UNIT 5: Electricity and Magnetism

Content Area: **Science**
Course(s): **IB physics, SL**
Time Period: **Third Marking Period**
Length: **4 Weeks**
Status: **Published**

Unit Overview

Electric charges create electric fields in space. The notion of electric field and the related concept of electric potential and electric potential energy are introduced in this unit. Electrical theory demonstrates the scientific thought involved in the development of a microscopic model (behavior of charge carriers) from macroscopic observation. One of the earliest uses for electricity was to produce light and heat. This technology continues to have a major impact on the lives of people around the world. Electric cells allow us to store energy in a chemical form.

STAGE 1- DESIRED RESULTS

2020 New Jersey Student Learning Standards- Science

SCI.9-12.HS-PS2	Motion and Stability: Forces and Interactions
SCI.9-12.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.9-12.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.
SCI.9-12.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
SCI.9-12.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.

Science and Engineering Practices

- Analyzing and Interpreting Data
- Asking Questions and Defining Problems
- Constructing Explanations and Designing Solutions
- Developing and Using Models

- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Information
- Using Mathematics and Computational Thinking

Cross Cutting Concepts

- Cause and Effect
- Energy and Matter
- Influence of Engineering, Technology, and Science on Society and the Natural World
- Interdependence of Science, Engineering, and Technology
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Functions
- Systems and System Models

Disciplinary Core Ideas

PS2 B: Types of Interactions

PS3 A: Definitions of Energy

PS3 B: Conservation of Energy and Energy Transfer

Physical Sciences

- PS1A: Structure and Properties of Matter
- PS1B: Chemical Reactions
- PS1C: Nuclear Processes
- PS2A: Forces and Motion
- PS2B: Types of Interaction
- PS3A: Definitions of Energy
- PS3B: Conservation of Energy and Energy Transfer
- PS3C: Relationship Between Energy and Forces
- PS3D: Energy in Chemical Processes and Everyday Life
- PS4A: Wave Properties

- PS4B: Electromagnetic Radiation
- PS4C: Information Technologies and Instrumentation

Life Sciences

- LS1A: Structure and Functions
- LS1B: Growth and Development of Organisms
- LS1C: Organization for Matter and Energy Flow in Organisms
- LS1D: Information Processing
- LS2A: Interdependent Relationships in Ecosystems
- LS2B: Cycles of Matter and Energy Transfer in Ecosystems
- LS2C: Ecosystems Dynamics, Functioning, and Resilience
- LS2D: Social Interactions and Group Behavior
- LS3A: Inheritance of Traits
- LS3B: Variation of traits
- LS4A: Evidence of Common Ancestry and Diversity
- LS4B: Natural Selection
- LS4C: Adaptation
- LS4D: Biodiversity and Humans

Earth and Space Sciences

- ESS1A: The Universe and its Stars
- ESS1B: Earth and the Solar System
- ESS1C: The History of Planet Earth
- ESS2A: Earth Materials and Systems
- ESS2B: Plate Tectonics and Large-Scale Systems
- ESS2C: The Role of Water in Earth's Surface Processes
- ESS2D: Weather and Climate
- ESS2E: Biogeology
- ESS3A: Natural Resources
- ESS3B: Natural Hazards
- ESS3C: Human Impacts on Earth Systems
- ESS3D: Global Climate Change

Engineering. Technology. and Applications of Science

- ETS1A: Defining and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutioins
- ETS1C: Optimizing the Design Solution

Essential Questions

- How do charges interact with electric and magnetic fields?
- Why are most objects electrically neutral?
- How does the total amount of charge in the universe change over time?
- How is the electrostatic force between two charges related to the magnitude of the charges and the distance between them?
- What determines the direction of the electric force between two charges?
- What is an electric field?
- What is the difference between electrical energy and potential difference?
- Why do wires usually warm up when an electric current is in them?
- What factors affect the resistance of a conductor?
- How many joules are in a kilowatt-hour?
- Why are schematic diagrams useful?
- What is a magnetic domain?
- What factors does the strength of the magnetic field of a solenoid depend on?
- Why does the picture on a television screen become distorted when a magnet is brought near the screen?

Enduring Understanding

Forces at a distance are explained by fields permeating space that can transfer energy through space. Magnets or changing electric fields cause magnetic fields. Electric charges or changing magnetic fields cause electric fields.

Students will know…

- Charge
- Electric field
- Coulomb's law
- Electric current
- Direct current (dc)
- Potential difference
- Circuit diagrams
- Kirchhoff's circuit laws

- Heating effect of current and its consequences
- Resistance expressed as R=VI
- Ohm's law
- Resistivity
- Power dissipation
- Cells
- Internal resistance
- Secondary cells
- Terminal potential difference
- Emf
- Magnetic fields
- Magnetic force

Possible Misconceptions

- The electric field and force are the same thing and in the same direction. Field lines can begin/end anywhere.
- Field lines are real.
- Voltage flows through a circuit.
- Current is the same thing as voltage.
- The bigger the battery, the more voltage.

Students will be able to...

- Identify two forms of charge and the direction of the forces between them
- Solve problems involving electric fields and Coulomb's law
- Calculate work done in an electric field in both joules and electron volts
- Identify sign and nature of charge carriers in a metal
- Identify drift speed of charge carriers
- Solve problems using the drift speed equation
- Solve problems involving current, potential difference and charge
- Draw and interpret circuit diagrams
- Identify ohmic and non-ohmic conductors through a consideration of the *V/I* characteristic graph
- Solve problems involving potential difference, current, charge, Kirchhoff's circuit laws, power, resistance and resistivity
- Investigate combinations of resistors in parallel and series circuits
- Describe ideal and non-ideal ammeters and voltmeters
- Describe practical uses of potential divider circuits, including the advantages of a potential divider over a series resistor in controlling a simple circuit
- Investigate one or more of the factors that affect resistance experimentally
- Investigate practical electric cells (both primary and secondary)
- Describe the discharge characteristic of a simple cell (variation of terminal potential difference with time)
- Identify the direction of current flow required to recharge a cell
- Determine internal resistance experimentally

- Solve problems involving emf, internal resistance and other electrical quantities
- Determine the direction of force on a charge moving in a magnetic field
- Determine the direction of force on a current-carrying conductor in a magnetic field
- Sketch and interpret magnetic field patterns
- Determine the direction of the magnetic field based on current direction
- Solve problems involving magnetic forces, fields, current and charges

STAGE 2- EVIDENCE OF LEARNING

Formative Assessment

- 3- Minute Pause
- A-B-C Summaries
- Analogy Prompt
- Choral Response
- Debriefing
- Exit Card / Ticket
- Hand Signals
- Idea Spinner
- Index Card Summaries
- Inside-Outside Circle Discussion (Fishbowl)
- Journal Entry
- Misconception Check
- Observation
- One Minute Essay
- One Word Summary
- Portfolio Check
- Questions & Answers
- Quiz
- Self-Assessment
- Student Conference
- Think-Pair-Share
- Web or Concept Map

Authentic Assessments

Simulation activities

Project building simple circuits

Worksheets on Electric fields & Coulombs law, **E**quipotential surfaces &field lines, Potential energy, Orbital energy of charged particles in circular orbital motion, Forces on charges in radial and uniform fields, Drift speed equation, Current, p.d & charge, EMF, internal resistance Kirchhoff's circuit laws, power, resistance and resistivity, Magnetic forces, fields, current and charges.

Sketching and interpreting magnetic field patterns

Lab Activity – Investigating Factors that affect resistivity, I –V characteristics of ohmic resistor & filament lamp, Electric cells, emf and Internal resistance, Combinations of resistors

Quizzes

Benchmark Assessments

Unit Test

STAGE 3- LEARNING PLAN

Instructional Map

- Students will be given the details of the learning outcome of the unit in the beginning of the unit. Every day at the beginning of the class, expected questions/goal will be written on the board.
- Students will identify the two types of electric charge and recognize that most objects contain equal amounts of each.
- Students will recognize that electric charge can be transferred between objects but is always conserved.
- Calculate the electrostatic force between two point charges.
- Identify the direction of the electric fields around positive and negative charges.
- Calculate the magnitude of the electric field at a point by applying superposition.
- Relate electric fields and electric potential energy to the mechanical work required to separate charges that attract each other.
- Have students list different types of potential energy and explain how each type is calculated.
- Describe how electrons move through a DC circuit.
- Calculate the current that passes through a resistor with a given resistance and applied voltage.

- Explain how the resistance of a wire depends on the material it is made of, its physical dimensions, and its temperature.
- students will measure the potential difference across and the current through 3 different resistors. Using the graphs they produce, they should recognize Ohm's Law.
- Calculate the equivalent resistance of a group of resistors connected in series.
- Calculate the equivalent resistance of a group of resistors connected in parallel.
- Have students list the characteristics of series circuits and the characteristics of parallel circuits.
- Challenge students to solve problems completely symbolically instead of relying on numerical values.
- Determine the emf and internal resistance of a cell.
- Calculate the power used by an electric device.
- Define kilowatt-hours and calculate the energy used by an electric device.
- The filament lamp should be described as a non-ohmic device; a metal wire at a constant temperature is an ohmic device .
- The use of non-ideal voltmeters is confined to voltmeters with a constant but finite resistance.
- The use of non-ideal ammeters is confined to ammeters with a constant but non-zero resistance.
- Application of Kirchhoff's circuit laws will be limited to circuits with a maximum number of two source-carrying loops.
- Determine the direction of the magnetic field around a current-carrying wire by using the right-hand rule.
- Calculate the magnitude of the magnetic field at a given point near a current-carrying wire.
- Determine the force between two current-carrying loops of wire.

    - Lab work
    - use of a hot-wire ammeter as an historically important device;
    - comparison of resistivity of a variety of conductors such as a wire at constant temperature, a filament lamp, or a graphite pencil;
    - determination of thickness of a pencil mark on paper;
    - investigation of ohmic and non-ohmic conductor characteristics;
    - using a resistive wire wound and taped around the reservoir of a thermometer to relate wire resistance to current in the wire and temperature of wire
    - Investigation of simple electrolytic cells using various materials for the cathode, anode and electrolyte;
    - software-based investigations of electrical cell design; comparison of the life expectancy of various batteries.
    - determine the internal resistance of a cell.

Modification/Differentiation of Instruction

Differentiation Strategies for Special Education Students

- Remove unnecessary material, words, etc., that can distract from the content
- Use of off-grade level materials
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Time allowed

- Level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Varied homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Ability to work at their own pace
- Present ideas using auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment
- Differentiated checklists and rubrics, if available and appropriate

<u>Differentiation Strategies for Gifted and Talented Students</u>

- Increase the level of complexity
- Decrease scaffolding
- Variety of finished products
- Allow for greater independence
- Learning stations, interest groups
- Varied texts and supplementary materials
- Use of technology
- Flexibility in assignments
- Varied questioning strategies
- Encourage research
- Strategy and flexible groups based on formative assessment or student choice
- Acceleration within a unit of study
- Exposure to more advanced or complex concepts, abstractions, and materials
- Encourage students to move through content areas at their own pace
- After mastery of a unit, provide students with more advanced learning activities, not more of the same activity
- Present information using a thematic, broad-based, and integrative content, rather than just single-subject areas

Differentiated Strategies for ELL Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials, including visuals
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Allow students to work at their own pace
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Role play
- Provide graphic organizers, highlighted materials
- Strategy and flexible groups based on formative assessment

Differentiation Strategies for At Risk Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts

- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment

504 Plans

Students can qualify for 504 plans if they have physical or mental impairments that affect or limit any of their abilities to:

- walk, breathe, eat, or sleep
- communicate, see, hear, or speak
- read, concentrate, think, or learn
- stand, bend, lift, or work

Examples of accommodations in 504 plans include:

- preferential seating
- extended time on tests and assignments
- reduced homework or classwork
- verbal, visual, or technology aids
- modified textbooks or audio-video materials
- behavior management support
- adjusted class schedules or grading
- verbal testing
- excused lateness, absence, or missed classwork
- pre-approved nurse's office visits and accompaniment to visits
- occupational or physical therapy

Peer Tutoring

Repeated Drill and Practice

Cooperative Grouping

Teacher notes

Use of additional reference materials

Modification Strategies

- Cooperative Grouping
- Extended Time
- Frequent Breaks
- Highlighted Text
- Interactive Notebook
- Modified Test
- Oral Directions
- Peer Tutoring
- Preferential Seating
- Re-direct
- Repeated Drill and Practice
- Shortened Assisgnment
- Teacher Notes
- Tutorials
- Use of Additional Reference Materials
- Use of Audio Resources

Differentiation Strategies

High Preparation

- Alternative Assessments
- Choice Boards
- Games and Tournaments
- Group Investigations
- Guided Reading
- Independent Research / Project
- Interest Groups
- Learning Contracts
- Leveled Rubrics
- Literature Circles
- Multiple Intelligence Options
- Multiple Texts
- Personal Agendas

- Project Based Learning (PBL)
- Stations / Centers
- Think-Tac-Toe
- Tiered Activities / Assignments
- Varying Graphic Organizers

Low Preparation

- Choice of Book / Activity
- Cubing Activities
- Exploration by Interest (using interest inventories)
- Flexible Grouping
- Goal Setting With Student
- Homework Options
- Jigsaw
- Mini Workshops to Re-teach or Extend Skills
- Open-ended Activities
- Think-Pair-Share by Readiness, Interest, or Learning Style
- Use of Collaboration
- Use of Reading Buddies
- Varied Journal Prompts
- Varied Product Choice
- Varied Supplemental Materials
- Work Alone / Together

Horizontal Intergration- Interdisciplinary Connections

See Appendix

Vertical Integration- Discipline Mapping

Physics IB SL course is offered during the Junior and Senior years of High School. At this point in their studies, students will have been exposed to the Performance Expectations of the NGSS in Middle school. This course will allow the student to further expand and develop a deeper understanding of the physics concepts taught in earlier years.

Tenth Grade Chemistry

Nineth Grade Biology

Eighth Grade - Chemical Interactions

Seventh Grade - Electromagnetic Force and Gravity and Kinetic Energy

Sixth Grade - Waves

Additional Materials

Internet resources:

Khan Academy

Physicsclassroom.com

Youtube videos

Phet.colorado.edu

http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc

http://phet.colorado.edu/en/simulation/charges-and-fields

http://phet.colorado.edu/en/simulation/efield