To read the full article, goto: <http://www.matterandinteractions.org/Content/Articles/circuit.pdf>

**Excerpts**

In introductory electricity courses, electrostatic and circuit phenomena are usually treated as separate and unrelated. By emphasizing the crucial role played by charges on the surfaces of circuit elements, it is possible to describe circuit behavior directly in terms of charge and electric field. This more fundamental description of circuits makes it possible to unify the treatment of electrostatics and circuits.

In the traditional syllabus for electricity, circuit phenomena are expressed solely in terms of the abstract concepts of potential and Kirchhoff's rules, making it seem that the fundamental Coulomb interaction plays little role in circuits. As a result, electrostatics and circuits appear to be two completely different and unrelated topics, and there is little learned in electrostatics that can be applied directly in analyzing circuits.

The new curriculum deals in a natural way with many of the difficulties observed in learning electricity. The immediate and direct benefit is a unified treatment of electrostatics and electric circuits, which closes the observed gaps in students’ reasoning about these topics. Furthermore, this treatment provides an improved basis for understanding circuits in terms of the more abstract concept of potential.

Common student misconceptions directly addressed by the new approach include the following:

* current is used up in a light bulb
* the electric field inside a metal is always zero (even when the system is not in static equilibrium)
* drifting electrons push each other through a wire just as water molecules push each other through a pipe (despite charge neutrality inside the metal)
* Ohm’s law applies to all circuit elements (not just resistors)
* the Kirchhoff loop rule is identical to Ohm’s law (instead of being a separate and much more general principle)
* there cannot be any potential difference across an open switch because V = IR, and there is no I
* a battery is either on or off and constitutes a constant-current device
* emf and potential difference are synonymous

The analysis of circuits in terms of surface charge provides answers to some profound questions students sometimes raise, questions which may have no satisfactory answer within the context of traditional analysis in terms solely of potential. Haertel5 reports students asking, “What is the difference in the conditions at the two ends of a resistor?” It is quite unsatisfying to say merely that the potential is different, and quite satisfying for the student to see that a difference in surface-charge density at the two ends of the resistor leads to a large electric field inside the resistor, which drives the current.

Another student question reported by Haertel is, “How does the current know how to split when there are parallel branches?” During the initial transient phase, current may run equally down two parallel branches, but different resistance in the two branches leads to different surface-charge buildup along the two branches, which in the steady state will steer appropriate amounts of current down each branch