

Teacher Toolkit - Electric Fields

Objectives:

1. To understand that all sources of charge create an influence or action upon other objects some distance away and that the electric field concept is used to describe that influence.
2. To state the mathematical definition of electric field (force/charge) and to describe the dependence of the electric field strength upon the variables that affect it.
3. To use an understanding of the convention for electric field direction to identify the electric field direction around a source charge.
4. To construct and to interpret electric field line diagrams for isolated charges and for collections of two or more charges.
5. To use the electric field equation, Coulomb's law equation, and Newton's laws to analyze physical situations that involve electric fields and to solve physics word problems associated with such situations.

Readings:

[The Physics Classroom Tutorial, Static Electricity Chapter, Lesson 4](#)

Interactive Simulations:

1. Electric Field Lines <http://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Electric-Field-Lines>
Study electric field patterns with this simple simulation. Learners drag positive or negative charges onto the field and observe the field lines that result from the configuration of charges. (**Note:** Specifically meets NGSS DCI: HS-PS2.B.2 – "Forces at a distance are explained by fields permeating space that can transfer energy through space.")
2. Electrostatics Landscapes <http://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Electrostatics-Landscapes>
This simulation was designed to help learners visualize the electric potential surrounding two point charge sources. Place two charges anywhere along the virtual conductive paper, tap Start, and observe the system approach equilibrium. You can view the landscape in two ways: 1) as electric field lines surrounding the charges, or 2) as electric potential shown in volts.
3. Put the Charge in the Goal <http://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Put-the-Charge-in-the-Goal>
Have Fun with the Physics by using your understanding of electric fields to guide a charged puck around obstacles to a goal. By placing charges on the virtual rink, your puck can be attracted or repelled around obstacles. Each time you level up, additional barriers are added!
4. Charges and Fields <https://phet.colorado.edu/en/simulation/charges-and-fields>
In this model, students drag a positive or negative charge (or both) onto the field, then place "E-field sensors" (small positive test charges). Tools include a virtual tape measure and a voltage sensor. Arrows show the force vectors. Registered PhET users can access a set of teacher-contributed lessons and student guides.
5. Electric Field and Potential in 2D Model <http://www.thephysicsfront.org/items/detail.cfm?ID=9412>
This Java model explores electric field and potential in a 2-dimensional situation. Students can turn on 1-5 charged particles, then move a test charge around the plane to sample both the electric field and potential. You can turn on a grid of field vectors that show the direction.

Video and Animation:

1. Education Commons RW: Electric Fields <https://www.youtube.com/watch?v=wpQ-PxRnnw4>
This high-quality 9-minute video uses a combination of grass seed demonstrations and whiteboard illustrations to show patterns and direction of electric field lines. Great resource for students with reading disabilities or who are struggling with the content.
2. Veritasium: What's in a Candle Flame https://www.youtube.com/watch?v=a7_8Gc_Llr8
We know that fire is an oxidizing chemical reaction that releases heat and light. But is a flame plasma? One test case would be whether a candle flame becomes conductive when exposed to an electric field of sufficient magnitude. Veritasium host Derek Muller travels to Paris where he and a French physicist test this very idea.
3. Electric Field Visualized with Crystals <https://www.youtube.com/watch?v=63FnT0W-Hxc>
Physics educator James Lincoln demonstrates electric field by using potassium permanganate crystals, an inorganic compound commonly used in water treatment plants. The crystals dissolve around a positive electrode. The permanganate ion is negative, creating a nice electric field pattern.

Physics Education Research

See Complete Toolkit on The Physics Classroom website for more details.

1. Contrasting Students' Understanding of Electric Field and Electric Force

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

Labs and Investigations:

<http://www.physicsclassroom.com/lab#estatic>

1. The Physics Classroom, The Laboratory, Electric Field Simulation
2. The Physics Classroom, The Laboratory, Coulomb's Hair Lab
3. The Physics Classroom, The Laboratory, Electric Field Lines

Demonstration Ideas:

1. AAPT Films: Ten Ways to "See" the Electric Field <https://www.youtube.com/watch?v=Y6YdC2UoDYY>
We can't see an electric field. So how can students visualize one? James Lincoln demonstrates how with his usual brand of humor and great science. The video explores ten experiments that could be done in the high school classroom. Editor's Note:
2. Equipotential Lines, Electric and Field Mapping <https://www.youtube.com/watch?v=WcSSWN4Tnoo>
This "how-to" video gives great guidance in setting up a classroom lab on field mapping. It gives detailed directions for two methods that both employ conducting paper and voltmeter.
3. Electric Potential and Field Maps Lab www.physics.rutgers.edu/ugrad/276/potential%20maps.pdf
This is a student guide for a lab on field mapping using a voltmeter and field map board. It explains procedures for doing the mapping with the apparatus and calculating electric potential.
4. Electric Field <http://www.compadre.org/Physlets/electromagnetism/intro23.cfm>
The Electric Field Physlet package features four explanatory models for concept introduction; three interactive explorations with supplementary worksheets; and 10 animation-based problems. Sub-topics include field line representation, electric fields from point charges, fields and test charges, ranking tasks, and how to calculate the electric field.

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 a student's conceptual understanding. Each question is accompanied by detailed help.

1. SE10 - Electric Field
2. SE11 - Electric Field Equation
3. SE12 – Electric Field Lines

Concept Building Exercises:

<http://www.physicsclassroom.com/curriculum/estatics>

1. The Curriculum Corner, Static Electricity, Electric Field
2. The Curriculum Corner, Static Electricity, Electric Field Lines

Problem-Solving Exercises:

<http://www.physicsclassroom.com/calcpad/estatics>

1. The Calculator Pad, Static Electricity, Problems #16 - #21, #26 - #32

Science Reasoning Activities:

<http://www.physicsclassroom.com/reasoning/electrostatics>

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

Common Misconceptions

See Complete Toolkit on The Physics Classroom website for more details.

1. Field Strength is NOT Force Strength
2. Convention for Direction
3. Electric Field Lines Show the Direction of Force

Elsewhere On the Web

See Complete Toolkit on The Physics Classroom website for more details.

1. Point Charge Electric Field Demo Model <http://www.thephysicsfront.org/items/detail.cfm?ID=10312>
2. The Electric Field – Concepts and Principles <http://web.monroec.edu/manila/webfiles/spiral/1.ElectricField.pdf>

Standards:

Next Generation Science Standards (NGSS) – Grades 9-12

Disciplinary Core Ideas –Types of Interactions: HS-PS2.B.1, HS-PS2.B.2, HS-PS2.B.3

Crosscutting Concepts: Patterns, Cause and Effect, 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