Unit 7: Electrostatic and Nuclear Forces

Content Area: **Science**
Course(s):
Time Period: **Marking Period 4**
Length: **4 Weeks**
Status: **Published**

Summary

In this unit, students will build off of their knowledge of chemistry from the previous school year to analyze electrostatic forces and relate them to their every day experiences. Coulomb's Law is introduced and used to calculate the force between charged particles. The relationship between moving electric charges and magnetic fields is also investigated. Strong nuclear and weak nuclear forces are introduced qualitatively, and the role they play in nuclear fusion is discussed. This is explained in the context of the lifecycle of a star.

Revised July 2021

CS.9-12.8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
CS.9-12.8.2.12.EC.2	Assess the positive and negative impacts of emerging technologies on developing countries and evaluate how individuals, non-profit organizations, and governments have responded.
CS.9-12.8.2.12.EC.3	Synthesize data, analyze trends, and draw conclusions regarding the effect of a technology on the individual, culture, society, and environment and share this information with the appropriate audience.
CS.9-12.8.2.12.ETW.4	Research historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product and present the competing viewpoints.
LA.RST.9-10	Reading Science and Technical Subjects
LA.RST.9-10.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.9-10.2	Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
LA.RST.9-10.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
LA.RST.9-10.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
LA.RST.9-10.5	Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
LA.RST.9-10.6	Determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
LA.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
LA.RST.9-10.8	Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
LA.RST.9-10.9	Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous

	explanations or accounts.
LA.RST.9-10.10	By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.
LA.WHST.9-10	Writing History, Science and Technical Subjects
LA.WHST.9-10.1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
LA.WHST.9-10.1.A	Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
LA.WHST.9-10.1.B	Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
LA.WHST.9-10.1.C	Use transitions (e.g., words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
LA.WHST.9-10.1.D	Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.
LA.WHST.9-10.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.9-10.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.9-10.2.A	Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
LA.WHST.9-10.2.B	Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
LA.WHST.9-10.2.C	Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
LA.WHST.9-10.2.D	Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
LA.WHST.9-10.2.E	Establish and maintain a style and tone appropriate to the audience and purpose (e.g., formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.
LA.WHST.9-10.2.F	Provide a concluding paragraph or section that supports the argument presented.
MA.K-12.1	Make sense of problems and persevere in solving them.
MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.3	Construct viable arguments and critique the reasoning of others.
MA.K-12.4	Model with mathematics.
MA.K-12.5	Use appropriate tools strategically.
MA.K-12.6	Attend to precision.
MA.K-12.7	Look for and make use of structure.
MA.K-12.8	Look for and express regularity in repeated reasoning.
SCI.HS.PS1.A	Structure and Properties of Matter

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.A	Definitions of Energy
SCI.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.
SCI.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.
TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).
TECH.9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
TECH.9.4.12.TL.3	Analyze the effectiveness of the process and quality of collaborative environments.

"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.

Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Assessment is limited to designing and conducting investigations with provided materials and tools.

Craft and Structure

Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.

The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

Assessment is limited to systems with two objects.

Range of Reading and Level of Text Complexity

Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.

Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Developing and Using Models

Text Types and Purposes

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Energy and Matter

Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Integration of Knowledge and Ideas

Use mathematical representations of phenomena to describe explanations.

Patterns

Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Using Mathematics and Computational Thinking

Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

Planning and Carrying Out Investigations

Key Ideas and Details

Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

Essential Questions/Enduring Understanding

Essential Questions

How do objects interact across large distances without contact?

How do electrostatic interactions help us understand some forms of energy and different types of forces on a microscopic scale?

How can an understanding of electrostatics help keep people safe?

Enduring Ubderstandings

Mathematical models, such as Coulomb's Law and Newton's Law of Universal Gravitation, help us see similarities between seemingly disparate physics phenomena.

Objectives

Students will know the difference between a good conductor and a good insulator.
Students will know two ways electric charges can be transferred.
Students will know what happens when a charged object is placed near a conductor or an insulator.
Students will be skilled at calculating the force between charged particles using Coulomb's Law.
Students will know the differences and similarities between Coulomb's Law and The Law of Universal Gravitation.
Students will be skilled at drawing electric and magnetic fields.
Students will know the role strong and weak nuclear forces play in nuclear fusion.
Students will know the life cycle of a star and explain how nuclear fusion powers a star.

Learning Plan

Students will conduct numerous observational experiments and testing experiments to probe the nature of electrostatic and magnetic forces. Hands-on equipment and small group work will be used extensively.

The PhET simulation Balloons and Static Electricity and/or John Travoltage will help students visualize the transfer of electrons during static electricity phenomena.

Real data will be provided for students to analyze in order to come up with the basic form of Coulomb's Law.

The experimental discovery of Coulomb's constant will be discussed and replicated using a PhET simulation. Students will review scientific notation and apply it to problem solving using Coulomb's Law.

Electric fields will be discussed and compared to magnetic fields and gravitational fields. Magnetic fields will be visualized in class using magnets, compasses, and iron filings. Students will use electroscopes to conduct experiments.

Students will investigate practical applications of electric field knowledge, such as what to do in a lightning storm or how spiders "fly".

At the end of the unit, students will make predictions of what will happen to various objects (including themselves) near the Van de Graaff generator and test those predictions with an in-class demonstration day.

Assessment

Formative: Students will draw many charge diagrams that are assessed during class through whiteboard presentations. Solutions to Coulomb's Law problems will be completed both in groups and independently for

teacher feedback. Students will complete independent homework assignments that will be reviewed in class so that they can self-assess.

Summative: Quizzes on Electrostatic and Nuclear Forces, Unit Text, Coulomb's constant lab, magnetic field lab. Optional project or alternative assessment: design your own electroscope.

Benchmark: This unit is included in the final exam.

Alternative: Presentation/Project on Magnetic Field

Materials

Computer with PowerPoint/Google Slides and internet access

Textbook Physics: Principles and Problems, Glencoe

Calculators, rulers, meter sticks, colored pencils, graph paper, Chromebooks for students, whiteboards for collaborative work, dry erase markers and erasers for student groups, electrostatics rods and fabrics, magnets, iron filings, compasses, food coloring, alcohol prep pads, paper, plastic cups, access to water, Van de Graaff generator and accessories, electroscopes, Cosmos: A Spacetime Odyssey series (hard copy or EdPuzzle).

Integrated Accommodations and Modifications

Integrated Accommodation and Modifications, Special Education students, English Language Learners, At-Risk students, Gifted and Talented students, Career Education, and those with 504s

https://docs.google.com/spreadsheets/d/18XhAi7Rm-E8LJwO4uMQS7ZEh0dh3NxYbTFH2IoHLH7Y/edit?usp=sharing