 135 cm of the wire is

a) 0.08 V b) 2.08 V
c) 2.88 V d) 1.08 V

261. A steady voltage drop is maintained across a potentiometer wire which is 5 m long. A Daniel cell is balanced by a length of 3m of wire. If length of potentiometer wire is increased to 6 m, find new length of wire across which Daniel cell will be balanced.

a) 3.6 m b) 6.6 m
c) 6.3 m d) 3.3 m

262. Two cells are connected in series and e.m.f. of combination is found to balance against length of 450 cm of potentiometer wire. When the two cells are connected in parallel emf of combination balances against 50 cm length of wire. The ratio

of e.m.f. of two cells is

a) 2.25 b) 1.55

c) 1.25 d) 2.55

263. The emf of cell is balanced by balancing length 450 cm. When the resistance of 10 Ω is connected across the cell, balancing length changes by 100 cm. The internal resistance of a cell is

a) 1.8 Ω b) 2.8 Ω

c) 3.8 Ω d) 2.5 Ω

264. A resistance of potentiometer wire is 1 Ω/m. A Daniel cell of e.m.f. 1.08 V balances. at 216 cm on potentiometer. The current through wire is

a) 1.5 A b) 0.25 A

c) 2.5A d) 0.5 A

265. In a potentiometer experiment the balancing length is found to be 1.80 m for a cell of emf 1.5 V. The balancing length for a cell of emf 1 V is

a) 1.2 m b) 0.5 m

c) 2.2 m d) 0.2 m

266. A potentiometer wire of length 4 cm has a some resistance. The resistance connected in series with the wire and accumulator of e.m.f. 2 V is 16 Ω. If the potential gradient along wire is 10^{-3} V/cm. The resistance of potentiometer wire is

a) 0.066 Ω b) 0.022 Ω

c) 0.033 Ω d) 0.044 Ω

267. The resistance of a potentiometer wire is 10 Ω and its length is 10 m. A resistance box and 2 V accumulator are placed in series with it. The value of resistance in the resistance box, if it is desired to have potential drop of 1 microvolt/mm is

a) 1990 Ω b) 1890 Ω

c) 1190 Ω d) 2290 Ω

Questions given in MHT–CET

268. Electromotive force is the force, which is able to maintain a constant

a) current b) resistance

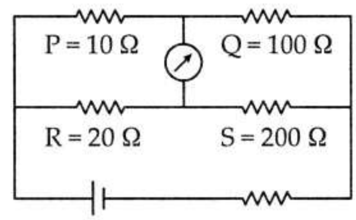
c) power d) potential difference

269. A series combination of two resistors 1 Ω each is connected a 12 V battery of internal resistance 0.4 Ω. The current flowing through is

a) 12 A b) 6A

c) 5 A d) 3.2 A

270. Figure given below shows a balance Wheatstone's network. Now it is disturbed by changing P to 15 Ω. Which of the following steps will not bring the bridge to balance again?



a) increasing R by 2 Ω

b) increasing Q by 10 Ω

c) increasing S by 20 Ω

d) all of these

271. The alloys, constant and maganin are used to make standard resistances because the have

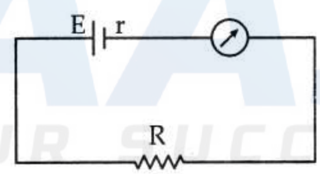
a) high resistivity

b) low temperature coefficient of resistance

c) low resistivity

d) both 'a' and 'b'

272. A battery of e.m.f. 10 V and internal resistance 3 Ω is connected to a resistor as shown in the figure. If the current in the circuit is 0.5 A, then what is the resistance of the resistor?



a) 13 Ω b) 15 Ω

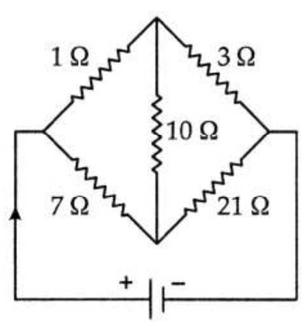
c) 17 Ω d) 19 Ω

273. When a wire stretched and its radius becomes r/2, then the resistance will be

a) 16 R b) 4 R

c) 2 R d) R/2

274. In the circuit shown, the current drawn from the battery is 4 A. If 10 Ω resistor is replaced by 20 Ω resistor, the current drawn from the circuit will be

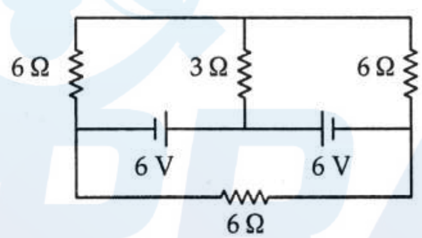


a) 1 A b) 2 A
c) 3 A d) 4 A

275. A cell of e.m.f. 2 V and internal resistance 0.5 Ω is connected across a resistor R. The current that flows is same as that, when a cell of e.m.f. 1.5 V and internal resistance 0.3 Ω is connected across the same resistor. Then
a) R = 0.3 Ω
b) R = 0.6 Ω
c) R = 0.5 Ω
d) R = 0.75 Ω

276. The terminal potential difference for a cell is 8.5 V when current is 2 A and 9 V when current is 1.5 A. What is the internal resistance of cell?
a) 4 Ω b) 2 Ω
c) 3 Ω d) 1 Ω

277. In the given circuit, find the power dissipated in 3 Ω resistance.



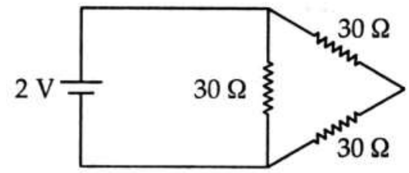
a) 6 W b) 7 W
c) 3 W d) 2 W

278. If length of a conductor is doubled by keeping volume constant, then what is its new resistance if initial were 4 Ω ?
a) 16 Ω b) 8 Ω
c) 4 Ω d) 2 Ω

279. Effective resistance of parallel combination is 6/5 Ω. If one of resistance is broken, then the resultant resistance becomes 2 Ω. Then other resistance is
a) 4 Ω b) 3 Ω
c) 6 Ω d) 5 Ω

280. In a metre bridge, copper strips are used
a) to decrease contact resistance
b) to reduce thermoelectric effect
c) to increase grip of wire
d) to increase length of wire

281. Current supplied by the cell in the adjoining 290. figure is

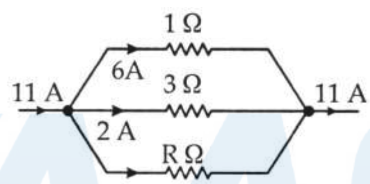


a) 1.5 A b) 1 A
c) 0.1 A d) 0.5 A

282. A wire of resistance 4 Ω is stretched to four times of its original length resistance of wire now becomes
a) 4 Ω b) 8 Ω
c) 64 Ω d) 16 Ω

283. An electric bulb is marked 100W. If it operates at 220 V, the resistance of bulb will be
a) 200 Ω b) 100 Ω
c) 484 Ω d) 450 Ω

284. In the circuit shown in figure, the value of R is



a) 1 Ω b) 2 Ω
c) 3 Ω d) 4 Ω

285. When length of wire is increased by 10%, then percentage increase in resistance is
a) 10 % b) 21%
c) 25 % d) 35 %

286. For two wires, length ratio is 1 : 4, radius ratio is 1 : 2, specific resistances ratio is 3 : 1. Compare their resistances.
a) 1 : 3 b) 1 : 2
c) 3 : 2 d) 3 : 1

287. In potentiometer experiment, a cell is balanced by length 120 cm. When a cell is shunted by resistance of 5 Ω, the balancing length is 80cm. The internal resistance of cell is
a) 2.5 Ω b) 3 Ω
c) 4 Ω d) 5 Ω

288. S.I. unit of specific resistance is
a) Ω cm b) Ω m
c) Ω / cm d) Ω / m

289. Four resistances arranged to form a Wheatstone's

network are 8Ω, 12Ω, 6Ω and $27\ \Omega$. The resistance that should be connected across $27\ \Omega$ resistance to balance the bridge is.

a) $13.5\ \Omega$ b) $15.5\ \Omega$
c) $27\ \Omega$ d) $12\ \Omega$

290. When galvanometer of unknown resistance is connected across a series combination of two identical batteries each of 1.5V, the current through the resistor is 1 A. When it is connected across a parallel combination of the same batteries, the current through it is 0.6 A. The internal resistance of each battery is

a) $1/5\ \Omega$ b) $1/4\ \Omega$
c) $1/3\ \Omega$ d) $1/2\ \Omega$

291. A potentiometer wire has a resistivity of $10^9\ \Omega$ cm and area of cross section 10^{-2} cm^2. If current of 0.01 mA passes through the wire, potential gradient is

a) 10^9 V/m b) 10^{-9} V/m
c) 10^8 V/m d) 10^6 V/m

292. In Wheatstone bridge, the resistances in four arms are $10\ \Omega$, $10\ \Omega$, $10\ \Omega$ and $20\ \Omega$. To make the bridge balance, resistance connected across $20\ \Omega$ is

a) 10Ω b) 5Ω
c) 20Ω d) 40Ω

293. If the length of wire is increased by 10%, its resistance increases by

a) 10 % b) 20%
c) 40% d) 21%

294. Sensitivity of the potentiometer can be increased by

a) increasing the length
b) increasing the PD
c) decreasing the series resistance
d) increasing the current in the potentiometer

295. A wire of length 1.6 m has a resistance $8\ \Omega$ is connected to a battery of 2 volts and internal resistance $2\ \Omega$. What is the potential gradient?

a) 1.5 V/m b) 0.5 V/m
c) 1 V/m d) 2 V/m

296. Specific resistance of a metal conductor is $4 \times 10^{-5}\ \Omega$ m and its area of cross section is 8 cm^2 when 0.2 A current passes through the conductor then potential gradient of the conductor is

a) 10^{-1} V/m b) 10^{-3} V/m
c) 10^{-2} V/m d) 10 V/m

297. S.I. unit of potential gradient is

a) V cm b) V / cm
c) V m d) V / m

298. Kirchhoff's first law is the consequence of Law of Conservation of

a) mass b) energy
c) charge d) momentum

299. S.I. unit of specific resistance is

a) Ω cm b) Ω m
c) Ω / cm d) Ω / m

300. Four resistances arranged to form a Wheatstone's network are $8\ \Omega$, $12\ \Omega$, $6\ \Omega$ and $27\ \Omega$. The resistance that should be connected across $27\ \Omega$ resistance to balance the bridge is

a) $13.5\ \Omega$ b) $1.5.5\ \Omega$
c) $27\ \Omega$ d) $12\ \Omega$

301. For measurement of potential difference, potentiometer is prefered in comparision to voltmeter because

a) potentiometer is more sensitive than voltmeter
b) the resistance of potentiometer is less than voltmeter
c) potentiometer is cheaper than volt meter
d) potentiometer does not take current from the circuit

302. When a resistance of $100\ \Omega$ is connected in series with a galvanometer of resistance R, its range is V. To double its range a resistance of $1000\ \Omega$ is connected in series. Find R

a) $700\ \Omega$ b) $800\ \Omega$
c) $900\ \Omega$ d) $100\ \Omega$

303. The e.m.f. of a thermocouple, cold junction of which is kept at -300 °C is given by $E = 40\,t + \frac{1}{10}t^2$. The temperature of inversion of thermocouple will be

a) 20 °C b) 400 °C
c) -200 °C d) -100 °C

304. Which of the following is correct relation between potential gradient, current I and specific resistance ρ ?

a) $A/I\rho$ b) $I\rho l/A$
c) $I\rho/A$ d) $I\rho/lA$

305. If the temperature of cold junction decreases then neutral temperature
a) increases
b) decreases
c) remains constant
d) may increase or may decrease

306. For a thermocouple, the temperature of inversion is that temperature at which thermo emf is
a) zero b) maximum
c) minimum d) none of the above

307. In a Wheatstone's network the positions of the battery and the galvanometer are interchanged. The balance condition
a) remains unaltered
b) alters
c) mayor may not altered depending on the resistance of the galvanometer and the battery
d) none of these

308. A wire of resistance 4 Ω is stretched to twice its original length. The resistance of stretched wire would be
a) 4 Ω b) 8 Ω
c) 16 Ω d) 2 Ω

309. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is
a) 0.5 Ω b) 0.8 Ω
c) 1.0 Ω d) 0.2 Ω

310. The resistances of the four arms P, Q, R and S in a Wheatstone's bridge are 10 ohm, 30 ohm, 30 ohm and 90 ohm, respectively. The e.m.f. and internal resistance of the cell are 7 Volt and 5 ohm respectively. If the galvanometer resistance is 50 ohm the current drawn from the cell will be
a) 0.2 A b) 0.1 A
c) 2.0 A d) 1.0 A

311. In Wheatstone's bridge, three resistors P, Q, R are connected in three arms in order and 4th arm s is formed by two resistors s_1 and s_2 connected in parallel. The condition for bridge to be balanced is $\frac{P}{Q} =$
a) $\frac{R(s_1+s_2)}{s_1s_2}$ b) $\frac{s_1s_2}{R(s_1+s_2)}$
c) $\frac{Rs_1s_2}{(s_1+s_2)}$ d) $\frac{(s_1+s_2)}{Rs_1s_2}$

312. An electron in potentiometer wire experiences a force 2.4×10^{-19} N. The length of potentiometer wire is 6m. The e.m.f. of the battery connected across the wire is (electronic charge = 1.6×10^{-19}C)
a) 6 V b) 9 V
c) 12 V d) 15 V

313. The masses of three copper wires are in the ratio 1 : 3 : 5 and their lengths are in the ratio 5 : 3 : 1. The ratio of their resistance is
a) 15 : 1 : 125 b) 1 : 125 : 15
c) 125 : 1 : 15 d) 125 : 15 : 1

314. The resistances in left and right gap of a meter bridge are 20 W and 30 W respectively. When the resistance in the left gap is reduced to half its value, the balance point shifts by
a) 15 cm to the right b) 15 cm to the left
c) 20 cm to the right d) 20 cm to the left

315. A potentiometer wire of length 10 m is connected in series with a battery. The e.m.f. of a cell balances against 250 cm length of wire. If length of potentiometer wire is increased by 1 m, the new balancing length of wire will be
a) 2.00 m b) 2.25 m
c) 2.50 m d) 2.75 m

Answers

1. (b)	2. (b)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)	8. (d)	9. (c)	10. (a)
11. (a)	12. (d)	13. (a)	14. (b)	15. (a)	16. (a)	17. (b)	18. (b)	19. (b)	20. (c)
21. (b)	22. (b)	23. (a)	24. (b)	25. (a)	26. (c)	27. (c)	28. (d)	29. (a)	30. (b)
31. (d)	32. (a)	33. (a)	34. (a)	35. (b)	36. (d)	37. (a)	38. (a)	39. (a)	40. (a)
41. (d)	42. (b)	43. (a)	44. (c)	45. (a)	46. (a)	47. (b)	48. (a)	49. (c)	50. (a)
51. (a)	52. (a)	53. (b)	54. (a)	55. (a)	56. (a)	57. (d)	58. (b)	59. (d)	60. (a)
61. (a)	62. (a)	63. (a)	64. (c)	65. (b)	66. (c)	67. (d)	68. (c)	69. (d)	70. (c)
71. (d)	72. (b)	73. (c)	74. (a)	75. (d)	76. (a)	77. (d)	78. (c)	79. (d)	80. (a)
81. (b)	82. (b)	83. (b)	84. (a)	85. (a)	86. (a)	87. (a)	88. (d)	89. (c)	90. (a)
91. (b)	92. (b)	93. (d)	94. (a)	95. (d)	96. (d)	97. (d)	98. (c)	99. (a)	100. (b)
101. (a)	102. (d)	103. (d)	104. (c)	105. (a)	106. (a)	107. (b)	108. (b)	109. (a)	110. (b)
111. (c)	112. (a)	113. (a)	114. (d)	115. (b)	116. (d)	117. (d)	118. (d)	119. (c)	120. (a)
121. (c)	122. (d)	123. (a)	124. (b)	125. (a)	126. (a)	127. (d)	128. (b)	129. (c)	130. (b)
131. (b)	132. (b)	133. (b)	134. (c)	135. (d)	136. (a)	137. (a)	138. (b)	139. (a)	140. (b)
141. (c)	142. (b)	143. (c)	144. (a)	145. (c)	146. (c)	147. (a)	148. (d)	149. (b)	150. (a)
151. (c)	152. (b)	153. (b)	154. (b)	155. (c)	156. (b)	157. (c)	158. (d)	159. (a)	160. (c)
161. (b)	162. (a)	163. (b)	164. (b)	165. (b)	166. (b)	167. (c)	168. (b)	169. (b)	170. (d)
171. (a)	172. (d)	173. (d)	174. (a)	175. (a)	176. (d)	177. (a)	178. (b)	179. (a)	180. (a)
181. (c)	182. (a)	183. (c)	184. (a)	185. (a)	186. (a)	187. (a)	188. (c)	189. (a)	190. (b)
191. (a)	192. (c)	193. (c)	194. (a)	195. (a)	196. (b)	197. (d)	198. (c)	199. (c)	200. (a)
201. (a)	202. (b)	203. (c)	204. (c)	205. (d)	206. (a)	207. (a)	208. (d)	209. (c)	210. (a)
211. (a)	212. (c)	213. (c)	214. (b)	215. (a)	216. (c)	217. (c)	218. (a)	219. (c)	220. (b)
221. (c)	222. (a)	223. (c)	224. (d)	225. (c)	226. (c)	227. (c)	228. (d)	229. (c)	230. (a)
231. (b)	232. (b)	233. (a)	234. (a)	235. (a)	236. (b)	237. (a)	238. (a)	239. (d)	240. (a)
241. (b)	242. (a)	243. (d)	244. (b)	245. (a)	246. (a)	247. (c)	248. (b)	249. (d)	250. (a)
251. (c)	252. (a)	253. (b)	254. (a)	255. (d)	256. (c)	257. (a)	258. (b)	259. (a)	260. (d)
261. (a)	262. (c)	263. (b)	264. (d)	265. (a)	266. (c)	267. (a)	268. (d)	269. (c)	270. (c)
271. (d)	272. (c)	273. (a)	274. (d)	275. (a)	276. (d)	277. (c)	278. (a)	279. (b)	280. (a)
281. (c)	282. (c)	283. (c)	284. (b)	285. (b)	286. (d)	287. (a)	288. (b)	289. (a)	290. (c)
291. (c)	292. (c)	293. (d)	294. (a)	295. (c)	296. (c)	297. (d)	298. (c)	299. (b)	300. (a)
301. (d)	302. (c)	303. (c)	304. (c)	305. (c)	306. (a)	307. (a)	308. (c)	309. (a)	310. (a)
311. (a)	312. (b)	313. (d)	314. (b)	315. (d)					

17. $I = \frac{ne}{t}$

$\therefore \quad n = \frac{It}{e} = \frac{300\times10^{-3}\times60}{1.6\times10^{-19}} = 1.125\times10^{20}$

18. $I = \frac{q}{t} = \frac{ne}{t} = \frac{10^{7}\times1.6\times10^{-19}}{1}$

$= 1.6\times10^{-12}$ A

19. Electric current due to flow of 10^{19} α-particles towards left is,

$I_1 = 2n_1e = 2\times10^{19}\times e$

Electric current due to flow of 10^{19} electrons towards left is,

$I_2 = 10^{19}\times e$

Electric current due to flow of 10^{19} protons towards left is,

$I_3 = 10^{19}\times e$

Thus, total electric current is,

$I = I_1 + I_2 + I_3 = 4\,e\times10^{19}$

$= 4\times1.6\times10^{-19}\times10^{19} = 6.4$ A

20. $I = \frac{q}{t} = \frac{e}{t} = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$

21. $I = \frac{ev}{2\pi r} = \frac{1.6\times10^{-19}\times4\times10^{6}}{6.28\times10^{-1}}$

$= 1.019\times10^{-12}$ A

22. $I = \frac{q}{t} = \frac{3000}{10\times60} = 5$ A

24. $I = \frac{q}{t} = \frac{e}{T} = \frac{e}{1/f} = fe$

$= 10^{16}\times1.6\times10^{-19} = 1.6\times10^{-3}$ A

39. $v_d \propto \frac{1}{r^2} \qquad \therefore\ v_{d1}\, r_1^2 = v_{d2}\, r_2^2$

$\therefore \quad v_{d2} = \left(\frac{r_1}{r_2}\right)^2 v_{d1} = \left(\frac{r}{2r}\right)^2 vd = 0.25\, v_d$

40. $v_d = \frac{I}{nAe}$

$= \frac{0.21}{8.4\times10^{28}\times10^{-6}\times1.6\times10^{-19}}$

$= 1.562\times10^{-5}$ m/s

42. $I = \frac{q}{t} = \frac{e}{t} = \frac{ev}{2\pi r}$

$= \frac{1.6\times10^{-19}\times2.18\times10^{6}}{6.28\times0.53\times10^{-10}}$

$= 1.048\times10^{-3}$ A

61. $v_d = \frac{I}{nAe}$

$= \frac{5}{5\times10^{26}\times4\times10^{-6}\times1.6\times10^{-19}}$

$= 1.5625\times10^{-2}$ m/s

84. $I_s = \frac{nE}{R+nr}$ and $I_p = \frac{nE}{nR+r}$

Given, $I_s = I_p$

$\therefore \quad \frac{nE}{R+nr} = \frac{nE}{nR+r} \qquad \therefore\ r = R$

85. Power delivered to the resistor is R or current through R is maximum when total internal resistance of the circuit is equal to the external resistance i.e. $R = r/2$.

113. $v_d = \frac{I}{nAe}$

$\therefore\ I = v_d\, nAe$

$= 1\times10^{-3}\times5\times10^{22}\times10^{6}\times10^{-6}\times1.6\times10^{-19}$

$= 8$ A

114. $\rho = \frac{RA}{l} = \frac{2.2\times0.5\times10^{-6}}{1} = 11\times10^{-7}\ \Omega$m

115. $R_2 = n^2R_1 = 3^2\times25 = 225\ \Omega$

116. $R_2 = n^2R_1 = 2^2\times R = 4R$

118. $\rho = \frac{RA}{l} = \frac{V}{I}\frac{A}{l} = \frac{2\times10^{-6}}{4\times0.5} = 1\times10^{-6}\ \Omega$ m

119. $\frac{R_1}{R_2} = \frac{(\rho_1 l_1/A_1)}{(\rho_2 l_2/A_2)} = \frac{A_2}{A_1}$

$\therefore \quad R_2 = \frac{A_1}{A_2}\times R_1 = \frac{3\times10}{1} = 30\ \Omega$

Total resistance of combination $= R_1 + R_2 = 40\ \Omega$

120. $\rho = \frac{RA}{l} \qquad \therefore\ l = \frac{RA}{\rho}$

Now, $E = \frac{V}{l} = \frac{V\rho}{RA} = \frac{I\rho}{A} \qquad \left(\because \frac{V}{R} = I\right)$

$= \frac{100\times1.7\times10^{-8}}{10^{-4}} = 1.7\times10^{-2}$ V/m

121. $R_2 = n^2R_1 = (1.25)^2R_1 = 1.5625\times1$

$= 1.5625\ \Omega$

Thus, increase in resistance is,

$R_2 - R_1 = 1.5625 - 1 = 0.5625\Omega = 56.25\%$

122. $R = \frac{V}{I} = \frac{20}{0.5} = 40\ \Omega$

123. $$I = \frac{E}{R+r} = \frac{2}{18+2} = 0.1\text{ A}$$

124. From graph,

$$\text{Resistance} = \text{Slope of graph}$$
$$= \frac{2}{1} = 2\ \Omega$$

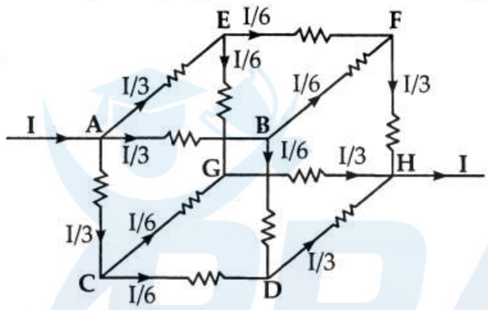
126. Area of cross section of tube,

$$A = \pi\,(r_2^2 - r_1^2)$$
$$= 3.14\,[(0.05)^2 - (0.045)^2]$$
$$= 14.91 \times 10^{-4}\ \text{m}^2$$

Thus, $$R = \frac{\rho l}{A} = \frac{1.7\times10^{-8}\times5}{14.91\times10^{-4}} = 5.7\times10^{-5}\ \Omega$$

146. Let R be the effective resistance between two diagonally opposite corners of cube i.e. between A and H. Thus, by Ohm's law we have,

$$V = I\cdot R \quad \text{.... (i)}$$



From figure,

$$V = V_{AB} + V_{BD} + V_{DH}$$
$$= \frac{I}{3}\times6 + \frac{I}{6}\times6 + \frac{I}{3}\times6$$
$$= 6\left[\frac{2I+I+2I}{6}\right] = 5\,I \quad \text{.... (ii)}$$

From equation (i) and (ii), we have,

$$IR = 5\,I$$
$$\therefore \quad R = 5\ \Omega$$

148. This is balanced Wheatstone's bridge. Thus, the resistance 7 Ω is ineffective and 5 Ω and 4 Ω are in series and 10 Ω and 8 Ω are in series.

Thus, $R_{s1} = 5 + 4 = 9\Omega$ and $R_{s2} = 10 + 8 = 18\Omega$ are in parallel, so effective resistance is,

$$R_p = \frac{R_{s1}\times R_{s2}}{R_{s1}+R_{s2}} = \frac{9\times18}{9+18} = 6\ \Omega$$

150. This is balanced Wheatstone's bridge. Thus, the resistance 2 Ω is ineffective and 1 Ω and 1 Ω are in series and 1 Ω and 1 Ω are in series.

Thus, $R_{s1} = 1 + 1 = 2\ \Omega$ and

$R_{s2} = 1 + 1 = 2\ \Omega$ are in parallel,

so effective resistance is,

$$R_p = \frac{R_{s1}\times R_{s2}}{R_{s1}+R_{s2}} = \frac{2\times2}{2+2} = 1\ \Omega$$

151. In figure, four resistances are in parallel. Thus, there effective resistance is,

$$\frac{1}{R_p} = \frac{1}{1}+\frac{1}{1}+\frac{1}{1}+\frac{1}{1} = \frac{4}{1}$$
$$\therefore \quad R_p = \frac{1}{4} = \frac{2}{8}\ \Omega$$

152. In figure, resistances 8 Ω, 2 Ω and 4 Ω, 6 Ω are in parallel. Their effective resistances are $R_1 = 1.6\ \Omega$ and $R_2 = 2.4\ \Omega$ respectively.

Now, resistances R_1 and R_2 are in series.

Thus, $R = R_1 + R_2 = 1.6 + 2.4 = 4\ \Omega$

Now, resistances 3 Ω, 4 Ω and 6 Ω are in parallel. There equivalent resistance is given by,

$$\frac{1}{R_p} = \frac{1}{3}+\frac{1}{4}+\frac{1}{6} \qquad \therefore\ R_p = \frac{12}{9} = \frac{4}{3}\ \Omega$$

153. Potential difference across 3 Ω and 6 Ω resistance is same.

Thus, $V = IR = 0.8 \times 3 = 2.4$ V

Thus, current flowing through parallel combination of 3 Ω and 6 Ω resistance is,

$$I = \frac{V}{R_p} = \frac{2.4}{2} = 1.2\text{ A}$$

Thus, potential difference across 4 Ω resistance is,

$$V_1 = 1.2 \times 4 = 4.8\text{ V}$$

154. The effective resistance of 1 Ω, 2 Ω and 3 Ω is,

$$R = 1.5\ \Omega$$

Now, $$I = \frac{E}{R+r} = \frac{1.5}{1.5+0} = 1\text{ A}$$

Thus, current through 3 Ω resistor is 0.5 A

155. From figure, equivalent resistance of three resistances connected in the form of triangle is 20 Ω.

Thus, $$I = \frac{V}{R} = \frac{2}{20} = \frac{1}{10}\text{ A}$$

156. The given network is a balanced Wheatstone's bridge. Thus, effective resistance of network is,

$$R = \frac{4\times4}{4+4} = \frac{16}{8} = 2\ \Omega$$

Thus, $$I = \frac{E}{R} = \frac{2}{2} = 1\text{A}$$

157. $$I_1 = \frac{E}{R_1+r} \quad \text{and} \quad I_2 = \frac{E}{R_2+r}$$

Thus, $$E = I_1(R_1+r) = I_2(R_2+r)$$
$$\Rightarrow 0.9\,(2+r) = 0.3\,(7+r)$$
$$\therefore \quad r = 0.5\ \Omega$$

158. The equivalent resistance of galvanometer and a resistance of 3 Ω is,

$$R_1 = \frac{15\times3}{15+3} = \frac{45}{18} = 2.5\ \Omega$$

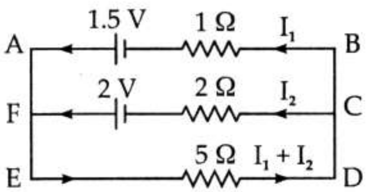
Thus, current supplied by cell is,

$$I = \frac{2}{5+2.5+0.5} = \frac{2}{8} = \frac{1}{4}\ A$$

Now, current through galvanometer is,

$$I_g = \left(\frac{3}{15+3}\right)\times\frac{1}{4} = \frac{1}{24}\ A$$

159.



Applying K.V.L. for the loop ABCFA,

we have, $-1.5 + I_1 - 2I_2 + 2 = 0$

$$I_1 - 2I_2 = -0.5 \quad \text{.... (i)}$$

By applying K.V.L. for the loop FCDEF,

we have, $-2 + 2I_2 + 5(I_1 + I_2) = 0$

$$5I_1 + 7I_2 = 2 \quad \text{.... (ii)}$$

To solve equation (i) and (ii), multiply equation (i) by (7) and equation (ii) by (2), we have,

$$7I_1 - 14I_2 = -3.5$$
$$10I_1 + 14I_2 = 4$$
$$\overline{17I_1 = 0.5}$$

$$\therefore \quad I_1 = \frac{0.5}{17} = \frac{1}{34}\ A$$

By substituting value of I_1 in equation (ii), we have,

$$I_2 = \frac{9}{34}\ A$$

∴ Current through external resistance is,

$$I_1 + I_2 = \frac{1}{34} + \frac{9}{34} = \frac{10}{34} = \frac{5}{17}\ A$$

160. From figure, effective resistance of network is,

$$R = 2 + 4 = 6\ \Omega$$

Thus, $V_P - V_Q = IR = 0.5 \times 6 = 3\ V$

167. To balance bridge, equivalent resistance of 15 Ω and its shunt should be $R_p = 10\ \Omega$

Thus, $$R_p = \frac{15\times S}{15+S}$$

$$\therefore \quad 10 = \frac{15\times S}{15+S} \qquad \therefore S = 30\ \Omega$$

171. For balanced bridge,

$$\frac{10}{40} = \frac{X}{16} \qquad \therefore X = 4\ \Omega$$

172. To balance bridge, $\frac{P}{Q} = \frac{S}{R}$

For option (a), $\frac{22}{200} = \frac{33}{300}$

For option (b), $\frac{22}{220} = \frac{30}{300}$

For option (c), $\frac{22}{200} \neq \frac{30}{350}$

Thus, bridge will balance by, (1) increasing S by 3 Ω and (2) increasing Q by 20 Ω.

178. $$X = \frac{l_x}{l_r}R = \frac{40\times60}{60} = 40\ \Omega$$

184. $$X = \frac{l_x}{l_r}R = \frac{30\times70}{70} = 30\ \Omega$$

185. For balanced bridge, $\frac{X}{R} = \frac{l_x}{l_r} \Rightarrow \frac{20}{40} = \frac{l_x}{l_r}$

$\therefore \quad 2\,l_x = l_r = (100 - l_x) \qquad \therefore l_x = 33.33$ cm

Now, 40 Ω resistance is shunted by 40 Ω.

Thus, $$R = \frac{40\times40}{40+40} = 20\ \Omega$$

Thus, to balanced bridge again, $\frac{20}{20} = \frac{l_x}{l_r}$

$\therefore \quad l_x = l_r = 50$ cm

Thus, shift in null point is,

$50 - 33.33 = 16.67$ cm

186. For balanced bridge, $\frac{X}{R} = \frac{l_x}{l_r}$

$$\therefore \quad \frac{P}{Q} = \frac{3}{4}$$

$$\therefore \quad 3Q - 4P = 0 \quad \text{..... (i)}$$

Now, $$\frac{P+20}{Q+20} = \frac{5}{6}$$

$$\therefore \quad 5Q - 6P = 20 \quad \text{..... (ii)}$$

From equation (i) and (ii), we have,

$P = 30\ \Omega$ and $Q = 40\ \Omega$

188. For balanced bridge,

$$\frac{X}{R} = \frac{l_x}{l_r} = \frac{35}{65} = \frac{7}{13}$$

211. $$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\therefore \quad E_2 = \frac{l_2}{l_1}E_1 = \frac{60\times10^{-2}\times1.018}{50\times10^{-2}} = 1.221\ V$$

212. $$I\rho = \left(\frac{E}{R+r}\right)\frac{R}{L} = \left(\frac{5}{5+4.5}\right)\frac{5}{10} = 0.2631 \text{ V/m}$$

$$E_1 = I\rho l_1 \quad \therefore\ l_1 = \frac{E_1}{I\rho} = \frac{0.4}{0.2631} = 1.52 \text{ m}$$

213. $$I = \frac{E}{R+r} = \frac{2}{4+1} = 0.4 \text{ A}$$

214. Potential gradient is,

$$I\rho = \left(\frac{E}{R+R_h+r}\right)\frac{R}{L} = \left(\frac{10}{5+995+0}\right)\frac{5}{10}$$
$$= 5 \times 10^{-3} \text{ V/m} = 5 \text{ mV/m}$$

215. $$V = IR = \left(\frac{E}{R+r}\right)R = \left(\frac{2}{50+10}\right)50 = 1.667 \text{ V}$$

216. $$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\therefore\ E_2 = \frac{l_2}{l_1}E_1 = \frac{180 \times 1.1}{140} = 1.414 \text{ V}$$

217. $$r_1 = R_1\left(\frac{l_1 - l_2}{l_2}\right) = 5\left(\frac{52-40}{40}\right) = 1.5\ \Omega$$

218. $$V_2 - V_1 = I\rho(l_2 - l_1)$$
$$= 5(40-20) \times 10^{-2}$$
$$= 5 \times 20 \times 10^{-2}$$
$$= 1 \text{ V}$$

219. $$E_1 = I\rho l_1$$

$$\therefore\ I = \frac{E_1}{\rho l_1} = \frac{2}{(1/10) \times 8} = \frac{2 \times 10}{8} = 2.5 \text{ A}$$

Now, $$I = \frac{2 \times 10}{8}$$

$$\therefore\ E = I(R + r + R_h)$$
$$= 2.5(10+1+0) = 27.5 \text{ V}$$

220. $$r_1 = R_1\left(\frac{l_1 - l_2}{l_2}\right)$$

$$= 1\left(\frac{5.5-5}{5}\right) = \frac{0.5 \times 1}{5} = 0.1\ \Omega$$

221. $$R_t = R_0(1 + \alpha t)$$

$$\therefore\ \alpha = \frac{R_t - R_0}{R_0 t} = \frac{20-10}{10 \times 273}$$

$$= \frac{1}{273} \text{ per degree C}$$

222. $$R = \frac{V}{I} = \frac{20}{5} = 4\ \Omega$$

224. $$\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2} = \frac{8+4}{8-4} = \frac{12}{4} = \frac{3}{1}$$

228. For same mass of wire, $R \propto \frac{1}{r^4}$

$$\therefore\ \frac{R'}{R} = \left(\frac{r}{r'}\right)^4 = \left(\frac{(r/r)}{2}\right)^4 = 16$$
$$R' = 16R$$

229. In series circuit, current is same

$$J = \frac{I}{A} \propto \frac{1}{r^2}$$

$$\therefore\ J_1 r_1^2 = J_2 r_2^2 \qquad \therefore\ \frac{J_1}{J_2} = \frac{9}{1}$$

230. $$P = \frac{W}{t} = I^2(R+r) = 1 \text{ J/s}$$

231. $$I = \frac{q}{t} = \frac{CV}{t} = \frac{10 \times 10^{-6} \times 40}{0.2} = 2 \text{ mA}$$

233. Resistance of 9 mm cable is 5 Ω.

Now, $R \propto \frac{1}{A} \quad \therefore R \propto \frac{1}{r^2}$

$\therefore$ Resistance of 3 mm cable = 9 × 5 = 45 Ω.

In second case, six wires are connected in parallel. Thus, its resistance is given by,

$$R_p = \frac{45}{6} = 7.5\ \Omega.$$

234. Copper and nickel are connected in parallel. Now, area of copper wire is

$$A_1 = \pi r_1^2 = \pi r^2$$

and area of nickel wire is

$$A_2 = \pi(2r)^2 - \pi r^2 = 3\pi r^2$$

$$\therefore\ \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \qquad \left(\because R = \frac{\rho l}{\pi r^2}\right)$$

$$\therefore\ \frac{1}{R_p} = \frac{\pi r^2}{\rho_c l} + \frac{3\pi r^2}{\rho_n l} = \frac{\pi r^2 \rho_n l + 3\pi r^2 \rho_c l}{\rho_c l \times \rho_n l}$$

$$\frac{1}{R_p} = \frac{\pi r^2}{\rho_c \rho_n l}[\rho_n + 3\rho_c)$$

$$\frac{1}{R_p} = \frac{\pi r^2}{l}\left[\frac{\rho_n}{\rho_c \cdot \rho_n} + \frac{3\rho_c}{\rho_c \rho_n}\right]$$

$$\frac{1}{R_p} = \frac{\pi r^2}{l}\left[\frac{1}{\rho_c} + \frac{3}{\rho_n}\right]$$

$$R_p = \frac{l}{\pi r^2\left[\frac{1}{\rho_c} + \frac{3}{\rho_n}\right]}$$

235. Let a be the radius of circle. Now, resistances π a r, 2 ra and πar, are connected in parallel.

Given $2a = 2\text{m} \qquad \therefore\ a = 1\text{m}$

$$\therefore \quad \frac{1}{R_P} = \frac{1}{\pi r} + \frac{1}{2r} + \frac{1}{\pi r} \Rightarrow R = 0.88\ r$$

236. Potential difference applied $= V = IR$

$$= 30 \times 10^{-3} \times 10$$

$$= 0.3\ V$$

Resistance at 120°C is given by,

$$R_{120} = R_{20}(1 + \alpha \times 100) = 15\ \Omega.$$

$\therefore$ Current at 120°C is given by,

$$I = \frac{V}{R_{120}} = \frac{0.3}{15} = 0.02\ A = 20\ mA$$

237. When the wire is stretched to three times, resistance becomes 9 times and area becomes one third.

$$\therefore \quad I = \frac{V}{R} = neAv_d$$

$$\therefore \quad v_d = \frac{V}{RneA} \qquad \therefore v_d \propto \frac{1}{AR}$$

$$\therefore \quad \frac{v_{d1}}{v_{d2}} = \frac{A_1 R_1}{A_2 R_2} = \frac{AR}{(A/3)(9R)} = \frac{1}{3}$$

$$\therefore \quad v_{d2} = \frac{v_{d1}}{3} = \frac{v}{3}$$

238. Let n be the number of cells in a row and m be the number of rows.

Now, maximum current is obtained for r = R. In mixed combination total resistance of the circuit is given by,

$$R = \frac{nr}{m} \quad \therefore 25 = \frac{n}{m} r \quad \therefore \frac{n}{m} = 25$$

$$\therefore \quad n = 25\ m \qquad \text{..... (i)}$$

In mixed combination, we have,

$$nm = 100 \qquad \text{..... (ii)}$$

From equation (i) and (ii) we have,

$$m \times 25\ m = 100$$

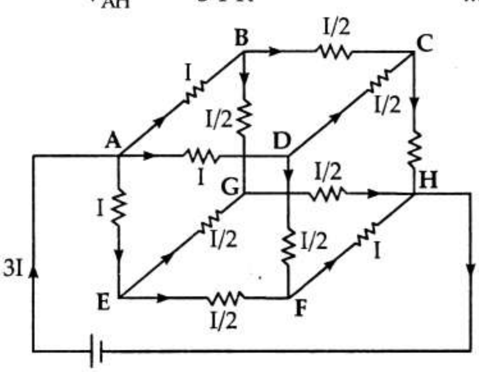
$$25\ m^2 = 100$$

$$m^2 = 4 \qquad \therefore m = 2 \text{ and } n = 50$$

239. From figure it is parallel combination of two Wheatstone's network.

240. Let R′ be the resistance between point A and H.

$$\therefore \quad V_{AH} = 3IR' \qquad \text{..... (i)}$$



From figure,

$$V_{AH} = V_{AB} + V_{BC} + V_{CH}$$

$$= IR + \frac{IR}{2} + IR = \frac{5}{2} IR \qquad \text{..... (ii)}$$

From equation (i) and (ii) we have,

$$R' = \frac{5}{6} R = \frac{5}{6} 1 = \frac{5}{6} \Omega.$$

From figure,

$$3I = \frac{E}{R'} = \frac{10}{(5/6)} = \frac{10 \times 6}{5} = \frac{60}{5}$$

$$3I = 12\ A$$

241. At junction point E we have,

$$I_1 + I_2 + I_3 = 0 \qquad \text{..... (i)}$$

Apply KVL for the loop EE_1FE we have,

$$I_1 - 3 + 2 - I_2 = 0$$

$$I_1 - I_2 = 1$$

$$\therefore \quad I_2 = I_1 - 1 \qquad \text{..... (ii)}$$

Apply KVL for the loop EE_1FE_3E we have,

$$I_1 - I_3 = 2$$

$$\therefore \quad I_3 = I_1 - 2 \qquad \text{..... (iii)}$$

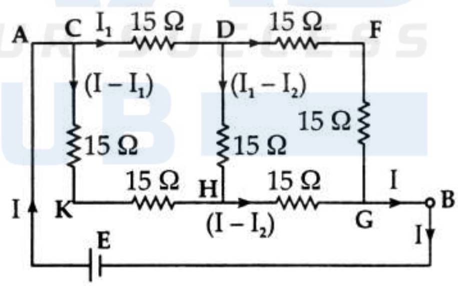
From equation (i), (ii) and (iii) we have,

$$I_1 = 1A, \quad I_2 = 0 \quad \text{and} \quad I_3 = -1A$$

Now, potential difference between point A and B = potential difference between E and F

$$\therefore \quad V_{EF} = E_2 - I_2 r_2 = 2 - 0 \times 1 = 2\ V$$

243.



Apply KVL for the loop CKHDC we have,

$$4I_1 - I_2 = 2I \qquad \text{..... (i)}$$

Apply KVL for the loop DHGFD we have,

$$-I_1 + 4I_2 = I \qquad \text{..... (ii)}$$

From equation (i) and (ii), we have,

$$I_1 = \frac{3}{5} I \quad \text{and} \quad I_2 = \frac{2}{5} I$$

Apply KVL for the loop ACKHGBEA we have,

$$-30(I - I_1) - 15(I - I_2) + E = 0$$

(After solving this equation and by putting values of I_1 and I_2 in this equation)

$$E = \frac{7}{5} IR \qquad \text{..... (iii)}$$

Let R′ be the resistance between A and B

$\therefore \quad E = I R'$ ..... (iv)

From equation (iii) and (iv), we have,

$$I R' = \frac{7}{5} I R$$

$$\therefore \quad R' = \frac{7}{5} R = \frac{7}{5} \times 15 = 21\ \Omega.$$

244. By symmetry the current ending at point A = current leaving at point B

The simplified form of above figure is as shown in the figure (1).

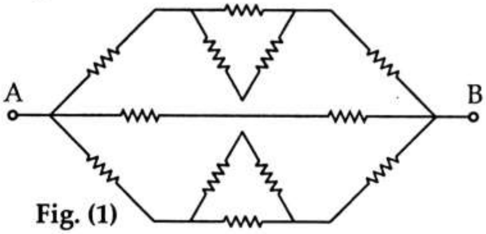


Fig. (1)

The simplified form of figure (1) is as shown in figure (2).

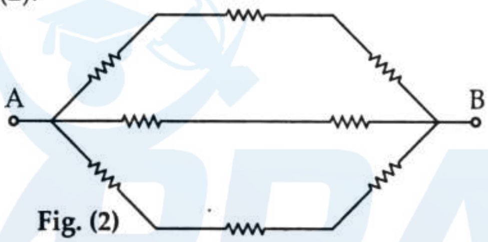
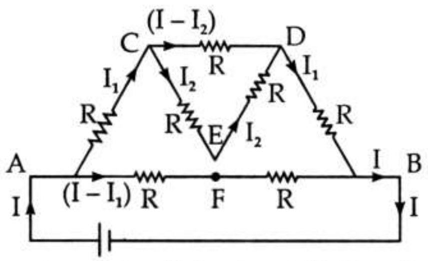


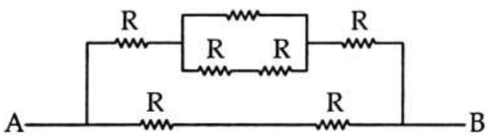
Fig. (2)

from figure, $R_{AB} = 8\ \Omega$.

245. As given circuit is symmetrical when a battery is connected across AB, the current entering at A must be symmetrical to current leaving at B. Therefore it is immaterial weather point E touches to point F or not



Thus, the above circuit is simplified as shown in the following figure.



Thus, from figure, equivalent resistance between point A and point B is given by,

$$R_{AB} = \frac{8}{7}\ \Omega.$$

246. $$R = \frac{\rho l}{A}$$

$$\therefore \quad l = \frac{10 \times 3.14 \times 25 \times 10^{-8}}{4.4 \times 10^{-7} \times 4} = \frac{78.5}{17.6} = 4.45\ \text{m}$$

247. $$\sigma = \frac{1}{\rho} = \frac{l}{RA} = \frac{40}{10 \times 3.14 \times 625 \times 10^{-10}}$$

$$= 2 \times 10^{7}\ \text{mho/m}$$

248. $$\frac{R_2}{R_1} = \left(\frac{l_2}{l_1}\right)^2$$

$$\therefore \quad R_2 = 9 \times 12 = 108\ \Omega$$

249. (i) $$I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I = \frac{4}{16} \times \frac{V}{R_P} = \frac{4 \times 2}{16 \times 4} = \frac{1}{8}\ \text{A}$$

(ii) $$I_2 = \left(\frac{R_1}{R_1 + R_2}\right) I = \frac{12}{16} \times \frac{V}{R_P} = \frac{12 \times 2}{16 \times 4} = \frac{3}{8}\ \text{A}$$

250. $$I = \frac{E_1 r_2 + E_2 r_1}{r_1 \cdot r_2 + R(r_1 + r_2)} = \frac{1.5 \times 2 + 2 \times 1}{1 \times 2 + 5(1+2)}$$

$$= 0.29\ \text{A}$$

251. $$I = \frac{E_1 + E_2}{R + r_1 + r_2} \quad \therefore E_1 + E_2 = 2.6 \quad \text{... (i)}$$

$$I = \frac{E_1 - E_2}{R + r_1 + r_2} \quad \therefore E_1 - E_2 = 0.4 \quad \text{... (iii)}$$

From equation (i) and (ii),

$E_1 = 1.5\ \text{V}$ and $E_2 = 1.1\ \text{V}$

252. The Wheatstone's network is in balanced condition. Thus,

$$R_R = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2\ \Omega$$

$$\therefore \quad I = \frac{V}{R} = \frac{2}{2} = 1\ \text{A}$$

253. $$8 = \frac{12.5}{12 + 5} \qquad 96 + 8.5 = 12.5$$

$$5 = \frac{96}{4} = 24\ \Omega$$

254. (i) $$\frac{X}{R} = \frac{l_x}{l_R} \quad \therefore l_x = l_R = 50\ \text{cm} \quad (\because x = R)$$

(ii) Now, if X = 2R

$$\frac{2R}{R} = \frac{l_x}{100 - l_x} \qquad 200 - 2 l_x = l_x$$

$$\therefore \quad l_x = 66.6\ \text{cm}$$

(iii) Shift = 66.66 – 50 = 16.66 cm

255. (i) $\frac{X}{R} = \frac{75}{25} \qquad \therefore X = 3R$

(ii) Now, $X' = \frac{X}{2} = \frac{3R}{2}$

$$\frac{X'}{R} = \frac{l_x}{100-l_x}$$

$$\frac{3}{2} = \frac{l_x}{100-l_x}$$

$300 - 3\,l_x = 2\,l_x \qquad 5\,l_x = 300$

$\therefore \quad l_x = 60$ cm

(iii) Shift = 75 – 60 = 15 towards left.

256. (i) $X_1 + X_2 = 100 \qquad \therefore X_2 = 100 - X_1$

$X_1 \cdot X_2 = 1600 \qquad \therefore 100\,X_1 - X_1^2 = 1600$

$\therefore \quad X_1 = 80\ \Omega$ or $X_1 = 20\ \Omega$

(ii) In parallel, $\frac{X_1 \cdot X_2}{(X_1+X_2)} = 16$

$X_1^2 - 100\,x_1 + 1600 = 0$

Thus, $X_2 = 20\ \Omega$ or $X_2 = 80\ \Omega$

257. (i) $\frac{P}{Q} = \frac{60}{40} \qquad P = \frac{3Q}{2}$

(ii) $\frac{P}{Q+10} = \frac{40}{60}$

$\frac{3Q}{20+20} = \frac{2}{3} \qquad 9\,Q = 4\,Q + 40 \qquad 5Q = 40$

$\therefore \quad Q = 8\ \Omega$

(iii) $P = \frac{3\times 8}{2} = 12\ \Omega$

258. $\frac{R_1}{R_2} = \frac{l_x}{l_r}$

$\therefore \quad \frac{l_1}{l_2} \times \frac{\pi r_2^2}{\pi r_1^2} = \frac{l_x}{100-l_x}$

$\therefore \quad l_x = 25$ cm

259. $\frac{R_1}{R_2} = \frac{l_x}{l_r}$

$\therefore \quad \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \frac{l_x}{l_r}$

$\therefore \quad \frac{\rho_1}{\rho_2} = \frac{l_2}{l_1} \times \frac{r_1^2}{r_2^2}$

$= \frac{4}{9} \times \frac{4}{6} = 8.27$

260. $\frac{E_1}{V} = \frac{I\rho l_1}{I\rho l} \qquad \therefore E_1 = \frac{4\times 1.35}{5} = 1.08$ V

261. $\frac{E_1}{l_1} = I\rho = \frac{V}{L}$

$\therefore \quad \frac{V}{E} = \frac{L}{l_1} = I\rho =$ constant

$\therefore \quad \frac{l_{1.2}}{l_{1.1}} = \frac{L_2}{L_1} \qquad \therefore l_{1.2} = 3.6$ m

262. $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2} = \frac{450+50}{450-50} = \frac{5}{4} = 1.25$

263. $r_1 = \left(\frac{l_1 - l_2}{l_2}\right) R = \frac{450-350}{350} \times 10 = \frac{1000}{350}$

$= 2.8\ \Omega$

264. $E_1 = I\rho l_1 \qquad \therefore I = \frac{1.08}{1\times 2.16} = 0.5$ A

265. $\frac{E_2}{E_1} = \frac{l_2}{l_1} \qquad \therefore l_2 = \frac{1\times 1.8}{1.5} = 1.2$ m

266. $I\rho = \left(\frac{E}{R+R_h}\right)\frac{R}{L}$

$\therefore \quad R + R_h = \frac{E\times R}{L\times I\rho} = \frac{2\times R}{10^{-2}\times 4\times 10^{-1}}$

$\therefore \quad R + 16 = \frac{2R}{4\times 10^{-3}} = 500\,R$

$\therefore \quad R = \frac{16}{499} = 0.033\ \Omega$

267. $\frac{V}{L} = I\rho = \left(\frac{E}{R+R_h}\right)\frac{R}{L}$

$\therefore \quad R + R_h = \frac{2\times 1}{10^{-8}} = 2000 \qquad \therefore R_h = 1990\ \Omega$

300. To balance the bridge equivalent resistance of R_4 and shunt x should be 9 Ω

$\therefore \quad R_P = \frac{R_4 \times x}{R_4 + x}$

$9 = \frac{27\times x}{27+x} \qquad \therefore x = 13.5\ \Omega.$

302. When a resistance of 100 Ω is connected in series

circuit, $I = \frac{I}{100+R}$ ..... (i)

When a resistance of 1000 Ω is connected in series to double its range

$I = \frac{2V}{1100+R}$ ..... (ii)

From eq^n. (i) and (ii) we have,

$\frac{V}{100+R} = \frac{2V}{1100+R} \therefore R = 900\ \Omega.$

303. $$E = 40\,t + \frac{1}{10}\,t^2$$

At inversion temperature E will be minimum

i.e. $$\frac{dE}{dt} = 0$$

$$\frac{d}{dt}\left[40t + \frac{1}{10}\,t^2\right] = 0$$

$$\therefore \quad t = -200°C.$$

304. Potential gradient is given by,

$$= I\,\rho'$$

$$= I \cdot \frac{R}{l} \qquad \text{but } \rho = \frac{RA}{l} \quad \therefore \quad \frac{R}{l} = \frac{\rho}{A}$$

$$= I \times \frac{\rho}{A}$$

308. $$\frac{R_2}{R_1} = \left(\frac{l_2}{l_1}\right)^2$$

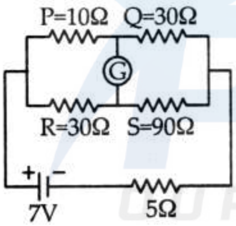
$$R_2 = \left(\frac{2\,l_1}{l_1}\right)^2 R_1 = 4 \times 4 = 16\ \Omega.$$

309. $$V = E - Ir = IR$$

$$\Rightarrow \quad 2.1 - 0.2\,r = 0.2 \times 10$$

$$\Rightarrow \quad r = 0.5\ \Omega.$$

310.



$$E = IR_T$$

$$I = \frac{E}{R_T} = \frac{7}{5 + \frac{40 \times 120}{40 + 120}}$$

$$= 0.2\ A.$$

311. For ballanced Wheatstone's network,

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

i.e., $$\frac{P}{Q} = \frac{R}{\frac{S_1 S_2}{S_1 + S_2}}$$

i.e., $$\frac{P}{Q} = R\left(\frac{S_1 + S_2}{S_1 S_2}\right).$$

312. $$F = qE'$$

$$F = q \cdot \frac{V}{l}$$

$$\therefore \quad V = \frac{Fl}{q} = \frac{2.4 \times 10^{-19} \times 6}{1.6 \times 10^{-19}} = 9\ V.$$

313. Resistance in terms of length and mass is given by,

$$R \propto \frac{l^2}{m}$$

$$\therefore \quad R_1 : R_2 : R_3 = \frac{l_1^2}{m_1} : \frac{l_2^2}{m_2} : \frac{l_3^2}{m_3}$$

$$R_1 : R_2 : R_3 = \frac{25 l_1^2}{m_1} : \frac{9 l_1^2}{3m_1} : \frac{l_1^2}{5m_1}$$

$$= 25 : 3 : \frac{1}{5}$$

$$= 125 : 15 : 1.$$

314. $$\frac{x}{R} = \frac{l_x}{l_r}$$

Case I : $$\frac{20}{30} = \frac{l_x}{100 - l_x}$$

$$\therefore \quad l_x = 40 \text{ cm}$$

Case II : $$\frac{10}{30} = \frac{l_x}{100 - l_x}$$

$$\therefore \quad l_x = 25 \text{ cm}$$

Now shift in null point = 40 – 25 = 15 cm towards left.

315. $$E_1 = \frac{V}{L} \times l_1 \quad \therefore \quad l_1 = \frac{E_1 L}{V} \quad \text{i.e., } l_1 \propto L$$

$$\therefore \quad \frac{l_2}{l_1} = \frac{L_2}{L_1}$$

i.e., $$l_2 = \frac{11 \times 2.5}{10} = 2.75 \text{ m.}$$