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.
   Robust interactive simulation lets students drag wires, batteries, resistors, bulbs, and switches to construct a model of a DC circuit.
   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-AqddgprrH17tSbwqFPl0LAKRg7xLd0KJDxAg/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:
   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.
   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 AV, 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:
   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.
   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.
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 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.smithsoniananmag.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

Standards:
A. Next Generation Science Standards (NGSS)
   Performance Expectations  HS-PS2-6 and HS-PS3
   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.)