ODM EDUCATIONAL GROUP
Changing your Tomorrow

Series and Parallel combinations of resistors

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 03
CHAPTER NAME : CURRENT ELECTRICITY

CHANGING YOUR TOMORROW

Website: www.odmegroup.org
Email: info@odmps.org

Toll Free: **1800 120 2316**
Sishu Vihar, Infocity Road, Patia, Bhubaneswar- 751024

Series Combination of resistances

As in series combination , V = V_1 + V_2 + V_3

$\Rightarrow IR_{eq} = I_1R_1 + I_2R_2 + I_3R_3$ Using equations (i) and (ii)

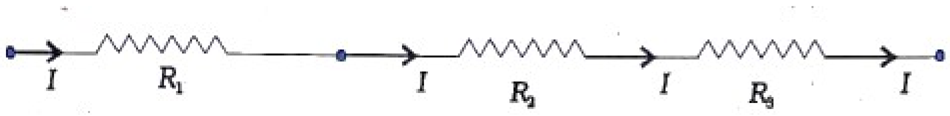
$\Rightarrow$ Req = R_1 + R_2 + R_3

For large number of resistances in series , Req = R_1 + R_2 + R_3+........

So in series combination equivalent resistance is equal to the sum of individual resistances. This is the law of a series combination of resistances.

For n-identical resistances in series

Req = nR



Ratio among voltages of resistances is

$V_1 : V_2 : V_3 : ..... = R_1 : R_2 : R_3 : .....$

The ratio among powers consumed by resistances $P_1 : P_2 : P_3 : .....\ ..... = R_1 : R_2 : R_3 : .....$

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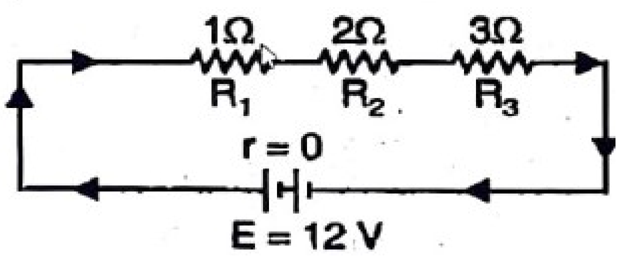
Numerical

Question: (a) Three resistors 1Ω, 2Ω and 3Ω are combined in series. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance , then obtain the potential drop across each resistor.



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Parallel Combination of resistances

For a large number of resistances in parallel, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots$

So in parallel combination reciprocal of equivalent resistance is equal to the sum of reciprocals of individual resistances. This is the law of a parallel combination of resistances.

For two resistances in parallel $$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

For three resistances in parallel $$R_{eq} = \frac{R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3}$$

For n identical resistances in parallel $$R_{eq} = \frac{R}{n}$$

The ratio among currents through individual resistances is $$I_1 : I_2 : I_3 : \ldots\ldots = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3} : \ldots\ldots$$

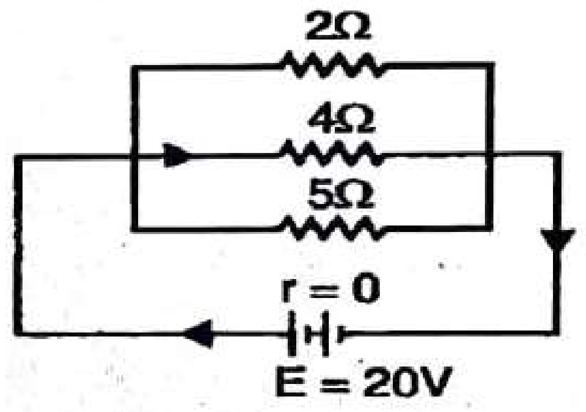
The ratio among powers consumed by resistances is $$P_1 : P_2 : P_3 : \ldots\ldots = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3} : \ldots\ldots$$

Numerical

Question:

(a) Three resistors 2Ω, 4Ω and 5Ω are combined in parallel. What is the total resistance of the combination?

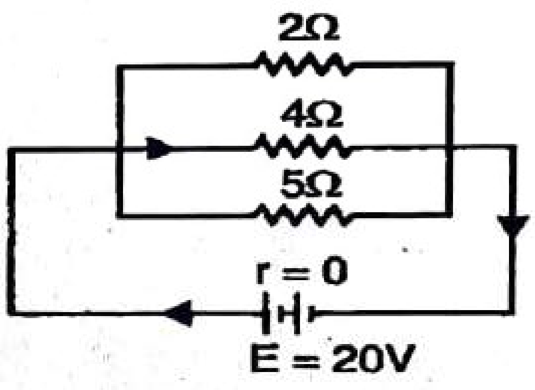
(b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, then obtain the current through each resistor and total current drawn from the battery.



Numerical

Solution :

(a) $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5} = \frac{10+5+4}{20} = \frac{19}{20}\Omega^{-1}$ $\Rightarrow R_{eq} = \frac{20}{19}\Omega$



(b) Current through 2Ω is; $I_1 = \frac{V}{R_1} = \frac{20}{2} = 10A$

Current through 4Ω is; $I_2 = \frac{V}{R_2} = \frac{20}{4} = 5A$

Current through 5Ω is; $I_3 = \frac{V}{R_3} = \frac{20}{5} = 4A$

So the total current is $I = I_1 + I_2 + I_3 = 10A + 5A + 4A = 19A$

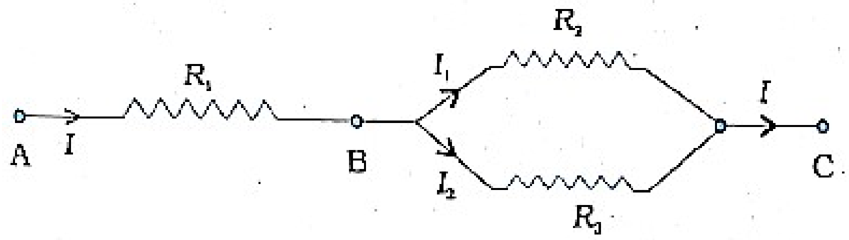
Numerical

Question: Three resistors of resistances R_1, R_2 and R_3 are connected between points A and C across a potential difference V. Obtain expressions for

(a) the total current is drawn from the source,

(b) the potential drop across each resistor.

(c) current through each resistor.



Numerical

Solution :

(a) In the combination R_2 and R_3 are in parallel between points B and C. Its equivalent resistance R_P is in series with R_1 .

$$\text{So } R_{eq} = R_1 + \frac{R_2R_3}{R_2+R_3} = \frac{R_1R_2+R_1R_3+R_2R_3}{R_2+R_3} \quad \Rightarrow I = \frac{V}{R_{eq}} = \frac{V(R_2+R_3)}{R_1R_2+R_1R_3+R_2R_3}$$

(b) $V_{AB} = IR_1 = \frac{V(R_2+R_3)R_1}{R_1R_2+R_1R_3+R_2R_3} = \frac{V(R_1R_2+R_1R_3)}{R_1R_2+R_1R_3+R_2R_3}$ = potential drop across R_1 .

$$V_{BC} = IR_P = \frac{V(R_2+R_3)}{R_1R_2+R_1R_3+R_2R_3}\frac{R_2R_3}{(R_2+R_3)} = \frac{V(R_2R_3)}{R_1R_2+R_1R_3+R_2R_3} =$$

the potential drop across R_2 and R_3 each.

(c) $I_1 = \frac{V_{BC}}{R_2} = \frac{1}{R_2}\frac{V(R_2R_3)}{R_1R_2+R_1R_3+R_2R_3} = \frac{V(R_3)}{R_1R_2+R_1R_3+R_2R_3}$

$$I_2 = \frac{V_{BC}}{R_3} = \frac{1}{R_3}\frac{V(R_2R_3)}{R_1R_2+R_1R_3+R_2R_3} = \frac{V(R_2)}{R_1R_2+R_1R_3+R_2R_3}$$

Numerical

(a) Given n resistors each of resistance R . How will you combine them to get

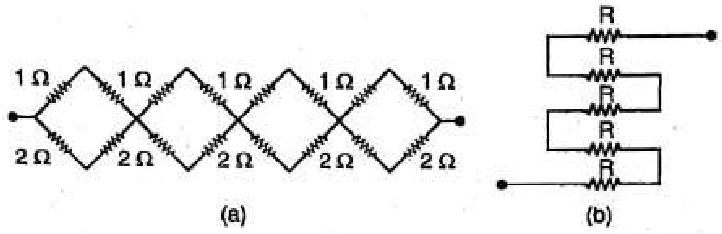
(i) maximum effective resistance

(ii) minimum effective resistance?

(b) What is the ratio of the maximum to the minimum resistance?

(c) Given the resistances of 1Ω, 2Ω and 3Ω, how will u combine them to get the equivalent resistance of (i) $\left(\frac{11}{3}\right)\Omega$ (ii) $\left(\frac{11}{5}\right)\Omega$ (iii) 6Ω (iv) $\left(\frac{6}{11}\right)\Omega$

(c) Determine the equivalent resistance of networks shown in the figure



PUBLIC SCHOOL

Numerical

A wire of uniform cross-section has resistance R .

(i) If a wire is bent to form a circle, then find equivalent resistance across a diameter.

(ii) If the wire is bent to form a square, then find equivalent resistance across (a) diagonal & (b) side

(iii) If the wire is bent to form an equilateral triangle, Find equivalent resistance across its side.

Numerical

Solution (i) Each half of the circle has resistance $R/2$ and they are in parallel. $R_{eq} = \frac{R/2}{2} = \frac{R}{4}$

(ii) Each side of the square has resistance. $R/4$

(a) Across a diagonal combination is the parallel combination of two arms each having two $R/4$ in series. So, $R_{eq} = \frac{(R/4+R/4)}{2} = \frac{R}{4}$

(b) Across its side, the combination is a parallel combination of two arms with one having three $R/4$ in series and the other having one $R/4$. So, $R_{eq} = \frac{(R/4+R/4+R/4)(R/4)}{(R/4+R/4+R/4)+(R/4)} = \frac{(3R/4)(R/4)}{R} = \frac{3R}{16}$

(iii) Each side has resistance $R/3$.

Across a side, the combination is the parallel combination of two arms with one having two $R/3$ in series and the other having one $R/3$. So, $R_{eq} = \frac{(R/3+R/3)(R/3)}{(R/3+R/3)+(R/3)} = \frac{(2R/3)(R/3)}{R} = \frac{2R}{9}$

Numerical

Question: Find the equivalent resistance across A and B in the given figures.

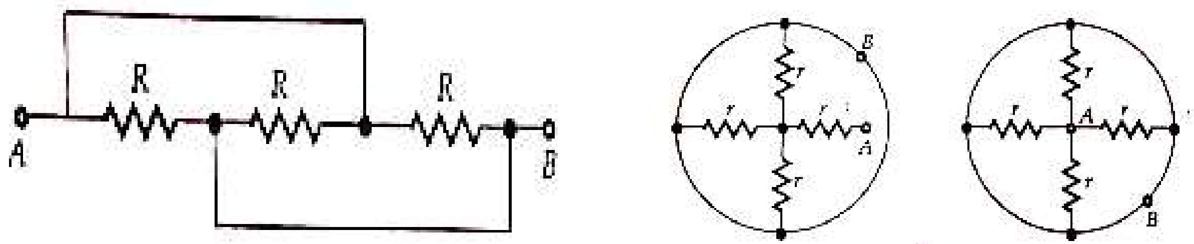
Solution :

(i) The first figure is equivalent to the parallel combination of three resistances each R.

So $R_{AB} = \frac{R}{3}$

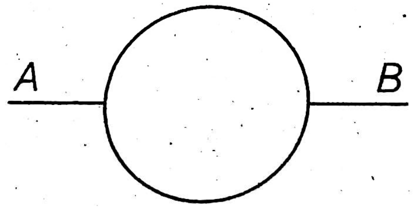
(ii) The second figure is equivalent to the series combination of one r with the parallel combination of three resistances each r. So $R_{AB} = \frac{r}{3} + r = \frac{4r}{3}$

(iii) The third figure is equivalent to the parallel combination of four resistances each r. So $R_{AB} = \frac{r}{4}$

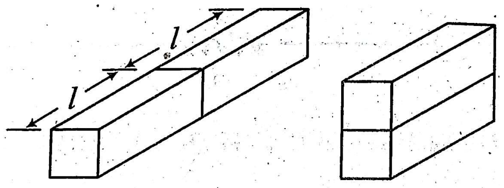


HOME ASSIGNMENT

1. Two wires of equal length, one of copper and the other of manganin have the same resistance. Which wire is thicker?
2. Two materials Si and Cu, are cooled from 300 K to 60 K. What will be the effect on their resistivity?
3. A wire of resistance 8Ω is bent in the form of a circle. What is the effective resistance between the ends of a diameter AB?



4. Two identical slabs, of a given metal, are joined together, in two different ways, as shown in figures (a) and (b).

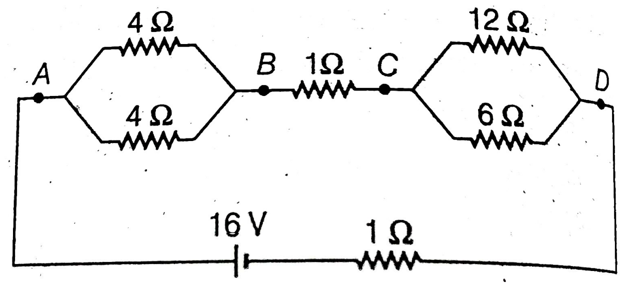


(a) (b)

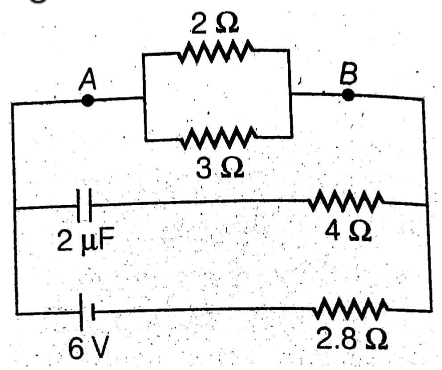
What is ratio of the resistance of these two combinations?

HOME ASSIGNMENT

5. A network of resistors is connected to a 16 V battery of internal resistance of 1 Ω as shown in the figure.
   a) Compute the equivalent resistance of the network.
   b) Obtain the voltage drops V_{AB} and V_{CD}.



6. Calculate the steady current through the 2 Ω resistor in the circuit shown in the figure.



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