Teacher Toolkit – Series Circuits

Objectives:

1. To recognize a series circuit, to distinguish it from a parallel circuit, and to construct and/or interpret a schematic diagram of a series circuit.
2. To compare the values of current and electric potential at various locations within a series circuit and to explain the principles that form the basis of such comparisons.
3. To calculate the equivalent resistance of a series circuit from values of individual resistances.
4. To mathematically analyze a series 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 series 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 – 4c

Interactive Simulations:

1. Nerd Island Studios DC Circuit Builder http://direct.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
   Robust interactive simulation lets students drag wires, batteries, resistors, bulbs, and switches to construct a model of a DC circuit.
3. The Concord Consortium: Electric Current Model http://concord.org/stem-resources/electric-current
   Explore the relationships between voltage, current, and resistance with this set of interactive models.
4. Electric Circuit Diagram Template https://docs.google.com/drawings/d/1m8Z3-AqddgyrH17lxbwq4FP0LAKRqtx4LdHKJDsaFg4/edit
   Login to your Google account to use this free tool for making sharable electric circuit diagrams. It's part of the Google Engineering ToolBox.

Video and Animation:

1. What Happens When a Current Passes Through a Circuit? https://www.youtube.com/watch?v=cEaT29Hqm7o
   Good choice for a flipped lesson, this 14-minute video from Education Commons uses circuit board demos and animated circuit diagrams to explain what happens when current flows through two light bulbs in a circuit.
2. Resistance at the Molecular Level http://micro.magnet.fsu.edu/electromag/java/filamentresistance/index.html
   Part of the Molecular Expressions website, this simple JAVA animation illustrates what happens to the movement of free electrons when voltage is applied across a conductor (a light bulb filament).

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 Series 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 Series 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 together in a series circuit.

Demonstration Ideas:

1. Circuit Construction Kit Presentation http://phet.colorado.edu/en/contributions/view/2822
   Set of 13 Power Point slides for classroom formative assessment on series/parallel circuits. Can be accessed as a PDF for presentation or as a Power Point document with answers provided in annotations.
2. MIT: Conductivity of Ionized Water http://techtv.mit.edu/videos/798-mit-physics-demo-conductivity-of-ionized-water
   This 1-minute video demonstrates a light bulb placed in series with two copper plates immersed in de-ionized water. The bulb lights up as kosher salt is dissolved into the de-ionized water.

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 EC7 - Series Circuits Concepts
2. Electric Circuits, Assignment EC9 - Series Circuits Calculations

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

1. The Curriculum Corner, Electric Circuits, Series 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 - #28

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

1. Science Reasoning Center, Electric Circuits, Bulb A and Bulb B
2. Science Reasoning Center, Electric Circuits, Series and Parallel Lab

Real Life Connections:

1. Edison vs. Westinghouse: A Shocking Rivalry
   http://www.smithsonianmag.com/history/edison-vs-westinghouse-a-shocking-rivalry-102146036/?no-ist
   This feature article from Smithsonian Magazine is an excellent resource for a lesson on ethics in scientific enterprise.
2. Department of Energy: The History of the Light Bulb http://energy.gov/articles/history-light-bulb
   Nicely presented interactive timeline with background article that discusses the evolution of the light bulb.

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

Elsewhere on the Web: **(See the complete toolkit at TPC's Teacher Toolkit website.)**

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).

Standards:

A. Next Generation Science Standards (NGSS)
Performance Expectations HS-PS2-6 and HS-PS3
Disciplinary Core Ideas MS.PS2.B.i, **HS-PS1.A.i**, **HS-PS3.A.i**, and **HS-PS3.D.i**
Crosscutting Concepts Cause & Effect and 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 – 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.)