

## Teacher Toolkit - Circuit Concepts

### Objectives:

1. To recognize current as the rate of charge flow and to distinguish it from drift speed.
2. To identify the conditions which must be met in order for electric current to be established in a circuit.
3. To describe the role of the battery in an electric circuit and to relate the voltage rating of the battery to the change in electric potential energy per unit of charge.
4. To describe electric power as the rate of energy consumption by a circuit element and to use the various power equations to calculate the power of a circuit element.
5. To identify the voltage-current-resistance relationship and to use the relationship to solve simple computational problems.
6. To relate the cost of using an electrical appliance for a given amount of time to circuit quantities such as voltage, current, power, and resistance.

### Readings:

[The Physics Classroom Tutorial, Current Electricity Chapter, Lesson 1](#)

[The Physics Classroom Tutorial, Current Electricity Chapter, Lesson 2](#)

[The Physics Classroom Tutorial, Current Electricity Chapter, Lesson 3](#)

### Interactive Simulations:

1. PhET Simulation: Ohm's Law <http://phet.colorado.edu/en/simulation/ohms-law>  
This interactive was developed to help students visualize the mathematical relations presented in Ohm's Law.
2. Circuit Builder <http://www.physicsclassroom.com/Physics-Interactives/Electric-Circuits/Circuit-Builder>  
This interactive simulation from The Physics Classroom's Physics Interactive section provides students with a virtual circuit building kit to build and explore circuit concepts. The Interactive is accompanied by a classroom-ready exercise that is designed to discover Ohms Law through a systematic alteration of variables.
3. Tesla Institute: Multimeter Simulation <http://www.tesla-institute.com!/app/sim/0008.php>  
This multimeter simulation helps students get a better feel for using the device correctly, reading measurements accurately, and learning some basic safety without risk.
4. Action Potential in an Axon [http://outreach.mcb.harvard.edu/animations/actionpotential\\_short.swf](http://outreach.mcb.harvard.edu/animations/actionpotential_short.swf)  
This beautifully-animated tutorial takes a deep look inside a neuron to explore how electrical impulses (signals) are transported along an axon to create an "action potential" allowing our nerve cells to talk to each other.
5. Concord Consortium: Electric Current Model <http://concord.org/stem-resources/electric-current>  
Take a deep exploration into the relationships between voltage, current, and resistance with this set of interactive models for introductory physics.

### Video and Animation:

1. Basics of Voltage and Current Laws <https://www.youtube.com/watch?v=m4jzggZu-4s>  
If your students don't quite get potential difference, they will after watching this video by electrical engineer Eugene Khutoryansky.
2. Battery Energy and Power <https://www.youtube.com/watch?v=u4FpbaMW5sk>  
This 3D video was developed to strengthen conceptual understanding of how charged particles flow in a very simple circuit that includes a battery, wire, and a lightbulb.
3. Education Commons: Electric Current <https://www.youtube.com/watch?v=cEaT29Hqm7o>  
Possibility for a flipped lesson, this 14-minute video uses circuit board demos and animated circuit diagrams to explain what happens when current flows through two light bulbs in a circuit.
4. How a Van de Graaff Generator Works <https://www.youtube.com/watch?v=EsZQS2GOMQE>  
This animated video explains the operation of a Van de Graaff generator,.

### AAPT Cross-Curricular Activity: Blending Physics and Biology

1. Explore How Neurons Work <http://www.thephysicsfront.org/items/detail.cfm?ID=14005>

### Labs and Investigations - The Laboratory at The Physics Classroom

1. Sparky the Electrician Lab
  2. First to Light Lab
  3. Voltage-Current-Resistance Lab
  4. Round vs. Oblong - the Greatest Resistance? Lab
  5. Greatest Current Lab
- <http://www.physicsclassroom.com/lab/circuits/Clabs.html>

**Electrical Safety in the Lab** (Further details available in the Complete Toolkit on our website.)

1. Electrical Safety <http://www.allaboutcircuits.com/textbook/direct-current/chpt-3/common-sources-hazard/>
2. Physics Lab Safety <http://mdk12.msde.maryland.gov/instruction/curriculum/science/safety/physics.html>

**Demonstration Ideas:** (Further details available in the Complete Toolkit on our website.)

1. Inducing Dipoles with a VDG <http://techtv.mit.edu/videos/1682-inducing-dipoles-with-a-van-de-graaff-generator>
2. Conducting Glass <http://techtv.mit.edu/videos/763-mit-physics-demo-conducting-glass>
3. Temperature Effect on Resistance <http://techtv.mit.edu/videos/1689-temperature-effect-on-resistance>

**Minds On Physics:** <http://www.physicsclassroom.com/mop>

Minds On Physics is a collection of interactive questioning modules targeting a student's conceptual understanding. Each question is accompanied by detailed help that addresses the components of the question.

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| Ass't EC1 - Current                                      | Ass't EC2 - Voltage                           |
| Ass't EC3 - Voltage, Power, and Energy                   | Ass't EC4 - Resistance, Voltage and Current   |
| Ass't EC5 - Voltage, Resistance and Current Calculations | Ass't EC6 - P, I, V, R, and Cost Calculations |

**Conceptual Building Exercises:** <http://www.physicsclassroom.com/curriculum/circuits>

The Curriculum Corner, Electric Circuits

1. Electric Potential Difference
2. Electric Circuits and Electric Current
3. Electrical Resistance
4. Electrical Power and Energy
5. Mathematical Relationships in Circuits

**Problem-Solving Exercises:** <http://www.physicsclassroom.com/calcpad/circuits/problems.html>

1. The Calculator Pad, Electric Circuits, Problems #1 - #19

**Science Reasoning Activities:** <http://www.physicsclassroom.com/reasoning/circuits>

1. Bulb A vs. Bulb B
2. Wire Gauge Characteristics

**Real Life Connections:** (Further details available in the Complete Toolkit on our website.)

1. Bureau of Labor Statistics: Smart Grid Careers <http://www.bls.gov/careeroutlook/2013/fall/art03.pdf>
2. Department of Energy: What is the Smart Grid? [https://www.smartgrid.gov/the\\_smart\\_grid/#smart\\_grid](https://www.smartgrid.gov/the_smart_grid/#smart_grid)

**Common Misconceptions:** (Further details available in the Complete Toolkit on our website.)

1. The Battery as the Source of Charge
2. Current versus Drift Speed

**Elsewhere on the Web:** (Further details available in the Complete Toolkit on our website.)

1. Basic Concepts & Test Equipment <http://www.allaboutcircuits.com/textbook/experiments/chpt-2/voltage-usage/>
2. Pioneers in Electricity and Magnetism <http://micro.magnet.fsu.edu/electromag/pioneers/index.html>

**Standards** (Further details available in the Complete Toolkit on our website.)

**Next Generation Science Standards (NGSS)**

**Disciplinary Core Ideas – Physical Science**

- Middle School: Forces and Interactions – MS.PS2.B.1
- High School: Structure of Matter – HS-PS1.A.1
- High School: Definitions of Energy – HS-PS3.A.4
- High School: Energy Conservation -- HS-PS3.D.1

**Performance Expectations – Physical Science**

- High School: Forces and Interactions -- HS-PS2-6
- High School: Energy – HS-PS3-2

**Crosscutting Concepts**

- Crosscutting Concept #2: Cause & Effect: Mechanism and Explanation
- Crosscutting Concept #4: Systems and System Models
- Crosscutting Concept #5: Structure and Function

**Science and Engineering Practices**

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| Developing and Using Models                          | Planning and Carrying Out Investigations |
| Analyzing and Interpreting Data                      | Engaging in Argument from Evidence       |
| Using Mathematics and Computational Thinking         | Constructing Explanations                |
| Obtaining, Evaluating, and Communicating Information |  |