Kirchhoff’s law

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Introduction to Kirchhoff’s law

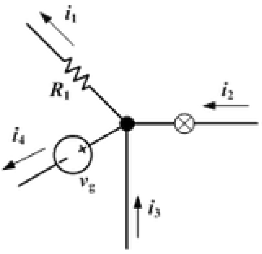
Kirchhoff's circuit laws are two basic laws of electrical engineering, which a German physicist, Gustav Kirchhoff, formalized in 1847. They are the two most important laws in the field of electricity, and include Kirchhoff’s Voltage Law and Kirchhoff’s Current Law. These two laws can be used to determine all voltages and currents of circuits.

Kirchhoff's Current Law

Kirchhoff's Current Law, which is also known as Kirchhoff's Junction Law and Kirchhoff's First Law, defines how an electrical current is distributed when it crosses a junction -- a point where three or more conductors meet. Specifically, the law states that:

The algebraic sum of current into any junction is zero.

Since current is the flow of electrons through a conductor, it cannot build up at a junction: what comes in must come out. Consequently, Kirchhoff’s Current Law means that current is conserved. If you have water flowing into and out of a junction of several pipes, water flowing into the junction must equal water flowing out. The same applies to electric currents. When performing calculations, currents flowing into and out of a junction typically have opposite signs. If a current does have a negative value, all this means is that the current is in the direction to the opposite of the arrow as drawn.



In the picture to the right, a junction of four conductors (i.e. wires) is shown. The currents i_2 and i_3 are flowing into the junction, while i_1 and i_4 flow out of it. In this example, Kirchhoff's Junction Rule yields the following equation:

$$i_2 + i_3 = i_1 + i_4$$

This equation states that
The sum of current into a junction equals the sum of current out of the junction.

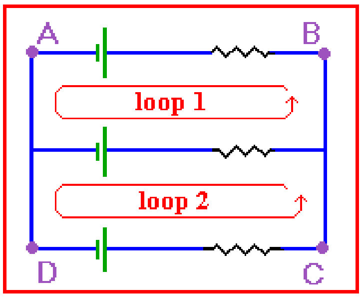
The equation means that there is no accumulation of electric charge at any point in the circuit. The current that flows toward a point is taken as positive while those flowing away from the point are taken as negative.

Kirchhoff's Voltage Law

In the water model, an increase in water pressure leads to an increased flow rate. The pressure of the flow and the resistance of the pipes due to factors such as friction determine the actual flow rate. Large pipes have low resistance, whereas small pipes have high resistance.

In electric circuits, current I increases linearly with applied voltage V as expressed by ohm’s law. Kirchhoff's Voltage Law (or Kirchhoff's Loop Rule) states that the total voltage around a closed loop must be zero. It is a result of the electrostatic field being conservative. If this were not the case, then when we traveled around a closed loop, the voltages would be indefinite. So

?V = 0



In Figure 1 the total voltage around loop 1 should aggregate to zero, as with the total voltage in loop2. Furthermore, the loop which consists of the outer part of the circuit (the path ABCD) should also sum to zero.

We can adopt the convention that potential gains
(i.e. going from lower to higher potential,
such as with an emf source) are taken to be positive.
Potential losses (such as across a resistor) will then be
negative.

Kirchhoff's voltage law is based on the law of conservation of energy, i.e., that net change in the energy of a charge after completing a closed path is zero. It states that the sum of the voltage drops around a closed loop will be equal to the applied voltage.

Want to know more about Kirchhoff’s law? Click here to schedule a live session with an eAge eTutor!

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Reference links:

http://www.hyperphysics.phy-astr.gsu.edu/hbase/electric/conins.html

http://physics.about.com/od/glossary/g/Current.htm

http://www.kpsec.freeuk.com/voltage.htm

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