# 09 Electric Potential

Content Area: **Science**
Course(s): **AP Physics C**
Time Period: **Semester 1**
Length: **3 weeks**
Status: **Published**

## Standards

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| HS-PS3-1 | Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. |
| | Using Mathematics and Computational Thinking |
| PS3.B | Conservation of Energy and Energy Transfer |
| | Systems and System Models |
| HS-PS3-2 | Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). |
| | Developing and Using Models |
| | Constructing Explanations and Designing Solutions |
| PS3.A | Definitions of Energy |
| | Energy and Matter |
| HS-PS3-5 | Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. |
| PS3.C | Relationship Between Energy and Forces |
| | Cause and Effect |

## AP Physics C Learning Objectives

**Note: Learning Objectives are taken verbatim from the AP Physics C - Mechanics Course and Exam Description. The verb "describe" could refer to a variety of different methods of expression (e.g. words, diagrams, graphs, mathematical expressions), as appropriate.**

Describe the electric potential energy of a system.

Describe the electric potential due to a configuration of charged objects.

Describe the relationship between electric potential and electric field.

Describe changes in a system due to a difference in electric potential between two locations.

## Enduring Understandings

Fields predict and describe interactions.

Conservation laws constrain interactions.

Excess charge on an insulated conductor will spread out on the entire conductor until there is no more movement of the charge.

## Essential Questions

What is the difference between electric potential and electric potential energy?

Why do different voltage batteries exist?

What is the difference between a 1.5 V AA battery and a 9 V battery?

Why is a car battery more dangerous than a 9 V battery?

Why are high voltage power lines dangerous?

## Knowledge and Skills

**Topic 9.1 Electric Potential Energy**

**Knowledge:**

- The electric potential energy of a system of two point charges equals the amount of work required for an external force to bring the point charges to their current positions from infinitely far away.
- The general form for the electric potential energy between two charged objects is given by the equation  .
- The total electric potential energy of a system can be determined by finding the sum of the electric potential energies of the individual interactions between each pair of charged objects in the system.

**Skills:**

- Create qualitative sketches of graphs that represent features of a model or the behavior of a physical system.
- Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

**Topic 9.2 Electric Potential**

**Knowledge:**

- Electric potential describes the electric potential energy per unit charge at a point in space.
- Expressions for the electric potential of charge distributions can be found using integration and the principle of superposition.
- The electric potential for single point charge is  .
- The electric potential due to multiple point charges can be determined by the principle of scalar superposition of the electric potential due to each of the point charges.
- The electric potential difference between two points is the change in electric potential energy per unit charge when a test charge is moved between the two points.
- Electric potential difference may also result from chemical processes that cause positive and negative charges to separate, such as in a battery.
- The value of an electric field component in any direction at a given location is equal to the negative of the spatial rate of change in electric potential at that location.
- The change in electric potential between two points can be determined by integrating the dot product of the electric field and the displacement along the path connecting the points.
- Electric field vector maps and equipotential lines are tools to describe the field produced by a charge or configuration of charges and can be used to predict the motion of charged objects in the field.
- Equipotential lines represent lines of equal electric potential. These lines are also referred to as isolines of electric potential.
- Isolines are perpendicular to electric field vectors. An isoline map of electric potential can be constructed from an electric field vector map, and an electric field map may be constructed from an isoline map.
- An electric field vector points in the direction of decreasing potential.
- There is no component of an electric field along an isoline.

**Skills:**

- Create quantitative graphs with appropriate scales and units, including plotting data.
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.
- Calculate or estimate an unknown quantity with units from known quantities by selecting and following a logical computational pathway.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.

**Topic 9.3 Conservation of Electric Energy**

**Knowledge:**

- When a charged object moves between two locations with different electric potentials, the resulting change in the electric potential energy of the object-field system is given by the following equation.
  
- The movement of a charged object between two points with different electric potentials results in a change in kinetic energy of the object consistent with the conservation of energy.

**Skills:**

- Create diagrams, tables, charts, or schematics to represent physical situations.
- Compare physical quantities between two or more scenarios or at different times and locations in a single scenario.
- Predict new values or factors of change of physical quantities using functional dependence between variables.

- Create experimental procedures that are appropriate for a given scientific question.
- Justify or support a claim using evidence from experimental data,
- physical representations, or physical principles or laws.

## Transfer Goals

In Unit 9, students are introduced to the concept of electric potential, which is another way to describe interactions between charged systems. A thorough understanding of the relationship between electric potential and electrical energy will support student's ability to analyze physical scenarios, such as the interaction between two charged objects, using the concept of energy. Students will begin to appreciate the real-world implications, including energy storage and transfer. Throughout the entire course, students will apply their knowledge of electric potential and potential energy to a wide array of scenarios to describe how electrical energy powers our world.

## Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

## Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing