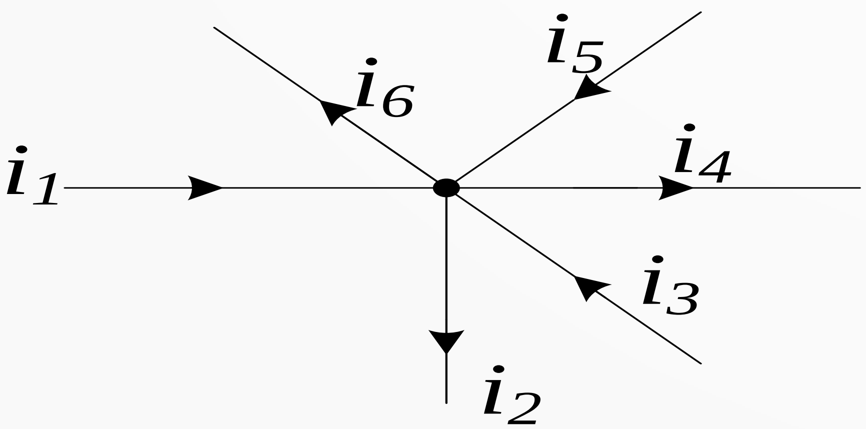
Kirchhoff's Laws - KCL

Kirchhoff's laws help us to solve the electrical networks. There are two laws which are stated as below.

1. Kirchhoff's current law (Point law or first law)

Its states that, “the algebraic sum of the currents meeting at a junction (node) I equal to zero”. At the node sum of incoming currents = sum of outgoing currents.



Sum of currents entering ⇨ $i_1 + i_3 + i_5$

Sum of currents leaving ⇨ $i_2 + i_4 + i_6$

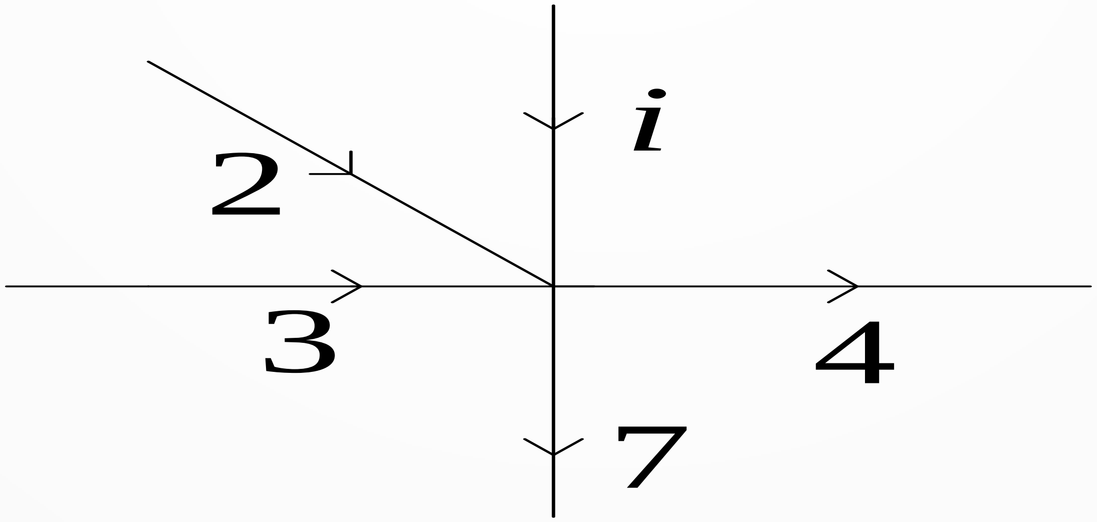
Applying KCL $i_1 + i_3 + i_5 - i_2 - i_4 - i_6 = 0$

Or $i_1 + i_3 + i_5 = i_2 + i_4 + i_6$

Kirchhoff's Laws - KCL

Example

Find the value of i in the figure below.



Solution

$$i + 2 + 3 = 4 + 7$$

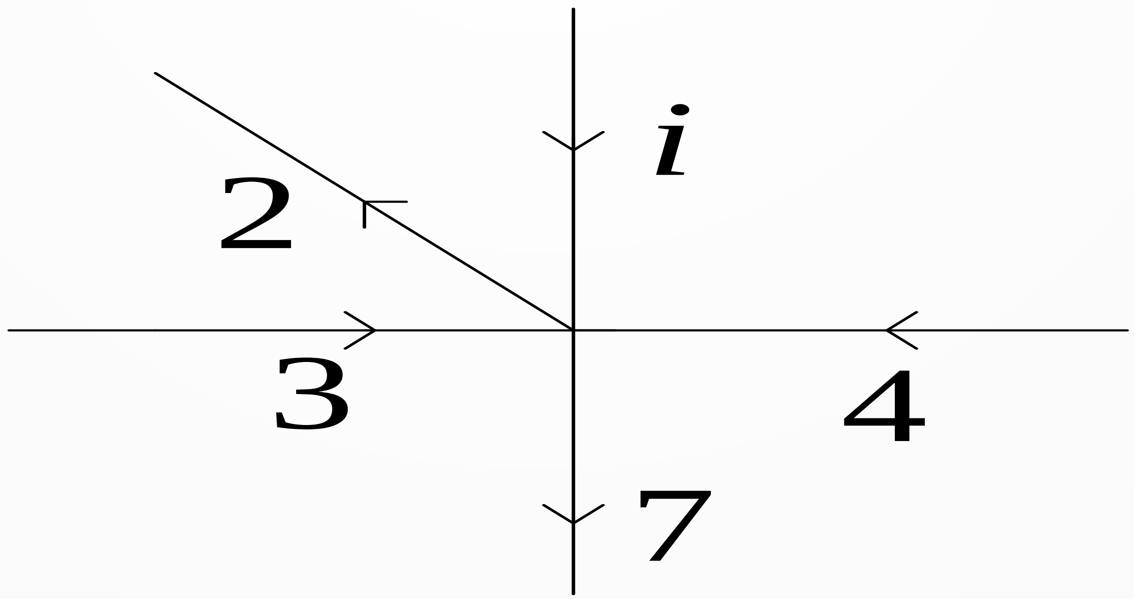
$$i + 5 = 11$$

$$i = 6$$

Kirchhoff's Laws - KCL

Try

Find the value of i in the figure below.



ANS $i = 2$

Kirchhoff’s KVL

Kirchhoff's laws help us to solve the electrical networks. There are two laws which are stated as below.

2. Kirchhoff’s Voltage Law (Mesh law or Second law)

.”The algebraic sum of electromotive forces plus the algebraic sum of voltages across the impedances, in any closed electrical circuit is equal to zero”

Mathematically , $\sum emf + \sum IZ \ = 0$

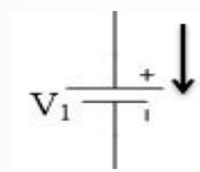
Alternatively, in a loop, he algebraic sum of voltage sources equals the algebraic sum of voltage drops.

Kirchhoff's KVL

Note 1:

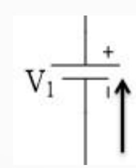
To determine the sign of electromotive force (emf)

1. If we go from a +ve terminal of the battery or source to the –ve terminal, there is a fall in potential and so the emf should be assigned negative sign.



$$\boldsymbol{V_1\ will\ be\ assigned\ a\ \ negative\ sign\ \ -V_1}$$

2. If we go from a -ve terminal of the battery or source to the +ve terminal, then, there is a rise in potential and so the emf should be given a positive sign.



$$\boldsymbol{V_1\ will\ be\ assigned\ a\ \ postive\ sign + V_1}$$

It is clear that the sign of emf is independent of the direction of current through it

Kirchhoff's KVL

Note 2:

To determine the sign of voltage across the impedance

When current flows through a resistor, there is a voltage drop across it.

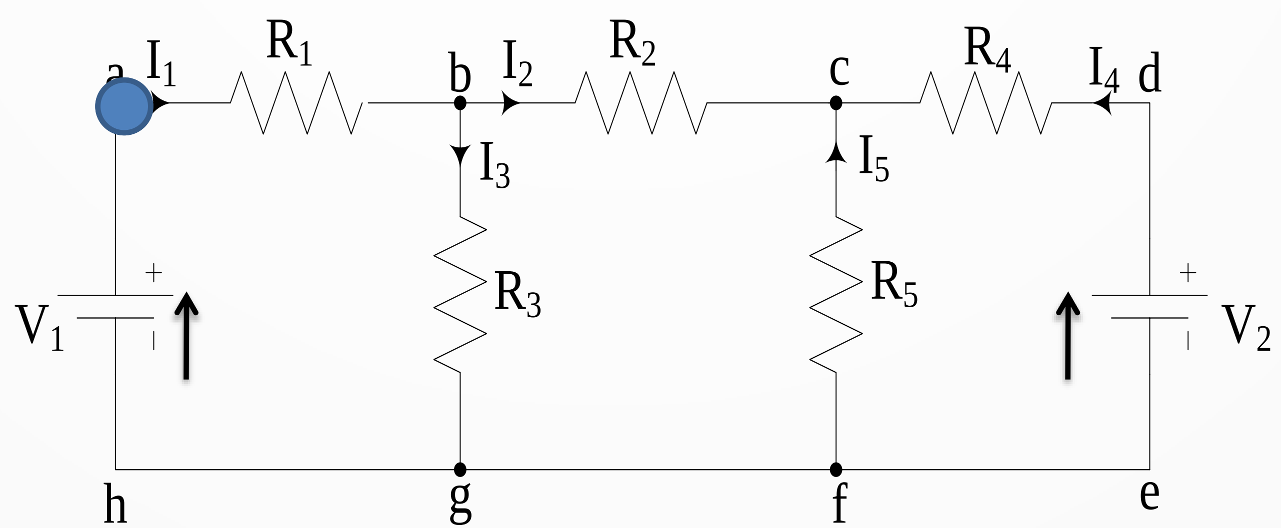
1. If we go through the resistance in the same direction as the current, there is a fall in potential(current flows from higher potential to lower potential). So, the sign of this voltage drop is negative.
2. If we go opposite to the direction of current flow, there is a rise in potential, and hence, this voltage drop should be given positive sign.. So, the sign of this voltage drop is negative.

It is clear that the sign of the voltage drop (i.e. *IR* drop) depends upon the direction of current flow and is independent of the polarity of the emf in the circuit under consideration.

Kirchhoff's KVL

KVL Illustration

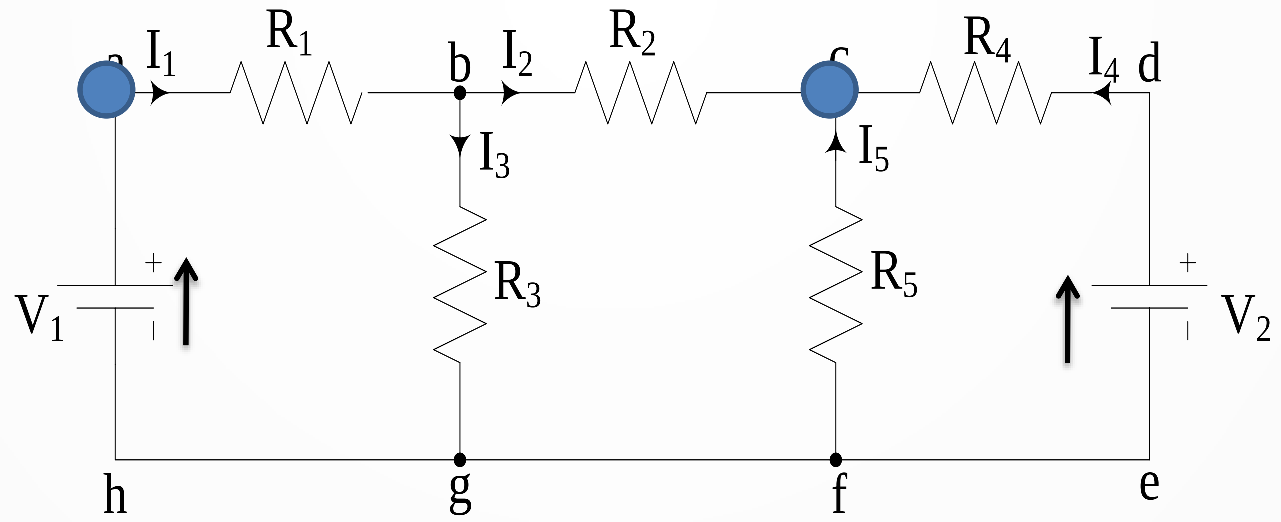
KVL



Loop abgha $V_1 = I_1R_1 + I_3R_3$

Loop adeha $V_1 - V_2 = I_1R_1 + I_2R_2 - I_4R_4$

Kirchhoff's KVL



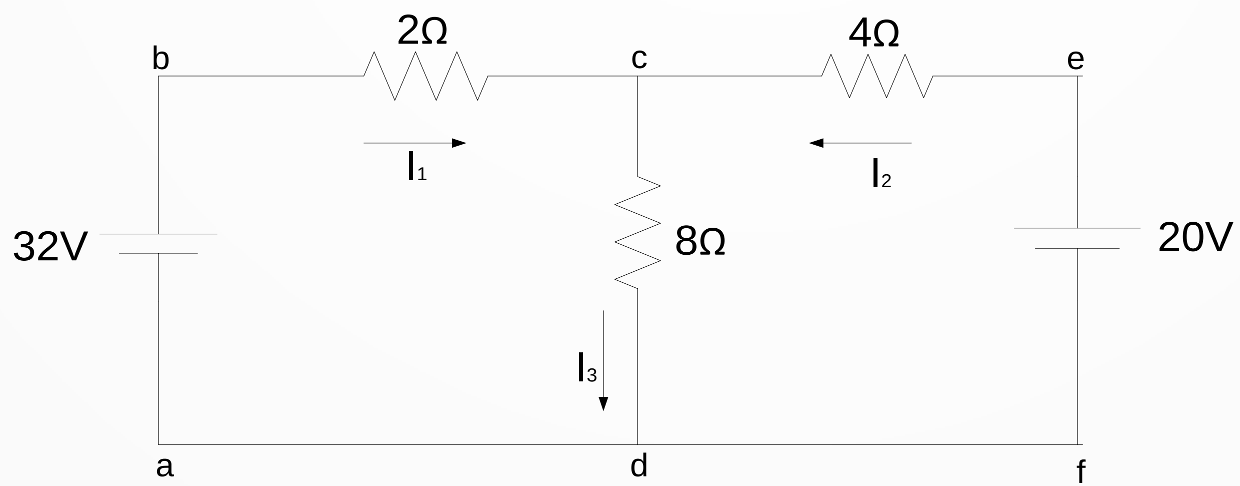
Loop cbgfc $\quad 0 = -I_2R_2 + I_3R_3 + I_5R_5$

Loop acfha $\quad V_1 = I_1R_1 + I_2R_2 - I_5R_5$

Kirchhoff's KVL

Example 1

Find the current in all parts of the circuit below.



Solution

Applying KVL to loop bcdab $$32 - 2I_1 - 8I_3 = 0$$

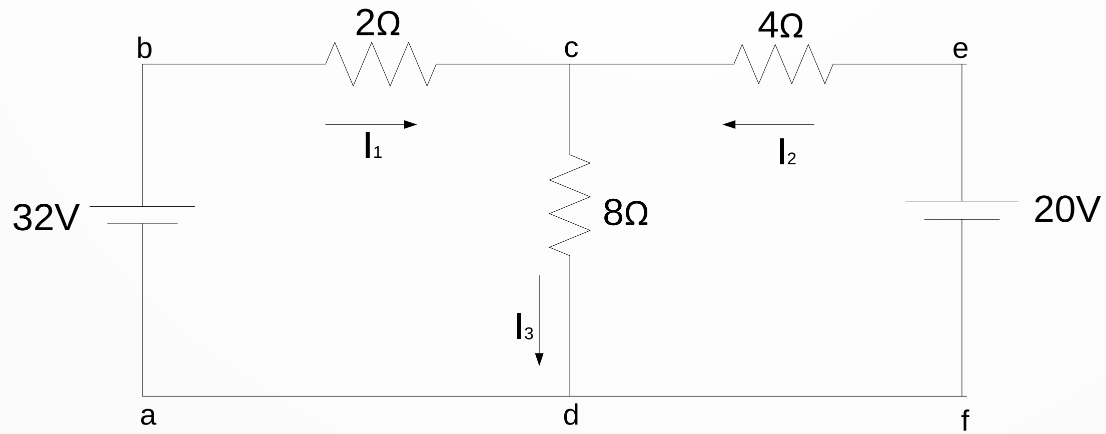
$$\Rightarrow 32 = 2I_1 + 8I_3 \qquad (1)$$

Applying KVL to loop ecdfe $$20 - 4I_2 - 8I_3 = 0$$

$$\Rightarrow 20 = 4I_2 + 8I_3 \qquad (2)$$

Kirchhoff’s KVL

Example 1 cont.



Applying KCL to node c: $$I_3 = I_1 + I_2 \qquad (3)$$

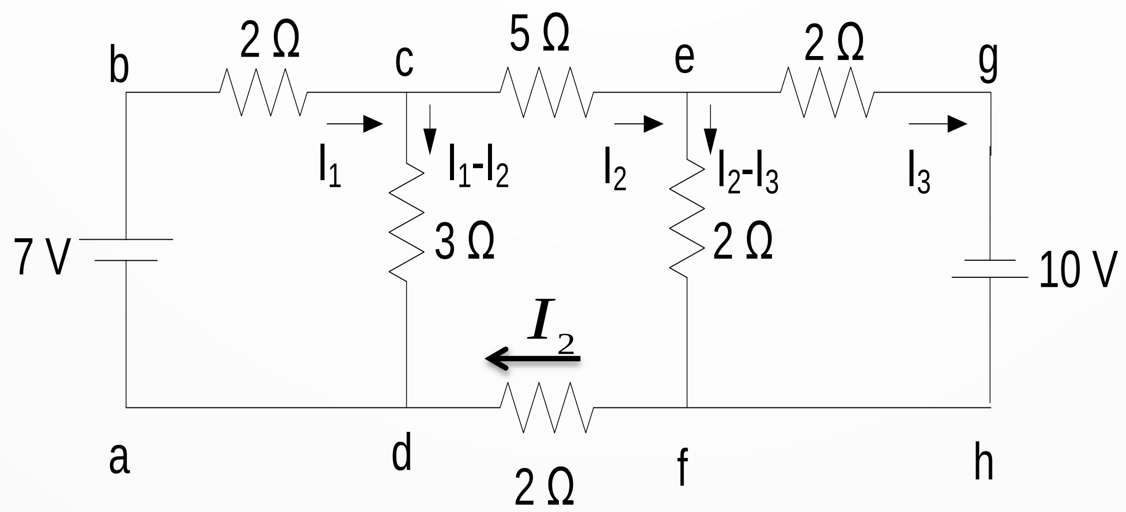
Solving the equations simultaneously yields

$$I_1 = 4A, \quad I_2 = -1A \quad \text{and} \quad I_3 = 3A$$

Kirchhoff's KVL

Example 2

Find the current in all parts of the circuit below.

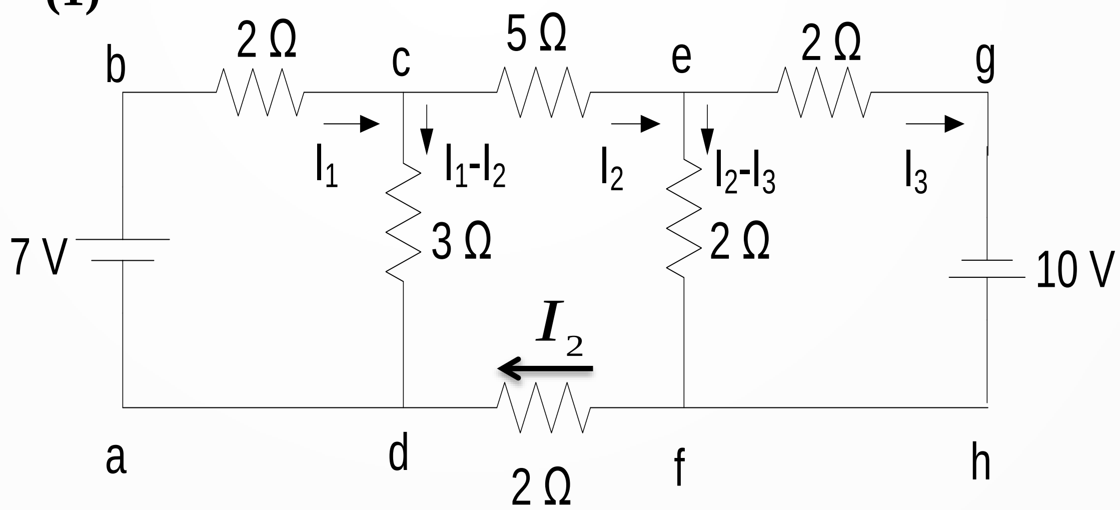


Solution

Applying KVL to loop cefdc $\quad \mathbf{5I_2 + 2(I_2 - I_3) + 2I_2 - 3(I_1 - I_2) = 0}$

Kirchhoff's KVL

$$0 = -3I_1 + 12I_2 - 2I_3 \qquad (1)$$



Applying KVL to loop abcda: $7 = 2I_1 + 3(I_1 - I_2)$

$$7 = 5I_1 - 3I_2 \qquad (2)$$

Applying KVL to loop ghfeg: $10 = -2(I_2 - I_3) + 2I_3$

$$10 = -2I_2 + 4I_3 \qquad (3)$$

Kirchhoff's KVL

Example 2 cont.

Solving the three equations:

$$0 = -3I_1 + 12I_2 - 2I_3 \qquad (1)$$

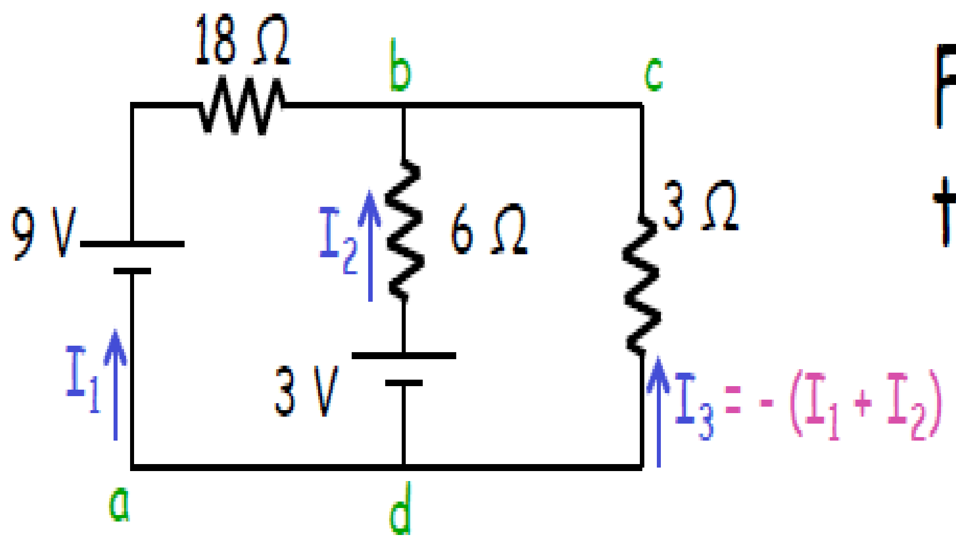
$$7 = 5I_1 - 3I_2 \qquad (2)$$

$$10 = -2I_2 + 4I_3 \qquad (3)$$

Simultaneously

$$I_1 = 2.0\text{A}, \quad I_2 = 1.0\text{A} \quad \text{and } I_3 = 3.0\text{A}$$

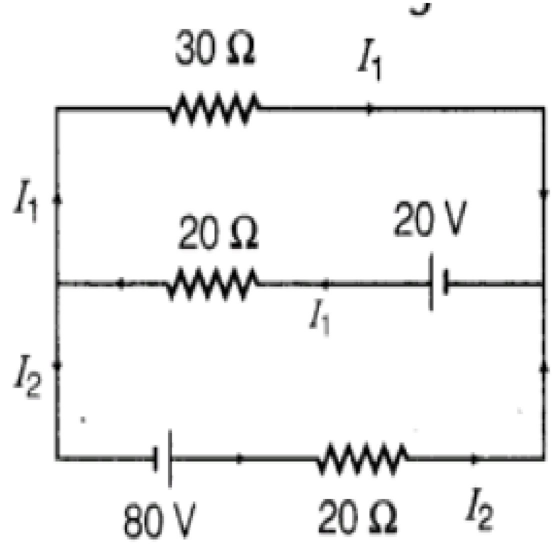
Try 1



Find the current through each battery.

Try 2

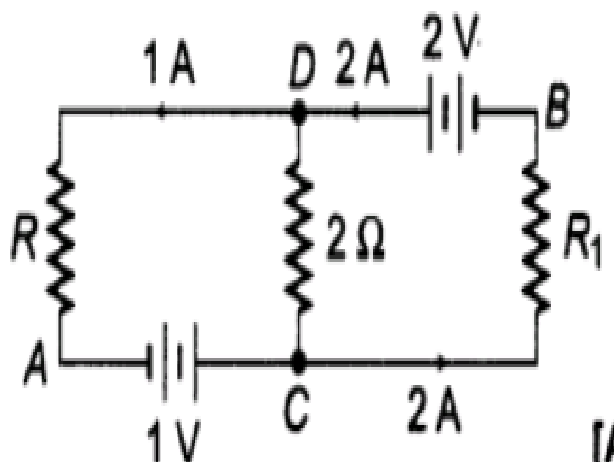
4.Use Kirchhoff's rules to determine the value of the current I_x flowing in the circuit shown in the figure.



[Delhi 2013C]

Try 3

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



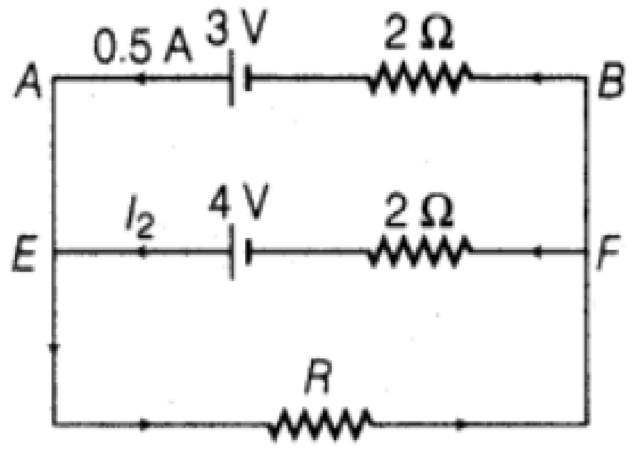
[All India 2011]

Try 4

7.Using Kirchhoff's rules in the given circuit, determine

(i)the voltage drop across the unknown resistor R and

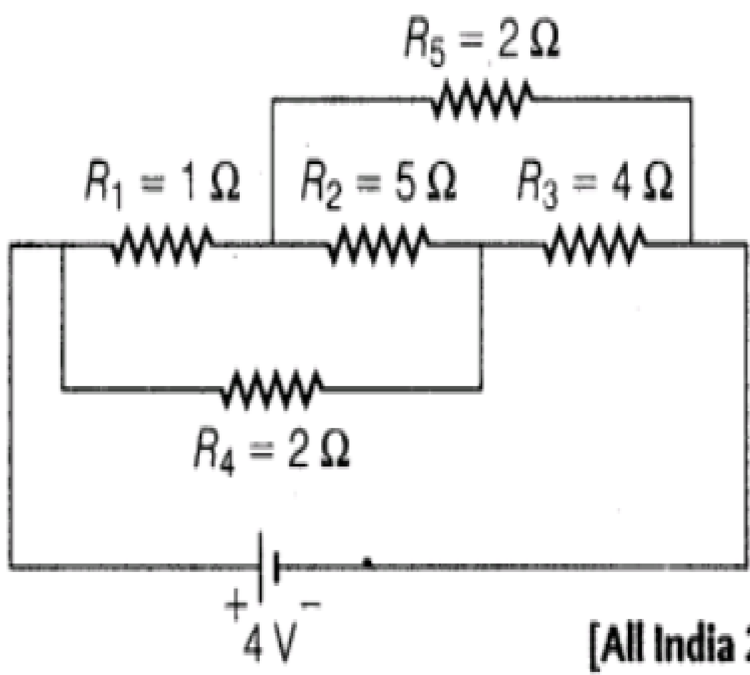
(ii)the current I_2 in the arm EF



[All India 2011]

Try 5

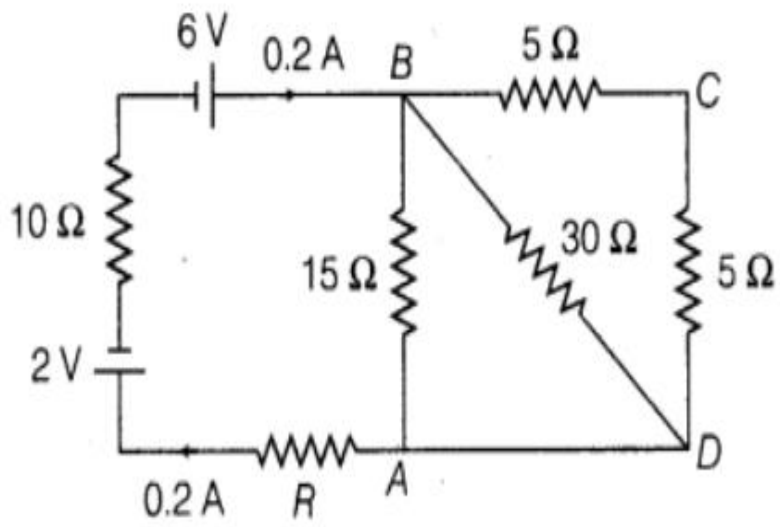
8.Calculate the current drawn from the battery in the given network



[All India 2009]

Try 6

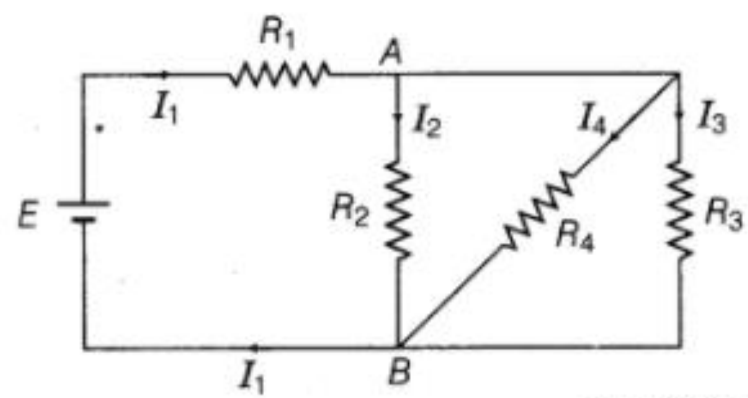
16.Calculate the value of the resistance R in the circuit shown in the figure, so that the current in the circuit is 0.2A. What would be the potential difference between points A and B ?



[All India 2012]

Try 7

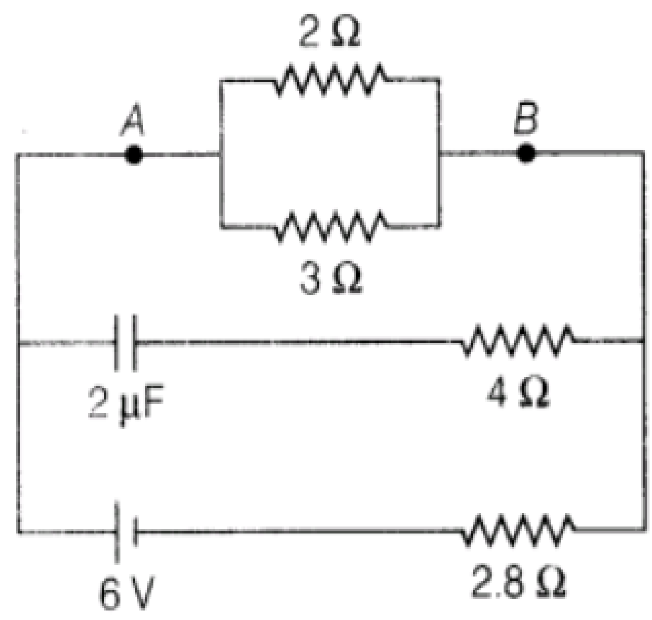
18. In the circuit shown, $R_1 = 4\,\Omega$, $R_2 = R_3 = 15\,\Omega$, $R_4 = 30\,\Omega$ and $E = 10\,\text{V}$. Calculate the equivalent resistance of the circuit and the current in each resistor.



[Delhi 2011]

Try 8

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



[Foreign 2010]

Thank You