CHAPTER TWENTY TWO
ELECTRICITY - PART TWO

Series and parallel connections:

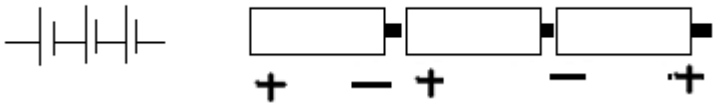
- Electrical components and devices can be connected in two ways and these are:

(i) the series connection.

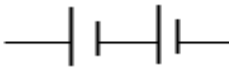
(ii) the parallel connection.

The arrangement of cells in series:

- When cells are arranged in such a way that the positive terminal of one is connected to the negative terminal of the other, then they are said to have been arranged or connected in series.
- Three cells connected in series can be represented by:



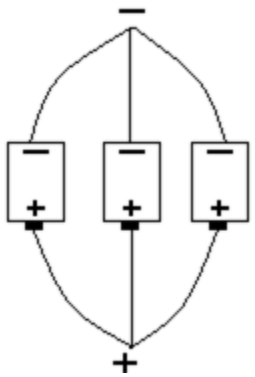
- The total voltage in this case will be thrice the voltage of a single cell.
- Also two cells connected in series can be represented by



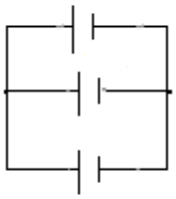
And the total voltage in this case will be twice that of a single cell.
With respect to the connection of cells in series, the total total voltage in the circuit is the sum ofthe voltages of each of the individual cells. For example, if two 3V cells are connected in series, the total voltage = 3 + 3 = 6.

The parallel arrangement of cells:

- Cells are said to have been arranged in parallel, when all their positive terminals are connected together and all their negative terminal are also connected together.
- For example, the connection of three cells in series can be illustrated as



or



- Connecting cells in parallel do not increase the voltage of the circuit beyond that of one cell.
- For this reason, three cells connected in parallel give the same voltage as that of a single cell.
- For example, by connecting three 5V cells in parallel, the voltage or the total voltage had willl be 5V.
- If two resistors of resistance R_1 and R_2 are connected in seies, then the combined resistance R is given by $R = R_1 + R_2$.
- Also if three resistors of resistances R_1, R_2 and R_3 are connected in series, then the total or the combined resistance R is given by $R = R_1 + R_2 + R_3$.

(Q1) Two resistors of values 2Ω and 6Ω are connected in series. Find the total resistance.

Soln:

$R_1 = 2\Omega$ and $R_2 = 6\Omega$.

If R = the combined resistance, then $R = R_1 + R_2$

$\Rightarrow R = 2 + 6 = 8\Omega$.

(Q2)Three resistors R_1, R_2 and R_3 of respective values 2Ω, 5Ω and 10Ω are connected in series. Find the combined resistance.

Soln:

Let $R_1 = 2\Omega$, $R_2 = 5\Omega$ and $R_3 = 10\Omega$.

If R = the combined resistance, then $R = R_1 + R_2 + R_3$,

$\Rightarrow R = 2 + 5 + 10 = 17\Omega$.

Parallel connection of resistors:

- Two resistors are said to have been arranged in parallel when they are placed side by side, and their corresponding ends joined together.
- If two resistors are arranged in parallel, they together give a lower resistance than either resistor.
- If two resistors R_1 and R_2 are connected in parallel, and R= their total or their overall resistance, then $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$.

- Also, if three resistors R_1, R_2 and R_3 are connected in parallel, then their overall or total resistance is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$.

- Lastly, if four resistors R_1, R_2, R_3 and R_4 are connected in parallel, then $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$.

(Q1) Two resistors of resistances 5Ω and 10Ω are connected in parallel. Determine their total resistance.

Soln:

Let R_1 = 5Ω, R_2 = 10Ω and R = the overall resistance.

Then $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

=> $\frac{1}{R} = \frac{1}{5} + \frac{1}{10}$,

=> $\frac{1}{R}$ = 0.3, => 0.3R = 1

=> R = $\frac{1}{0.3}$, => R = 3.3,

=>the overall resistance = 3.3Ω

(Q2) Find the combined resistance of two resistors which are connected in parallel, if they are of values 6Ω and 20Ω.

Soln:

Let R = the combined resistance, R_1 = 6Ω and R_2 = 20Ω.

Then from $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

=> $\frac{1}{R} = \frac{1}{6} + \frac{1}{20}$, => $\frac{1}{R}$ = 0.17 + 0.05,

=> $\frac{1}{R}$ = 0.22 => 0.22R = 1,

=> R = $\frac{1}{0.22}$ = 5.5

The combined resistance = 5.5Ω.

(Q3) The combined resistance of two resistors R_1 and R_2 is 4Ω. If the first resistor has a value of the 5Ω, find the value of the other one, if they are connected in parallel.

Soln;

Let R = the combined resistance = 4, R_1 = 5Ω and R_2 = the value of the resistance of the other resistor = ?

From $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$, =>, $\frac{1}{4} = \frac{1}{5} + \frac{1}{R_2}$,

=> 0.25 = 0.2 + $\frac{1}{R_2}$ => 0.25 – 0.2 = $\frac{1}{R_2}$,

=> 0.05 = $\frac{1}{R_2}$ => 0.05R_2 = 1,

=> R_2 = $\frac{1}{0.05}$ = 20.

The value of the other resistance = 20Ω.

(Q4) Two resistors are connected in parallel and their total resistance is 1.3Ω. If the second resistor has a value of 4Ω, find that of the first one.

Soln:

Let R = the total resistance,

R_1 =? and R_2 = 4Ω

Then from $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\Rightarrow \frac{1}{1.3} = \frac{1}{R_1} + \frac{1}{4} \Rightarrow 0.8 = \frac{1}{R_1} + 0.25,$

$\Rightarrow 0.8 - 0.25 = \frac{1}{R_1},$

$\Rightarrow 0.55m = \frac{1}{R_1} \Rightarrow 0.55R_1 = 1,$

$\Rightarrow R_1 = \frac{1}{0.55} = 1.8\Omega.$

(Q5) Three resistors of values
$2\Omega, 3\Omega \; and \; 5\Omega \; are \; connected \; in \; parallel. Calculater \; the \; overallresistance.$

Soln:

Let $R_1 = 2\Omega$, $R_2 = 3\Omega$, $R_3 = 5\Omega$ and R the overal resistance.

Then since $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3},$

$\Rightarrow \frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{5},$

$\Rightarrow \frac{1}{R} = 0.5 + 0.33 + 0.2,$

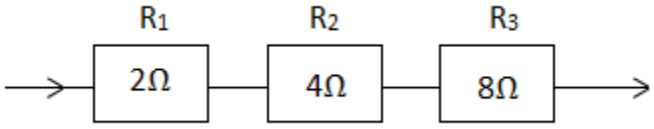
$\Rightarrow \frac{1}{R} = 1.03 \Rightarrow 1.03R = 1,$

$\Rightarrow R = \frac{1}{1.03} = 0.97\Omega.$

(Q6) Three resistors have resistances 2Ω, 4Ω and 8Ω respectively. With the aid of diagrams, calculate their total resistance when they are connected in

(a) series (b) parallel.

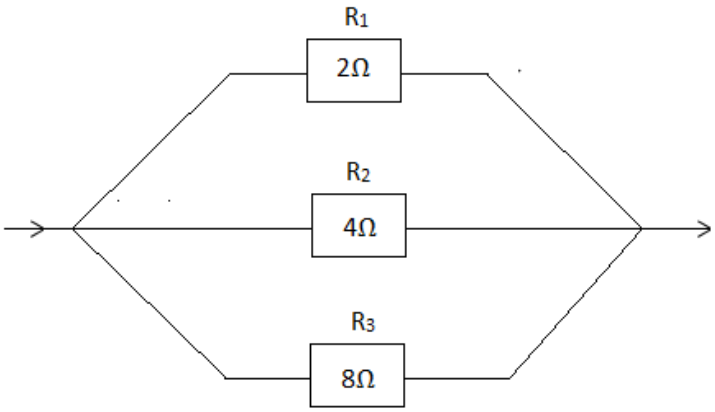
Soln:



The total resistance when they are connected in series is given by $R = R_1 + R_2 + R_3,$

$\Rightarrow R = 2 + 4 + 8 = 14\Omega.$

(b).



The total resistance R of the three resistors when thay are connected in parallel, is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$,

=> $\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{8}$,

=> $\frac{1}{R} = 0.5 + 0.25 + 0.125$,

=> $\frac{1}{R} = 0.88, => 0.88R = 1$,

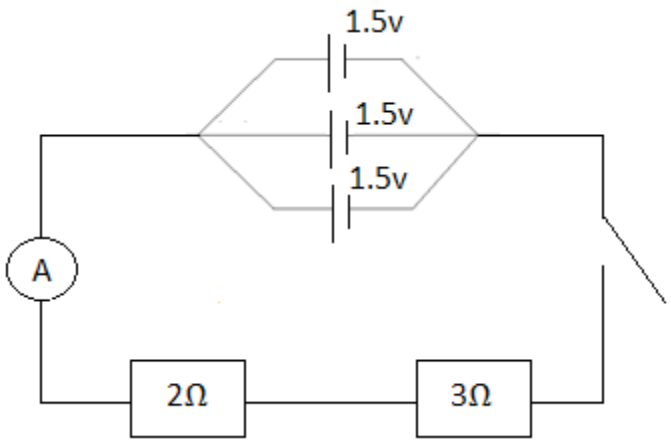
=> R = $\frac{1}{0.88}$ = 1.14Ω.

(Q7) Three dry cells, each of e.m.f 1.5V are conectedin parallel. They are in turn arranged in series with a switch, two resistors of resistances 2Ω and 3Ω respectively and an ammeter.

(1) Draw a circuit diagram for this arrangement.
(2) Calculate
(a) the total e.m.f
(b) the total resistance.
(c) The current which flows through the circuit when the switch is closed.

Soln:

(I)

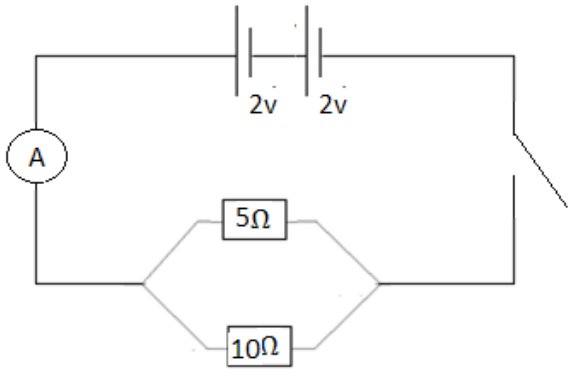


(II)

(a) The total e.m.f = 1.5v, since the cells are identical and connected in parallel.
(b) The total resistance R, is given by R = 2Ω + 3Ω = 5Ω, since the two resistors are connected in series.
(c) Current = I = $\frac{V}{R} = \frac{1.5}{5} = 0.3A$

N/B: Since the e.m.f is the same as the voltage, then the total e.m.f is the same as the total voltage.

(Q8) Two dry cells, each of e.m.f 2.0v are connected in series and arranged in series with a key and ammeter as well as two resistors of resistances 5Ω ans 10Ω which are connected in parallel.
(a) Draw a circuit diagram for this arrangement.
(b) Calculate
(i) the total e.m.f.
(ii) the overall resistance of the circuit.
(iii) the current which flows through the circuit, when the key is closed.


2v
2v
A
5Ω
10Ω