Kirchhoff's Circuit Laws

ARC Workshop

Outline

- Understanding Concepts
- Example Problems

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Kirchhoff’s Laws

- What are Kirchhoff’s Laws?
  - Kirchhoff’s laws govern the conservation of charge and energy in electrical circuits.
- Kirchhoff’s Laws

1. The junction rule
2. The closed loop rule

Junction Rule

- “At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node, or: The algebraic sum of currents in a network of conductors meeting at a point is zero”.
- The sum of currents entering the junction are thus equal to the sum of currents leaving. This implies that the current is conserved (no loss of current).

$$\sum I_{in} = \sum I_{out}$$

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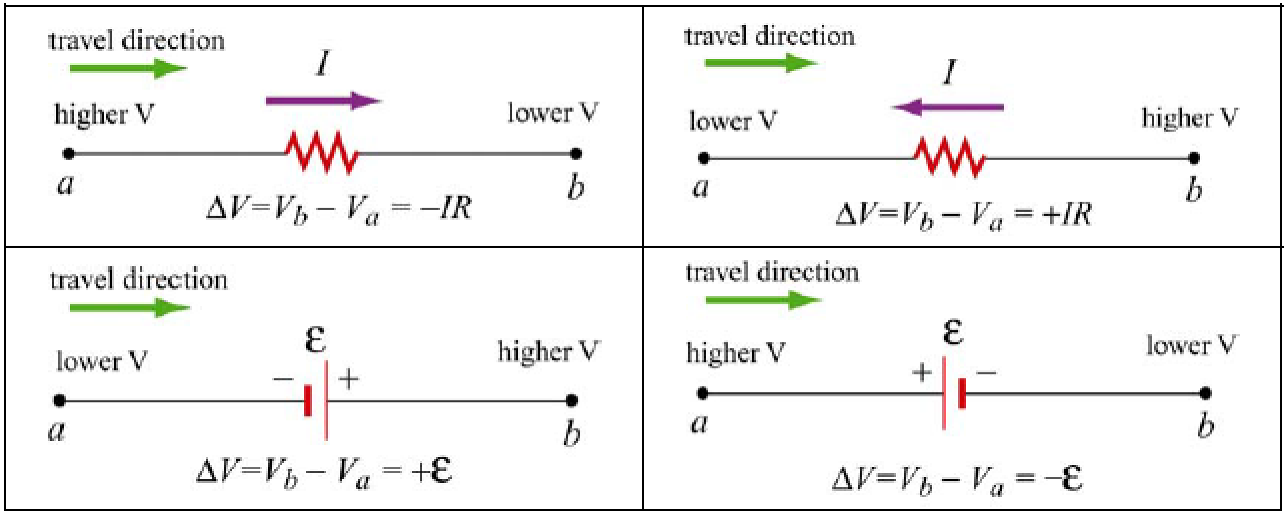
Close Loop Rule

- The principles of conservation of energy imply that the directed sum of the electrical potential differences (voltage) around any closed circuit is zero.

$$\sum \Delta V_{close\ loop} = 0$$

Conventions for Loop Rule

- The following conventions apply for determining the sign of delta V across circuit elements. The travel direction is the direction that we choose to proceed around the loop.



Procedure for Applying Rules

1. Assume all voltage sources and resistances are given. (If not label them V1, V2 ..., R1, R2 etc)

2. Label each branch with a branch current. (I1, I2, I3 etc)

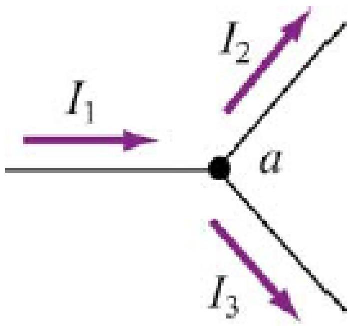
3. Apply junction rule at each node.

4. Applying the loop rule for each of the independent loops of the circuit.

5. Solve the equations by substitutions/linear manipulation.

Examples

- Let's consider the following examples
- Example 1: Express the currents in junction "a" as an equality.

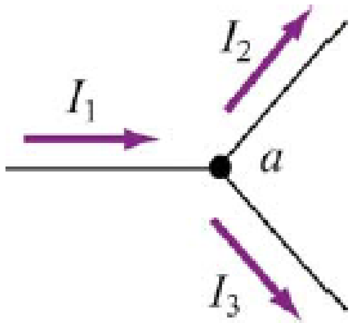


Answer: Applying the junction rule, we obtain that:

$$I_1 = I_2 + I_3$$

- Example 2: If the currents exiting from junction "a" are to be of 2 amps each, what is the value for the current entering the junction?

Recall the junction rule for this case:



$$I_1 = I_2 + I_3$$

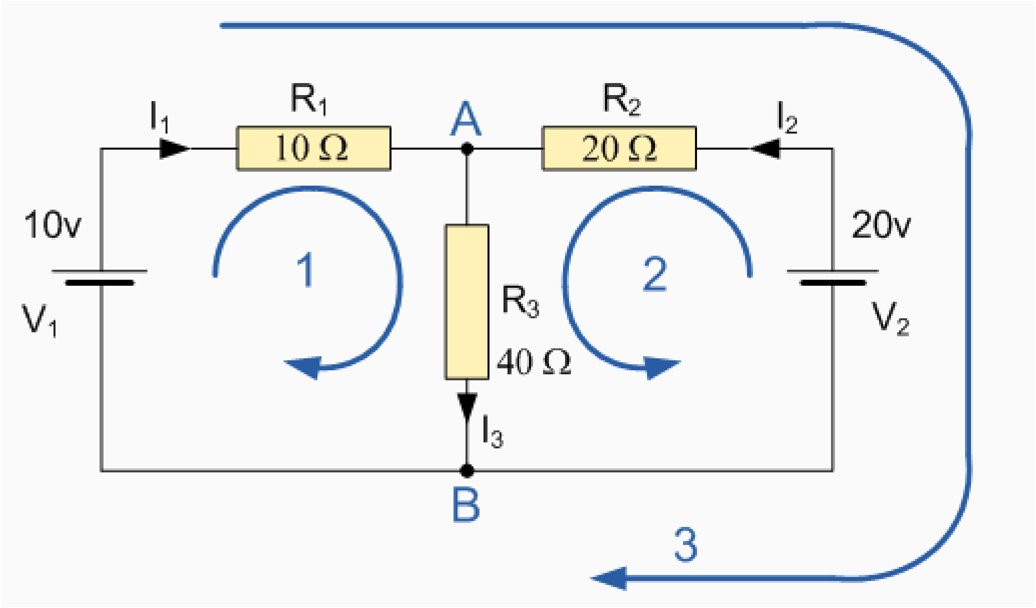
We know the following values:

$$I_2 = I_3 = 2\ amps$$

Then, we can solve for current entering the junction:

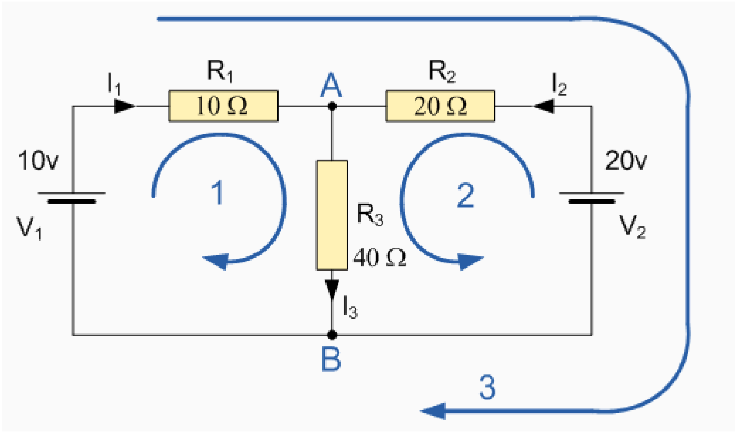
$$I_1 = 2 + 2 = 4\ amps$$

- Example 3: Determine the values of the the current flowing through each of the resistors.



- Example 3 (cont'd)

  The circuit has two nodes (at A and B). We have the choice of choosing only two of the three loops shown (blue). This is because only two of the loops are independent.



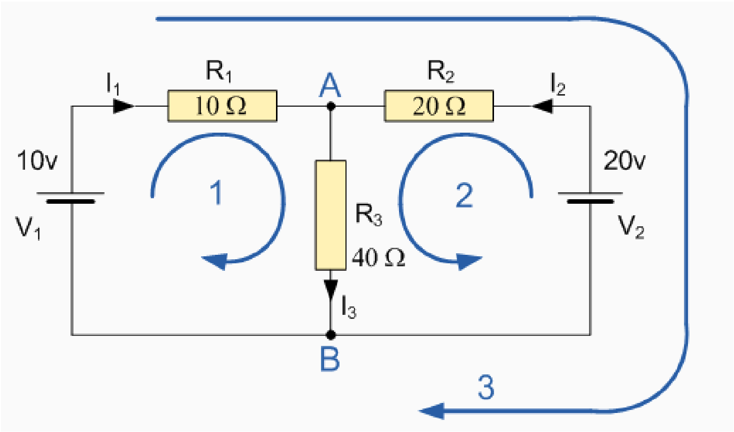
Node A $$I_1 + I_2 = I_3$$

Node B $$I_3 = I_1 + I_2$$

Loop 1 $$10 - I_1 R_1 - I_3 R_3 = 0$$

Loop 2 $$20 - I_2 R_2 - I_3 R_3 = 0$$

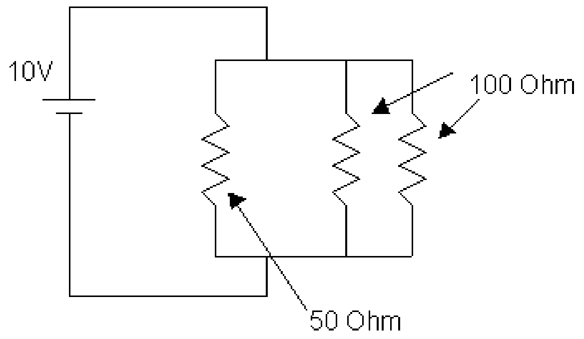
$$I_1 + I_2 = I_3$$
$$I_3 = I_1 + I_2$$
$$10 - I_1 R_1 - I_3 R_3 = 0$$
$$20 - I_2 R_2 - I_3 R_3 = 0$$



- By substitution, the answer can be shown to be I1=-0.143amps, and I2=0.429amps.

- Example 4

Find the current across the 10V battery.



Answer: 0.4 Amps

References

"Free Online Course Materials. Physics. MIT OpenCourseWare." Web. 28 Feb. 2012. <http://ocw.mit.edu/courses/physics/>.

"Physics for Engineers and Scientists (Extended Third Edition) [Hardcover]." *(9780393926316): Hans C. Ohanian, John T. Markert*. 28 Feb. 2012. <http://www.amazon.com/Physics-Engineers-Scientists-Extended-Chapters/dp/0393926311>.

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