Teacher Toolkit - Coulomb's Law

Objectives:

1. To understand that objects are charged if there is an imbalance of protons and electrons and to calculate the amount of charge on an object if given the number of excess protons or electrons.
2. To use Coulomb's Law equation to make predictions of the effect of alteration in the quantity of charge or the separation distance upon the amount of electrostatic force.
3. To use Coulomb's Law equation to algebraically solve for an unknown quantity (F, d, Q_1 or Q_2) in a physics word problem.
4. To combine Coulomb's Law equation with Newton's second law, free-body diagrams and trigonometric functions to analyze physical situations that include interacting charges.

Readings:

The Physics Classroom Tutorial, Static Electricity Chapter, Lesson 3

Interactive Simulations:

1. Coulomb's Law Interactive http://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Coulomb-s-Law
   This simulation lets students visualize charge interaction to see why Coulomb's Law works mathematically. Switch the sign of the charge, change quantity of charge, and move the charges around on a grid.
2. PhET: Charges and Fields https://phet.colorado.edu/en/simulation/charges-and-fields
   In this model, learners move charges around a simulated electric field to determine how certain variables affect interactions among charged bodies. Force vectors are automatically generated.
3. Point Charge Forces in 1D Model http://www.opensourcephysics.org/items/detail.cfm?ID=9977
   This very simple Java model investigates the electric force that one particle exerts on another. It promotes understanding of Coulomb's Law uaing vector arrows, graphs, and digital displays.

Video and Animation:

1. UCLA Physics Videos https://www.youtube.com/watch?v=B5LVoU_a08c
   This video-demo by James Lincoln uses a Coulomb apparatus with a "twist": a neon laser that measures the small amount of twist on the wire in the apparatus. Reflected light from the laser is displayed on a chart.
2. PSSC Film Collection: Coulomb's Law https://archive.org/details/coulombs_law
   Noted physicist Eric Rogers demonstrates charge interaction using a steel ball-spring balance system. Don't miss the last 5 minutes: Rogers places a young girl in a metal cage, which he then charges with electricity.
3. MIT: Electrostatics Visualizations http://web.mit.edu/viz/EM/visualizations/electrostatics/index.htm
   This is one of the best collections on the web for helping students visualize the invisible processes involved in charge interaction. However, the file formats will not play in all browsers, especially Edge or Chrome.
4. Physlet: Charge and Coulomb's Law http://www.compadre.org/Physlets/electromagnetism/illustration22_1.cfm
   Students explore charge by placing charged particles in a virtual electric field. It gives guided instruction for investigating charges of equal or unequal magnitude and charges with the same or different polarities.

Digital Labs

1. Electric Field: What is Wrong? Package http://www.opensourcephysics.org/items/detail.cfm?ID=9964
   This resource consists of a collection of models for electrostatics with errors intentionally built into each model. Can you identify the errors?
2. Ranking Tasks: Three Charged Particles http://www.opensourcephysics.org/items/detail.cfm?ID=7636
   This model displays up to three charged objects, one at each corner of an equilateral triangle. The charges have different magnitudes – your job is to rank the charges from largest-to-smallest magnitude.

Hands-On Labs and Investigations:

1. The Physics Classroom, The Laboratory, Coulomb's Law Lab http://www.physicsclassroom.com/lab#estatic
   Students make measurements (mass, separation distance, string length) in order to determine the number of electrons transferred to two balloons when rubbed against animal fur.

Demonstration Ideas:

1. Electrostatics and Coulomb's Law http://demoweb.physics.ucla.edu/content/experiment-3-electrostatics
   Features a discussion of fundamental electrostatics theory and numerous electrostatic demonstrations.

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

Problem-Based Learning Activity

1. A Tale of Two Charges http://www.cse.emory.edu/cases/cases_materials_download/TwoCharges_TG.pdf
   This activity developed for Emory University's Cases Online presents a unique task: Write a 21st-Century encyclopedia article about Coulomb's Law.

Elsewhere on the Web

1. Coulomb's Law Lecture Notes http://web.mit.edu/8.02t/www/802TEAL3D/visualizations/coursenotes/modules/guide02.pdf
   This 45-page document from MIT's TEAL Project (Technology Enabled Active Learning) on Coulomb's Law dives deep into the Coulomb interaction for two point charges as well as multiple charges.

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

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

1. Static Electricity, Ass't SE8 - Coulomb's Law Equation as a Guide to Thinking
2. Static Electricity, Ass't SE9 - Coulomb's Law Calculations

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

1. The Curriculum Corner, Static Electricity, Coulomb's Law

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

1. The Calculator Pad, Static Electricity, Problems #1 - #14

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

1. Science Reasoning Center, Electrostatics, Charge Interactions
2. Science Reasoning Center, Electrostatics, Sticky Tape Experiments

Historical Connections **See Complete Toolkit on website for more details.**

1. Charles-Augustin de Coulomb
2. Magnet Academy: The Torsion Balance

Common Misconceptions **See Complete Toolkit on website for more details.**

1. A Coulomb of Charge
2. Separation Distance

Standards:

A. Next Generation Science Standards (NGSS) – Grades 9-12
Performance Expectations – Physical Science: Motion and Forces HS-PS2-4
Disciplinary Core Ideas –Types of Interactions HS-PS2.B.1 HS-PS2.B.2
Crosscutting Concepts - Grades 9-12
Patterns
Scale, Proportion, and Quantity
Structure and Function
Science and Engineering Practices
Practice #3: Constructing Explanations
Practice #4: Developing and Using Models
Practice #6: Obtaining, Evaluating, and Communicating Information
Practice #8: Using Mathematics and Computational Thinking