Teacher Toolkit - Parallel Circuits

Objectives:

1. To recognize a parallel circuit, to distinguish it from a series circuit, and to construct and/or interpret a schematic diagram of a parallel circuit.
2. To compare the values of current and electric potential at various locations (inside and outside of the branches) within a parallel circuit and to explain the principles that form the basis of such comparisons.
3. To calculate the equivalent resistance of a parallel circuit from values of individual resistances.
4. To mathematically analyze a parallel circuit in order to relate the current value in each resistor to the battery voltage and the resistance values of the individual resistors.
5. To mathematically analyze a parallel circuit and use the Ohm's law equation in order to determine the voltage drops across each resistor and to compare each of these values to the voltage of the battery.

Readings: The Physics Classroom Tutorial, Current Electricity Chapter, Lesson 4a, 4b, and 4d

Interactive Simulations:

1. Nerd Island Studios' DC Circuit Builder http://www.physicsclassroom.com/Physics-Interactives/DC-Circuit-Builder/Circuits
   An iPad-, tablet-, Chromebook-, and mobile-friendly app for exploring circuit mathematics and concepts. Done in cooperation with The Physics Classroom; includes three ready-to-use lab activities.
2. PhET DC Circuit Construction Kit http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
   Explore basic electricity relationships in either series or parallel circuits by dragging wires, batteries, resistors, bulbs, and switches to construct a model DC circuit. Students can even take measurements of ΔV and I.
3. PhET Battery-Resistor Circuit http://phet.colorado.edu/en/simulation/battery-resistor-circuit
   Explore a model of charge flow and resistance in this interactive simulation of a very simple battery-powered circuit. Resistance and potential difference can be adjusted to see how this affects the current.
4. Build Electric Circuits: Creating Schematic Diagrams http://www.build-electronic-circuits.com/circuit-schematic/
   Good choice for students who want to push the envelope with circuit building. This website aims is to share the science of circuit building without using a breadboard.

Video and Animation:

1. Potential Difference and Resistance – Parallel Circuit https://www.youtube.com/watch?v=V3jRxnoStAU
   This 13-minute video from Education Commons uses animation and demonstrations to illustrate how to measure current in the circuit and explains the effect on current if more resistors are added.
2. Potential Difference and Resistance https://www.youtube.com/watch?v=QOBbBBdM-FA
   This 13-minute video from Education Commons provides highly-scaffolded support for using circuit diagrams to calculate current passing through each resistor in both series and parallel circuits.

Labs and Investigations: http://www.physicsclassroom.com/lab#circuits

1. The Physics Classroom, The Laboratory, Series versus Parallel Lab
   Students explore series and parallel circuits in a very conceptual manner in order to determine how they are similar and how they are different.
2. The Physics Classroom, The Laboratory, Comparing Voltage Drops and Currents in Parallel Lab
   Students use ammeters and voltmeters to make measurements and investigate mathematical relationships between ΔV, I and R for individual resistors and the overall circuit.
3. The Physics Classroom, The Laboratory, Bulbs in Parallel Circuit Lab
   Students make comparisons of the relative brightness, the current and the electric potential difference (ΔV) for a low-resistance and a high-resistance light bulb placed in branches of a parallel circuit.

Demonstration Ideas:

1. Forces on a Current-Carrying Wire http://techtv.mit.edu/videos/813-mit-physics-demo-forces-on-a-current-carrying-wire
   This short MIT Tech TV physics demonstration shows two wires suspended vertically. The wires are connected first in series, then in parallel to a 12-V battery.
2. Circuit Construction Kit Presentation http://phet.colorado.edu/en/contributions/view/2822
   Set of 13 Power Point slides from PhET Teacher Contributions for classroom formative assessment on series/parallel circuits.

This is the *To Go* version of the Teacher Toolkit; it is an abbreviated version of the complete Toolkit.

Minds On Physics Internet Modules: http://www.physicsclassroom.com/mop

The Minds On Physics Internet Modules are interactive questioning modules that target conceptual understanding. Each question is accompanied by detailed help that addresses the various components of the question.

1. Electric Circuits, Assignment EC8, Parallel Circuits Concepts
2. Electric Circuits, Assignment EC10, Parallel Circuits Calculations

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

1. The Curriculum Corner, Electric Circuits, Parallel Circuits
2. The Curriculum Corner, Electric Circuits, Circuit Analysis

Problem-Solving Exercises: http://www.physicsclassroom.com/calcpad/circuits

1. The Calculator Pad, Electric Circuits, Problems #20 - #21, #29 - #34

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

1. Science Reasoning Center, Electric Circuits, Series and Parallel Lab

Related PER (Physics Education Research) http://www.ncsu.edu/per/Articles/Engelhardt&Beichner.pdf

1. *Students' understanding of direct current resistive electric circuits*, Engelhardt and Beichner, American Journal of Physics 72 (1), 98 (2004).

Real Life Connections:

1. Eric Giler – A Demo of Wireless Electricity http://www.ted.com/talks/eric_giler_demos_wireless_electricity?language=en#t-10107
   Wouldn't it be great to get rid of all those wires? It's been 5 years since this somewhat iconic video hit TED Talks, but it's definitely worth student viewing. In 2006, a team of theoretical physicists at MIT developed a technology that uses resonant energy transfer to transmit power over distance. It uses specially designed magnetic resonators to transfer the electrical energy from power sources. It might interest students to know that the technology was patented and team members formed a start-up company.

Common Misconceptions **(See the complete toolkit at TPC's Teacher Toolkit website.)**

Elsewhere on the Web:

1. Build a Voltage Divider http://www.tryengineering.org/lesson-plans/using-ohm%E2%80%99s-law-build-voltage-divider
   Completely turn-key lesson plan from TryEngineering provides a blueprint for designing and building a voltage divider – a form of linear circuit capable of producing a wide range of output voltages.
2. Circuit Tool http://jersey.uoregon.edu/vlab/circuit/Circuit.html
   Investigate current flow in a parallel circuit, Kirchoff Loop, voltage divider, or Wheatstone Bridge by dragging batteries and resistors onto a virtual breadbox, then see the current displayed in amps.

Standards:

A. Next Generation Science Standards (NGSS)
Performance Expectations HS-PS2-6 and HS-PS3-2
Disciplinary Core Ideas MS.PS2.B.i, HS-PS1.A.i, HS-PS3.A.i, an HS-PS3.D.i
Crosscutting Concepts Cause and Effect, Systems and System Models, and Energy and Matter
Science and Engineering Practices #2, #3, #4, #5, #6, and #8
The Nature of Science Scientific Investigations Use a Variety of Methods

B. Common Core Standards for Mathematics (CC) – Grades 9-12
Functions – Interpreting Functions F-IF.4 and F-IF.6
Linear, Quadratic, and Exponential Models F-LE.1.b and F-LE.5

C. Common Core Standards for English/Language Arts (ELA) – Grades 9-12
Key Ideas and Details RST.11-12.3 and RST.11-12
Craft and Structure RST.11-12.5 and RST.11-12.6
Integration of Knowledge and Ideas RST.11-12.9
Range of Reading and Level of Text Complexity RST.11-12.10

D. College Ready Physics Standards (Heller and Stewart)
(See the complete toolkit at TPC's Teacher Toolkit website for details.)