Progressive Science Initiative® (PSI®)
PHYS6664: Learning and Teaching PSI AP Physics C – Electricity & Magnetism

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Course Credit: 4.0 NJCTL credits

Dates & Times:
This is a 4-credit, self-paced course, covering 9 modules of content. The exact number of hours that you can expect to spend on each module will vary based upon the module coursework, as well as your study style and preferences. You should plan to spend approximately 15 hours per credit working online, and up to 30 hours per credit working offline.

Graduate Student Handbook: www.njctl.org/graduate-handbook/

COURSE DESCRIPTION:

This course is designed for those who are learning to teach calculus-based AP Physics C for high school or an equivalent course to college students, focusing on conveying physics and mathematical concepts and understandings. The critical topics of this course include applying general principles of physics in the areas of electric charge and field, Gauss's Law, electric potential and capacitance, currents and circuits, magnetic field and force, sources of magnetic field, electromagnetic induction, inductance, and alternating current. The course asks students to identify, understand and communicate the elements, representations and models of scientific phenomena to solve scientific problems, using calculus as a mathematical base. Technology serves as a tool to establish these connections through exploration, problem solving, formative assessment, presentation, and communication.

STUDENT LEARNING OUTCOMES:

Upon completion of the course, the student will be able to:

1. Apply general principles of physics in the areas of vectors, one and two-dimensional kinematics, dynamics, energy, momentum, rotational motion, universal gravitation, and simple harmonic motion.
2. Apply student-centered pedagogy to teach physics to students.
3. Apply basic mathematical tools commonly used in physics including algebra, trigonometry, and graphical analysis.
4. Identify, understand, and communicate the elements, representations, and models of scientific phenomena to solve scientific problems.
5. Analyze concepts, graphs, data, and variable relationships to determine electric force, electric field, and electric potential in relation to their currents and circuits.
6. Examine, investigate, and assess the relationships between various physics models and their variables.

TEXTS, READINGS, INSTRUCTIONAL RESOURCES:

Required Texts:

- PSI AP Physics C: Mechanics uses a free digital textbook accessible at: https://njctl.org/courses/science/ap-physics-c-electricity-magnetism/
- Participants will download SMART Notebook presentations, homework files, labs, and teacher resources from the PSI AP Physics C Course

Recommended Texts and Resources:

- Next Generation Science Standards for Physical Science: https://www.nextgenscience.org/sites/default/files/HS%20PS%20topics%20combined%206.12.13.pdf
- AP Central: https://apcentral.collegeboard.org/

COURSE REQUIREMENTS:

Consistent attendance in your online courses is essential for your success. Failure to verify your attendance within the first 7 days of this course may result in your withdrawal. If for some reason you would like to drop a course, please contact your advisor.

Online classes have assignments and participation requirements just like on-campus classes. Budget your time carefully. If you are having technical problems, problems with your assignments, or other problems that are impeding your progress, let your instructor know as soon as possible.

In order to receive a Passing grade, the participant must complete the following course requirements: all short answer assignments, mastery exercises, labs, exams, and the reflection paper outlined in the *Assignments* section of the Class Schedule (below).

Grade Distribution:

Module Exams	70%
Final Exam	10%
Short Answer Assignments	6%
Labs	6%
Mastery Exercises	6%
Reflection Paper	2%

Grade Scale:

A	93 – 100
A-	90 – 92
B+	86 – 89
B	83 – 86
B-	80 – 82
C+	77 – 79
C	73 – 76
C-	70 – 72
D	60.0 – 69.9
F	59.9 or below

ACADEMIC STANDING:

NJCTL has established standards for academic good standing within a student's academic program. Students enrolled in any NJCTL online course must receive an 80 or higher to successfully complete a course and receive credit for that course. An 80 is equivalent to a GPA of 2.7 or B-. Additionally, students in an endorsement program must receive a cumulative GPA of 3.0 for all courses combined in order to successfully complete the program.

ACADEMIC INTEGRITY:

Students must assume responsibility for maintaining honesty in all work submitted for credit and in any other work designated by the instructor of the course. Academic dishonesty includes cheating, fabrication, facilitating academic dishonesty, plagiarism, reusing /repurposing your own work, unauthorized possession of academic materials, and unauthorized collaboration.

CITING SOURCES WITH APA STYLE:

All students are expected to follow proper writing and APA requirements when citing in APA (based on the APA Style Manual, 6th edition) for all assignments.

DISABILITY SERVICES STATEMENT:

We are committed to providing reasonable accommodations for all persons with disabilities. Any student with a documented disability requesting academic accommodations should contact the Dean of Students, Melissa Axelssson, for additional information to coordinate reasonable accommodations for students with documented disabilities (melissa@njctl.org).

NETIQUETTE:
Respect the diversity of opinions among the instructor and classmates and engage with them in a courteous, respectful, and professional manner. All posts and classroom communication must be conducted in accordance with the student code of conduct. Think before you push the Send button. Did you say just what you meant? How will the person on the other end read the words?

Maintain an environment free of harassment, stalking, threats, abuse, insults or humiliation toward the instructor and classmates. This includes, but is not limited to, demeaning written or oral comments of an ethnic, religious, age, disability, sexist (or sexual orientation), or racist nature; and the unwanted sexual advances or intimidations by email, or on discussion boards and other postings within or connected to the online classroom.

If you have concerns about something that has been said, please let your instructor know.

CLASS SCHEDULE:

Module	Module Learning Outcomes	Assignments

1 - Electric Charge & Field	● Understand the origin of electric charge and relate it to the structure of the atom. Distinguish between how electric charge is stored and moves on conductors and insulators. ● Predict the direction and the magnitude of the force exerted on an object with an electric charge placed in an electric field using the mathematical model of the relation between an electric force and an electric field. ● Qualitatively and quantitatively apply the vector relationship between the electric field and the net electric charge creating that field. ● Distinguish the characteristics that differ between monopole fields and dipole fields and make claims about the spatial behavior of the fields using qualitative or quantitative arguments based on vector addition of fields due to each point source, including identifying the locations and signs of sources from a vector diagram of the field. Derive the potential energy and torque for the electric dipole. ● Apply mathematical routines to determine the magnitude and direction of the electric field at specified points in the vicinity of a small set (2–4) of point charges, and express the results in terms of magnitude and direction of the field in a visual representation by drawing field vectors of appropriate length and direction at the specified points. ● Create representations of the magnitude and direction of the electric field at various distances (small compared to plate size) from two electrically charged plates of equal magnitude and opposite signs and is able to recognize that the assumption of uniform field is not appropriate near edges of plates. ● Calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation. ● Represent the motion of an electrically charged particle in the uniform field between two oppositely charged plates and express the connection of this motion to projectile motion of an object with mass in the Earth's gravitational field. ● Derive the electric field for continuous charge distributions such as the uniformly charged rod, semicircle of charge, ring of charge and disc of charge using integral calculus and the definition of the electric field.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

2 - Gauss's Law	• Relate the electric field to electric flux and calculate the flux through an arbitrary surface using geometry and calculus. State and apply the relationship between flux and lines of electric force. • Show how Gauss's Law arises from the concept of electric flux, and state it in integral form so it can be applied qualitatively and quantitatively to relate electric flux and charge for various surfaces. • Apply Gauss's Law to solve for the electric fields produced by a Charged Sphere (insulated and conducting), infinite rod, and infinite plane. • Define Electrostatic equilibrium and use its principles, along with Gauss's Law to predict and verify the charge distribution and electric field on various shapes.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam

3 - Electric Potential & Capacitance	● Explain the relationship between electric field, electric potential energy and potential, and calculate electric potential energy and electric potential. ● Calculate the magnitude and determine the direction of the uniform electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation. ● Determine the structure of equipotential lines by constructing them due to a single point charge and more complex configurations. Calculate the electric potential and the electric potential energy of point charges in a system. ● Calculate the electric potential from continuous charge distributions, such as a charged sphere, uniform ring of charge and a uniform disc of charge, using geometry and calculus. Derive the Electric Field using calculus from the electric potential for various charge configurations. Compare and contrast the use of Gauss's Law to calculate the electric field vs. calculating the electric field from the electric potential. ● Relate the capacitance to stored charge, voltage, energy and its physical configuration. Predict what happens to a circuit when the capacitor's physical dimensions are changed. Write and apply expressions for calculating the dielectric constant as a function of the voltage, the electric field, or the capacitance. ● Derive the equations for finding equivalent capacitance for capacitors in series and in parallel. Use these equations to find the equivalent capacitance for various circuit configurations. ● Qualitatively use the concept of equipotential lines to construct equipotential lines in an electric field and determine the effect of that field on electrically charged objects and compare to gravitational field analogue. ● Apply mathematical routines to calculate the average value of the magnitude of the electric field in a region from a description of the electric potential in that region using the displacement along the line on which the difference in potential is evaluated. Demonstrate this graphically.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

4 - Currents & Circuits	• Define electric current, using water flow analogies to aid the explanation. Relate current to voltage and resistance and derive expressions for power and energy. Define EMF and relate it to the terminal voltage of a battery in a circuit. • Design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance of a circuit element and relate results to the basic properties of resistors. Understand the relationship of resistivity to resistance. • Make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel. • Derive the equations for finding equivalent resistance for resistors in series and in parallel. Use these equations to find the equivalent resistance for various circuit configurations. • Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. • Use Kirchoff's rules to determine unknown variables in a circuit and relate them to the conservation of charge and the conservation of energy. • Draw circuit diagrams for and explain how voltmeters and ammeters measure voltage and current. Calculate the value of the shunt resistor and explain how the measuring devices are configured using the shunt resistor. • Develop an understanding of the behavior of RC circuits as various switches are opened and closed in the circuit. • Using calculus, derive the equations for charging and discharging in an RC circuit and graph the charge and discharge curves for voltage and current in the circuit based on the equations.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam

5 - Magnetic Force & Field	● Understand and be able to explain the origin of magnetic fields and discuss their relationship to electric current. ● Describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet. ● Apply mathematical routines to express the force exerted on a moving charged object by a magnetic field. ● Create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires and calculate the magnetic force between the wires. ● Use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material. ● Use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current-carrying conductor. ● Plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion. ● Calculate the force and torque on a current carrying loop and derive the magnetic dipole moment. ● Describe the operation of a Mass spectrometer and describe how the electric and magnetic fields are related in separating out different masses. ● Relate the calculation of the magnetic flux to the electric flux and derive Gauss's Law for Magnetism. ● Apply the concept of the magnetic force on a moving charge to explain the Hall Effect – and determine whether positive or negative charges are moving in a circuit.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

6 - Sources of Magnetic Field	● Show how EMF is induced in a circuit loop by its own current and is called self-inductance. Understand that the effect is magnified by having multiple circuit loops, which leads to a solenoid. ● Understand the effect that inductance has on steady direct current, and direct current that is changing in magnitude. ● Expand on the concept of self-inductance and show how a changing magnetic flux in one circuit loop affects another – mutual inductance. ● Determine some practical day to day applications of mutual inductance. ● Use Kirchoff's rules and a first order differential equation to solve for the magnetic field energy stored in an LC circuit. Compare and contrast this with the energy stored in an RC circuit. ● Use Kirchoff's rules and a first order differential equation to solve for the circuit behavior of RL, LC and RLC circuits.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam
7 - Electromagnetic Induction	● Construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux created by changing current through an area defined by a current loop (i.e., a simple microphone or generator), or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area. ● Define magnetic flux and relate it to electric flux, and show how Gauss's Law is derived from it. ● 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. ● Apply Faraday's Law to calculate magnetic flux and electromotive force. ● Explain and describe a Faraday Cage. ● 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 – and how an EMF is induced in a moving conductor – which when reversed, serves as a model for a motor. ● Use Lenz's law to determine the direction of induced currents. Explain how it is another statement of the conservation of energy. ● Write all four of Maxwell's equations and be able to relate them to the source equations (Ampere's Law, Gauss's Law and Faraday's Law). Describe the extra term added by Maxwell to Ampere's Law.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

8 - Inductance	• Make claims about the force on an object due to the presence of other objects with the same property, leading to the application of Newton's Law of Universal Gravitation. Apply F=mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. • Apply g=GM/r2 to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M. Understand that this is only applicable when the objects are very close to each other. • Calculate, using calculus and vector algebra, the gravitational potential energy of objects at a significant distance from each other, from the gravitational force performing work on one of the objects. • Understand, and derive Kepler's Three Laws, and predict the orbital motion of planetary/stellar objects by applying the laws to physical phenomena. • Using Conservation of Energy to calculate the total energy and orbital velocity of objects in orbit and the escape velocity for planetary masses. Explain how objects stay in orbit due to the interplay of Newton's Law of Universal Gravitation and their tangential velocity.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam
9 – Reflection & Final Exam	• Review Course Topics as needed • Discussion board posts and Zoom meeting with instructor, as needed	• Reflection Paper • Final Exam