Course: *Physics* **Unit #4:** Electricity & Magnetism	**Year of Implementation:** 2023-2024

Curriculum Team Members
Matt Bush, mbush@lrhsd.org; Kyle Louis, klouis@lrhsd.org; Brian Mack, bmack@lrhsd.org; Jeffrey Thompson, jthompson@lrhsd.org

Stage One - Desired Results

Link(s) to New Jersey Student Learning Standards for this course:
https://www.state.nj.us/education/cccs/2020/
https://www.state.nj.us/education/cccs/2020/2020%20NJSLS-CLKS.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion9-10.pdf
https://www.nj.gov/education/standards/ela/Docs/2016NJSLS-ELA_Companion11-12.pdf

- **Unit Standards:**
  - ***Content Standards***
    - 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.
    - HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
    - 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.
  - ***21st Century Life & Career Standards***
    - 9.4.12.CI.1 - Demonstrate the ability to reflect, analyze and use creative skills and ideas
    - 9.4.12.IML.3 - Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
  - ***English Companion Standards***

        - RST.11-12.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
        - WHST.9-10.2 - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
        - WHST.11-12.8 - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation
        - WHST.9-10.9 - Draw evidence from informational texts to support analysis, reflection, and research

    - ***Interdisciplinary Content Standards***
        - MP.2 - Reason abstractly and quantitatively.
        - MP.4 - Model with mathematics.
        - HSN-Q.A.1 - Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
        - HSN-Q.A.2 - Define appropriate quantities for the purpose of descriptive modeling.
        - HSN-Q.A.3 - Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
        - HSA-SSE.A.4 - Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

    - ***NJ Statutes:*** NJ State law mandates the inclusion of the following topics in lesson design and instruction as aligned to elementary and secondary curriculum.

      Amistad Law: N.J.S.A. 18A 52:16A-88 Every board of education shall incorporate the information regarding the contributions of African-Americans to our country in an appropriate place in the curriculum of elementary and secondary school students.

      Holocaust Law: N.J.S.A. 18A:35-28 Every board of education shall include instruction on the Holocaust and genocides in an appropriate place in the curriculum of all elementary and secondary school pupils. The instruction

shall further emphasize the personal responsibility that each citizen bears to fight racism and hatred whenever and wherever it happens.

LGBT and Disabilities Law: N.J.S.A. 18A:35-4.35 A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards (N.J.S.A.18A:35-4.36) A board of education shall have policies and procedures in place pertaining to the selection of instructional materials to implement the requirements of N.J.S.A. 18A:35-4.35.

Diversity and Inclusion (N.J.S.A. 18A:35-4.36a) A board of education shall incorporate instruction on diversity and inclusion in an appropriate place in the curriculum of students in grades kindergarten through 12 as part of the district's implementation of the New Jersey Student Learning Standards.

Asian American and Pacific Islanders (AAPI) P.L.2021, c.410 Ensures that the contributions, history, and heritage of Asian Americans and Pacific Islanders (AAPI) are included in the New Jersey Student Learning Standards (NJSLS) for Social Studies in kindergarten through Grade 12 (P.L.2021, c.416)

For additional information, see

NJ Amistad Curriculum: http://www.njamistadcurriculum.net/

Diversity and Inclusion: https://www.nj.gov/education/standards/dei/index.shtml

- *(Sample Activities/ Lessons): https://www.nj.gov/education/standards/dei/samples/index.shtml*

Asian American and Pacific Islanders:

- *Asian American and Pacific Islander Heritage and History in the U.S.*
  A Teacher's Guide from EDSITEment offering a collection of lessons and resources for K-12 social studies, literature and arts classrooms that center around the experiences, achievements and perspectives of Asian Americans and Pacific Islanders across U.S. history.

Transfer Goal: Students will be able to independently use their learning of electromagnetism to construct, evaluate, and communicate detailed scientific explanations to describe the production, distribution and uses of electrical energy.

As aligned with LRHSD Long Term Learning Goal(s):

Students will be better able to:

- design, critique, and carry out experiments in order to investigate scientific questions and/or propose solutions.
- collect, interpret, and analyze data in order to solve a defined problem.
- apply mathematics to express relationships efficiently and accurately.
- draw evidence-based conclusions from data in order to make informed decisions.
- construct, interpret, and refine models (scientific and mathematical) to explain the physical and natural world.
- effectively communicate scientific ideas and evidence-based arguments to an appropriate audience through written and oral means.

Enduring Understandings	*Essential Questions*
Students will understand that. . . *EU 1* forces that act at a distance can be modeled by fields. *EU 2* electricity is a form of energy produced when moving charges do work in various devices. *EU 3* electric current can produce a magnetic field and a changing magnetic field can produce an electric current.	*EU 1* ● What IS electric charge and how does an object acquire it? ● How can gravitational, electrical, and magnetic forces act when the objects are not touching each other? *EU 2* ● Why does a battery die? ● How do the interplay of voltage, resistance, current, and power affect electricity? ● What exactly does the electric company really sell you?

	● How would the world be different if there was no electricity? *EU 3* ● Where does electricity come from? ● Which form of current is more useful? ● How is magnetism related to electricity? ● How are the magnetic force and electric force similar and different?
<u>Knowledge</u> *Students will know . . .* *EU 1* ● electric charge is quantized. ● like charges repel one another and opposite charges attract. (PS1.A) ● the force between two charges depends on the magnitude of each charge and their separation. (PS2.B) ● like gravity, the electric force between two charges varies by the inverse square of the distance between them. (PS2.B) ● an electric field exists around all charged objects and is characterized by its magnitude and direction. (PS2.B) *EU 2*	*<u>Skills</u>* *Students will be able to. . .* *EU 1* ● demonstrate how to charge an object. ● apply coulomb's law as a model to predict the force between two charges that are a known distance apart. (SEP2) ● use mathematical and computational thinking to draw and interpret electric field lines. (SEP5) ● analyze and interpret data in order to make predictions concerning the motion of charged objects in electric fields. (SEP4) *EU 2*

● electric current is determined by the amount of charge that flows through a circuit in a given time. (PS3.A) ● the current that flows through a conductor is related to the resistance of the conductor and the applied voltage. (PS3.A) ● the current that flows through a combination of resistors depends on how those resistors are arranged. (PS3.A) ● that batteries store electrical energy. (PS3.A) ● electric power is the rate at which energy is used by a device. (PS3.A)	● construct a scientific explanation that details the difference between an insulator and a conductor. (SEP6) ● use diagrams to model simple DC circuits. (SEP2) ● design an investigation that tests Ohm's Law as an effective model to describe DC circuits with resistors in series and parallel. (SEP3)
EU 3 ● magnetic fields are produced by moving electric charges. (PS2.B) ● the magnetic field around permanent magnets and current-carrying wires can be visualized by magnetic field lines. (PS2.B) ● the magnetic field lines produced by a long, straight wire are concentric about the wire. (PS2.B) ● a moving electric charge can experience a force in a magnetic field. ● current-carrying wires can experience a force in a magnetic field. ● a changing magnetic flux can induce a current in a closed loop of wire. (PS2.B)	*EU 3* ● describe the magnetic field produced by a bar magnet. (SEP6) ● describe the magnetic field produced by a current-carrying wire. (SEP6) ● use mathematical and computational thinking to determine if a particular charge will experience a force when it is located in a magnetic field. (SEP5) ● construct an explanation that describes how magnetic forces can be used to make a motor spin. (SEP6) ● apply Faraday's Law of Induction as a computational model to predict an induced electromotive force and the resulting current. (SEP2) ● describe how a generator could be used to produce an electric current. (SEP6) ● define the challenges of transmitting electrical power over long distances and develop an explanation as to

● a transformer is a device that employs electromagnetic induction to either step up or step down a primary voltage.	how transformers allow for the efficient transport of electrical energy.

Stage Two - Assessment

Stage Three - Instruction

Learning Plan: **Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.** *The following color codes are used to notate activities that correspond with interdisciplinary connections and 21st Century Life & Career Connections (which involves Technology Literacy): Red = Interdisciplinary Connection; Purple = 21st Century Life & Career Connection*

PHENOMENON 1: A balloon that is first rubbed on hair can then stick to a wall (A/M, EU1).
Goal: Students will be able to learn how to charge objects and how forces such as the electric force can act at a distance.

1. Demo: Charge a balloon by rubbing it on your hair and then stick it against the wall. Ask the students to discuss by using these questions as prompts: (A/M, EU1)
    - How can an object become charged?
    - How can objects be attracted or repelled from each other?
    - What other types of forces act at a distance (are field forces)?
2. Discovery Lab: Tape and Charges. Use tape and paper to show charge interaction and polarization. (A/M, EU1)
3. Demo: Various Rods and Fabric. Inducing charge in objects. (Electroscope, lifting paper, pith ball) (A, EU1)
4. Teacher-led Discussion: Positive & Negative Charge (Ben Franklin), movement of electrons from one place to another. Fundamental Charge, electron (quantization), conservation of charge. (A, EU1)
5. Demo/Discussion: Inverse Square Law. How does the electric field force compare to the gravitational field force? (M, EU1)
6. Teacher-led Discussion: Coulomb's Law and how it relates to positive and negatively charged objects. (A, EU1)

7. Students will utilize Coulomb's Law by calculating the force generated on two charged objects at a distance. (M, EU1)
8. Teacher-led discussion: Michael Faraday and Electric Field Lines. (A, EU1)
9. Demo: Electric Field lines (Seeds in Oil). (A, EU1)
10. Students will draw electric field lines around single and multiple charges. (M, EU1)
11. Lab: Electric Field Mapping (M, EU1)
12. Teacher-led Discussion: Potential Difference and how it relates to Gravitational Potential Energy. (A, EU1)

PHENOMENON 2: A generator connected with wires to a light bulb will make the light bulb emit light. (A, EU2)
Goal: Students will be able to describe the concept of electricity and how it can be generated by several different methods.

1. Demo: Use a hand crank generator and wires connected to a light bulb to make it emit light. Ask the following guiding questions for discussion: (A/M, EU2)
    - Why doesn't the light bulb emit light on its own?
    - What happens when the generator is cranked?
    - What happens when the generator is turned faster?
    - Why are wires connected from the generator to the light bulb?
2. Discussion: What makes a good conductor? (A, EU2)
3. Jigsaw: Insulators, Conductors, Semi-conductors. (M, EU2)
4. Teacher-led Discussion: Electric Current, Resistance, and Power and their definition. (A,EU2)
5. Students will problem solve and perform calculations utilizing equations that involve current, power, and resistance. (M, EU2)
6. Student Investigation: Students will carry out an experiment to verify the relationship known as Ohm's Law. (T, EU2)
7. Demo: Series and Parallel Circuit, advantages and disadvantages. (M, EU2)
8. Activity: What type of circuit is best? Students are given different scenarios and a cost sheet to provide lighting in a park. (T, EU2)
9. Lab: Build your own Series and Parallel Circuits. (M, EU2)
10. Mechanical Universe Videos - War of the Currents, The Electric Battery, Electric Current, The Magnetic Field (A, EU2)
11. Phet Simulation - Circuit Construction Kit (AC/DC), Charges and Field, Electric Field of Dream, Battery Resistor Circuits (A/M, EU2)

PHENOMENON 3: Maglev Trains
Goal: Students will be able to compare the benefits of a maglev train to a traditional train and describe how the maglev train operates through the concepts of electricity and magnetism.

1. Show a picture of a maglev train while briefly explaining the fundamental idea (or show a video such as https://www.youtube.com/watch?v=XjwF-STGtfE . Ask the following guiding questions for discussion: (A/M, EU2,3)
    - What is the fundamental process by which a maglev train will function?
    - How might a maglev train be beneficial to a standard, traditional train?

- How are electricity and magnetism involved in the operation of the train?

2. Teacher-led Discussion: Moving charge creates magnetic fields, (A, EU3)
3. Demo: compasses around a current carrying wire (A, EU3)
4. Students will draw magnetic field lines around various magnets (M, EU3)
5. Demo: deflection of an electron beam in a cathode-ray tube (A, EU3)
6. Teacher-led Discussion: Moving charges in a magnetic field will feel a force. (A, EU3)
7. Student Investigation: Students will investigate and research how motors and generators function. (A/M, EU3)
8. Demo: phet.colorado.edu PhET simulation - Faradays Law (A, EU3)
9. Teacher Led Discussion: Transformers and Electric Power Transmission (A, EU3)
10. Simulation Lab: PhET Transformer Lab (M, EU3)
11. Student Investigation: Step-up and step-down transformers and energy loss (T, EU3)
12. Writing Exercise: Students will provide a written explanation of how a maglev train works by including information from the physics learned from all three EU's. (T, EU1,2,3)

Pacing Guide

Unit #	*Title of Unit*	*Approximate # of teaching days*
1	Kinematics	40
2	Newton's Laws & Forces	40
3	Energy	30
4	Electricity and Magnetism	40
5	Waves	30

Instructional Materials

A fully equipped physics lab

Accommodations

Special Education: The curriculum will be modified as per the Individualized Education Plan (IEP). Students will be accommodated based on specific accommodations listed in the IEP.
Students with 504 Plans: Students will be accommodated based on specific accommodations listed in the 504 Plan.
English Language Learners: Students will be accommodated based on individual need and in consultation with the ELL teacher.
Students at Risk of School Failure: Students will be accommodated based on individual need and provided various structural supports through their school.
Gifted and Talented Students: Students will be challenged to enhance their knowledge and skills through acceleration and additional independent research on the subject matter.