03 Electricity and Magnetism

Content Area: **Science**
Course(s): **Physics A**
Time Period: **Semester 2**
Length: **10 weeks**
Status: **Published**

Standards

	Patterns
PS2.B	Types of Interactions
	Using Mathematics and Computational Thinking
HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
PS3.A	Definitions of Energy
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
	Planning and Carrying Out Investigations
	Developing and Using Models

Enduring Understandings

1. Students will understand that invisible gravitational, electric, and magnetic fields permeate space to transfer energy and exert non-contact forces between distant objects, which can be mathematically modeled and predicted using inverse-square relationships like Newton's Law of Universal Gravitation and Coulomb's Law.

2. Students will understand that electric charges create electric fields and interact through attractive or repulsive forces, while the dynamic interplay between moving matter dictates that changing electric fields induce magnetic fields, and changing magnetic fields conversely induce electric fields.

3. Students will understand that the atomic-scale attraction and repulsion between electric charges explain the fundamental properties, structures, and contact forces of everyday macroscopic matter, while strong and weak nuclear interactions dictate the internal stability and radioactive decay patterns of atomic nuclei.

4. Students will understand that the total energy of a system of point charges is strictly conserved as it transfers between various configurations, manifesting macroscopically as electrical energy stored within field boundaries like batteries or transmitted through space and circuits by electric currents.

Essential Questions

1. What underlying fundamental forces explain the variety of interactions observed in everyday matter, and how do they scale from atomic nucleus stability down to macroscopic contact forces?

2. How can we use field models to explain the cause-and-effect mechanism behind electrostatic phenomena, such as a plastic comb making hair stand up or a charged rubber rod bending a stream of water?

3. How would you evaluate the design and placement of materials when it is necessary to shield sensitive technological or biological systems against destructive external electric fields?

4. How are non-contact forces mathematically related to the energy stored within a field, and how does altering the relative position of interacting objects change that field energy?

5. How would you critique the structural and predictive limitations of using Newton's Law of Universal Gravitation and Coulomb's Law to model interactions between distant objects?

6. How does analyzing a topographical map of gravitational elevations help us conceptualize, map, and analyze a three-dimensional electric field's voltage distribution?

7. How is energy transferred, transformed, and absolutely conserved within a complex system composed of a moving collection of point charges?

8. How do the concepts of electric potential difference (voltage) and system boundaries explain why a bird can safely land on a high-voltage wire while a grounded object touching the same wire would experience a catastrophic energy transfer?

Knowledge and Skills

Knowledge:

1. Analyze how inverse-square laws (Newton’s Law of Universal Gravitation and Coulomb’s Law) function as parallel mathematical frameworks to predict non-contact forces between distant point masses or point charges.

2. Deconstruct a multi-charge system by analyzing how net electrostatic force is determined via vector superposition, using the resultant net force vector and initial conditions to calculate an object’s acceleration, velocity changes, and exact trajectory.

3. Analyze the mechanistic difference between how an external electric field shifts mobile charges in a conductor versus reorienting dipoles in an insulator to polarize a neutral object.

4. Evaluate the cause-and-effect relationship that allows a purely neutral, polarized object to experience a net attractive force toward a nearby charged object.

5. Formulate a conceptual model explaining how energy is stored within permeating space (gravitational, electric, and magnetic fields), and how changing the relative position of interacting objects transforms that field energy.

6. Analyze the reciprocal nature of electromagnetic induction: how moving electric charges or currents

generate magnetic fields, and how changing magnetic fields conversely generate electric fields.

7. Analyze electric current as a rate of charge transport through a cross-sectional area, evaluating its direct proportional relationship to potential difference (voltage) and its inverse relationship to material resistance.

Skills :

1. Analyze and manipulate algebraic representations of Coulomb's Law and Universal Gravitation to calculate, compare, and predict vector forces acting within multi-object systems at varying scales.

2. Plan, conduct, and refine an experimental investigation that isolates the specific variables required to prove that an electric current induces a magnetic field, and that a changing magnetic flux induces an electric current.

3. Develop, utilize, and critique diagrammatic or computational models (such as electric field line mappings or equipotential contours) to illustrate how mechanical work done on a system alters both the physical forces and the potential energy stored within an electric or magnetic field.

Assessments

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

Modifications

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