SAN LEANDRO UNIFIED SCHOOL DISTRICT
COURSE PROPOSAL

SECTION A. COVER PAGE

1. Course Title: AP Physics 2	7. Action ☒ New Course ☐ Course Revision ☐ Title Change Only
2. Date Submitted: 1/12/15	8. Grade Level ☐ 9 ☐ 10 ☒ 11 ☒ 12
3. Transcript Title/Abbreviation(s) AP Physics 2	9. Prerequisites (Please list.) ☒ Required: AP Physics 1 and algebra 2/trig ☐ Recommended
4. Transcript Course Code/Course Number :	10. Seeking Program Distinction? ☒ YES ☐ NO ☐ Honors ☒ AP
5. Subject Area Physics	11. Is this a CTE course? ☐ YES ☒ NO If YES, complete Section C
6. Department Science	12. Previously approved by UC? ☐ YES ☒ NO Year approved Year removed
13. UC ELIGIBILITY Already eligible? ☐ YES ☒ NO a ☐ b ☐ c ☐ d ☐ e ☐ f ☐ g ☐ Proposing eligibility? ☒ YES ☐ NO a ☐ b ☐ c ☐ d ☒ e ☐ f ☐ g ☐ Please mark one for approved eligibility or proposed eligibility.	14. Unit Value/Course Credit/Length of Course ☐ 0.5 (semester or half-year ☒ 1.0 (one year equivalent) ☐ 2.0 (two-year equivalent) ☐ Other
15. School Contact: Name:Sarah Kayler Phone:510-618-4600 ext 2341 Email: sKayler@SLUSD Position: Dept. Head	
16. Signatures: Department Chair: Principal: Reynold Richardson	DISTRICT OFFICE USE ONLY Date approved by Curriculum Committee Date approved by Board

Macintosh HD:Users:SarahKayler:Downloads:AP PHys2 .doc

SECTION B. COURSE CONTENT

17. Course Description

This is the second year of algebra based AP Physics. AP Physics 1 and Algebra II/trig are prerequisites. This is a rigorous college level course that covers electromagnetism, thermodynamics, geometric optics, and nuclear physics. This is a laboratory-based class that provides opportunities for inquiry and development of scientific practices. 25% or more of the class time is spent doing hands on lab work. It is aligned with the Next Generation Science Standards.

18. Course Goals and/or Major Student Outcomes

The course is organized around 7 big ideas:

Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure. The internal structure may determine the properties of the system.

Big Idea 2: Fields existing in space can be used to explain interactions. A field associates a value of some physical quantity with every point in space. Field models describe forces that act over a distance.

Big Idea 3: The interactions of an object with other objects can be described by forces. All forces share certain characteristics when considered by observers in inertial reference frames. Forces are described by vectors. A force one object is always due to another object.

Big Idea 4: Interactions between systems can result in changes in those systems.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Big Idea 6: Waves can transfer energy and momentum from one location to another without the transfer of mass and serve as a mathematical model for the description of other phenomena.

Big Idea 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems.

Curricular Requirements:

- Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.
- The course design provides opportunities for students to develop understanding of the foundational principles of thermodynamics in the context of the big ideas that organize the curriculum framework.
- The course design provides opportunities for students to develop understanding of the foundational principles of fluids in the context of the big ideas that organize the curriculum framework.
- The course design provides opportunities for students to develop understanding of the foundational principles of electrostatics in the context of the big ideas that organize the curriculum framework.

- The course design provides opportunities for students to develop understanding of the foundational principles of electric circuits in the context of the big ideas that organize the curriculum framework.
- The course design provides opportunities for students to develop understanding of the foundational principles of magnetism and electromagnetic induction in the context of the big ideas that organize the curriculum framework.
- The course design provides opportunities for students to develop understanding of the foundational principles of optics in the context of the big ideas that organize the curriculum framework.
- The course design provides opportunities for students to develop understanding of the foundational principles of modern physics in the context of the big ideas that organize the curriculum framework.
- Students have opportunities to apply AP Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.
- The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.
- The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.
- The laboratory work used throughout the course includes a variety of investigations that support the foundational AP Physics 2 principles.
- The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.
- The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.
- The course provides opportunities for students to develop written and oral scientific argumentation skills.

19. Course Objectives (standards)

AP physics 2 Learning objectives

BIG IDEA 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Enduring Understanding 1.A: The internal structure of a system determines many properties of the system.

1.A.1: A system is an object or a collection of objects. Objects are treated as having no internal structure.

1.A.2: Fundamental particles have no internal structure.

LO 1.A.2.1: The student is able to construct representations of the differences between a fundamental particle and a system composed of fundamental particles and to relate this to the properties and scales of the systems being investigated. [*See* SP 1.1, 7.1]

1.A.3: Nuclei have internal structures that determine their properties.

1.A.4: Atoms have internal structures that determine their properties.

LO 1.A.4.1: The student is able to construct representations of the energy-level structure of an electron in an atom and to relate this to the properties and scales of the systems being investigated. [*See* SP 1.1, 7.1]

1.A.5: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an object.

LO 1.A.5.2: The student is able to construct representations of how the properties of a system are determined by the interactions of its constituent substructures. [*See* SP 1.1, 1.4, 7.1]

Enduring Understanding 1.B: Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge.

1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.

LO 1.B.1.1: The student is able to make claims about natural phenomena based on conservation of electric charge.

LO 1.B.1.2: The student is able to make predictions, using the conversation 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.

1.B.2: There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge.

LO 1.B.2.1: The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices.

LO 1.B.2.2: The student is able to make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes.

LO 1.B.2.3: The student is able to challenge claims that polarization of electric charge or separation of charge must result in a net charge on the object.

1.B.3: The smallest observed unit or charge that can be isolated is the electron charge, also known as the elementary charge.

LO 1.B.3.1: The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated.

Enduring Understanding 1.C: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conversation principles.

1.C.1: Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with the other objects or systems.

1.C.2: Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.

1.C.3: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conversation principles.

1.C.4: In certain processes, mass can be converted to energy and energy can be converted to mass according to $E= mc^2$, the equation derived from the theory of special relativity.

LO 1.C.4.1: The student is able to articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass-energy.

Enduring Understanding 1.D: Classical mechanics cannot describe all properties of objects.

1.D.1: Objects classically thought of as particles can exhibit properties of waves.

LO 1.D.1.1: The student is able to explain why classical mechanics cannot describe all properties of objects by articulating the reasons that classical mechanics must be refined and an alternative explanation developed when classical particles display wave properties.

1.D.2: Certain phenomena classically thought of as waves can exhibit properties of particles.

1.D.3: Properties of space and time cannot always be treated as absolute.

LO 1.D.3.1: The student is able to articulate the reasons that classical mechanics must be replaced by special relativity to describe the experimental results and theoretical predictions that show that the properties of space and time are not absolute. [Students will be expected to recognize situations in which nonrelativistic classical physics breaks down and to explain how relativity addresses that breakdown, but students will not be expected to know in which of two reference frames a given series of events corresponds to a greater or lesser time interval, or a greater or lesser spatial distance; they will just need to know that observers in the two reference frames can "disagree" about some time and distance intervals.]

Enduring Understanding 1.E: Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.

1.E.1: Matter has a property called density.

LO 1.E.1.1: The student is able to predict the densities, differences in densities, or changes in densities under different conditions for natural phenomena and design an investigation to verify the prediction.

LO 1.E.1.2: The student is able to select from experimental data the information necessary to determine the density of an object and/or compare densities of several objects.

1.E.2: Matter has a property called resistivity.

LO 1.E.2.1: The student is able to choose and justify the selection of data needed to determine resistivity for a given material.

1.E.3: Matter has a property called thermal conductivity.

LO 1.E.3.1: The student is able to design an experiment and analyze data from it to examine thermal conductivity.

1.E.4: Matter has a property called electric permittivity.

1.E.5: Matter has a property called magnetic permeability.

1.E.6: Matter has a property called magnetic dipole moment.

BIG IDEA 2: Fields existing in space can be used to explain interactions.

Enduring Understanding 2.A: A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena.

2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.

2.A.2: A scalar field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a scalar. In Physics 2, this should include electric potential.

Enduring Understanding 2.B: A gravitational field is caused by an object with mass.

2.B.1: A gravitational field at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field.

Enduring Understanding 2.C: An electric field is caused by an object with electric charge.

2.C.1: The magnitude of the electric force F exerted on an object with electric charge q by an electric Field is F = q. The direction of the force is determined by the direction of the field and the sign of the charge, with positively charged objects accelerating in the direction of the field and negatively charged objects accelerating in the direction opposite the field. This should include a vector field map for positive point charges, negative point charges, spherically symmetric charge distribution, and uniformly charged parallel plates.

LO 2.C.1.1: The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using the mathematical model of the relation between an electric force and an electric field: F= qE; a vector relation.[

LO 2.C.1.2: The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities.[

2.C.2: The magnitude of the electric field vector is proportional to the net electric charge of the object(s) creating that field. This includes positive point charges, negative point charges, spherically symmetric charge distributions, and uniformly charged parallel plates.

LO 2.C.2.1: The student is able to qualitatively and semi-quantitatively apply the vector relationship between the electric field and the net electric charge creating that field.

2.C.3: The electric field outside a spherically symmetric charged object is radial and its magnitude varies as the inverse square of the radial distance from the center of that object. Electric field lines are not in the curriculum. Students will be expected to rely only on the rough intuitive sense underlying field lines, wherein the field is viewed as analogous to something emanating uniformly from a source.

LO 2.C.3.1: The student is able to explain the inverse square dependence of the electric field surrounding a spherically symmetric electrically charged object.

2.C.4: The electric field around dipoles and other systems of electrically charged objects (that can be modeled as point objects) is found by vector addition of the field of each

individual object. Electric dipoles are treated qualitatively in this course as a teaching analogy to facilitate student understanding of magnetic dipoles.

LO 2.C.4.1: The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semiquantitative 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.

LO 2.C.4.2: The student is able to 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.

2.C.5: Between two oppositely charged parallel plates with uniformly distributed electric charge, at points far from the edges of the plates, the electric field is perpendicular to the plates and is constant in both magnitude and direction.

LO 2.C.5.1: The student is able to 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.

LO 2.C.5.2: The student is able to 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.

LO 2.C.5.3: The student is able to 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.

Enduring Understanding 2.D: A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations o dipoles and never by single poles.

2.D.1: The magnetic field exerts a force on a moving electrically charged object. That magnetic force is perpendicular to the direction of velocity of the object and to the magnetic field and is proportional to the magnitude of the charge, the magnitude of the velocity and the magnitude of the magnetic field. It also depends on the angle between the velocity, and the magnetic field vectors. Treatment is quantitative for angles of 0°, 90°, or 180° and qualitative for other angles.

LO 2.D.1.1: The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field.

2.D.2: The magnetic field vectors around a straight wire that carries electric current are tangent to concentric circles centered on that wire. The field has no component toward the current-carrying wire.

LO 2.D.2.1: The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires.

2.D.3: A magnetic dipole placed in a magnetic field, such as the ones created by a magnet

or the Earth, will tend to align with the magnetic field vector.

LO 2.D.3.1: The student is able to 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.

2.D.4: Ferromagnetic materials contain magnetic domains that are themselves magnets.

LO 2.D.4.1: The student is able to use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material.

Enduring Understanding 2.E: Physicists often construct a map of isolines connecting points of equal value for some quantity related to a field and use these maps to help visualize the field.

2.E.1: Isolines on a topographic (elevation) map describe lines of approximately equal gravitational potential energy per unit mass (gravitational equipotential). As the distance between two different isolines decreases, the steepness of the surface increases. [Contour lines on topographic maps are useful teaching tools for introducing the concept of equipotential lines. Students are encouraged to use the analogy in their answers when explaining gravitational and electrical potential and potential differences.]

LO 2.E.1.1: The student is able to construct or interpret visual representations of the isolines of equal gravitational potential energy per unit mass and refer to each line as a gravitational equipotential.

2.E.2: Isolines in a region where an electric field exists represent lines of equal electric potential, referred to as equipotential lines.

LO 2.E.2.1: The student is able to determine the structure of isolines of electric potential by constructing them in a given electric field.

LO 2.E.2.2: The student is able to predict the structure of isolines of electric potential by constructing them in a given electric field and make connections between these isolines and those found in a gravitational field.

LO 2.E.2.3: The student is able to qualitatively use the concept of isolines to construct isolines of electric potential in an electric field and determine the effect of that field on electrically charged objects.

LO 2.E.3.1: The student is able to 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.

LO 2.E.3.2: The student is able to apply the concept of the isoline representation of electric potential for a given electric charge distribution to predict the average value of the electric field in the region.

BIG IDEA 3: The interactions of an object with other objects can be described by forces.

Enduring Understanding 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.

3.A.2: Forces are described by vectors.

LO 3.A.2.1: The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.

3.A.3: A force exerted on an object is always

due to the interaction of that object with another object.

LO 3.A.3.2: The student is able to challenge a claim that an object can exert a force on itself.

LO 3.A.3.3: The student is able to describe a force as an interaction between two objects and identify both objects for any force.

LO 3.A.3.4: The student is able to make claims about the force on an object due to the presence of other objects with the same property: mass, electric charge.

3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction.

LO 3.A.4.1: The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces.

LO 3.A.4.2: The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact.

LO 3.A.4.3: The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces.

Enduring Understanding 3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using F=ma.

3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.

LO 3.B.1.3: The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object.

3.B.2: Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.

LO 3.B.2.1: The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.

Enduring Understanding 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.

3.C.2: Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge.

LO 3.C.2.1: The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges (interactions between collections of electric point charges are not covered in Physics 1 and instead are restricted to Physics 2).

LO 3.C.2.3: The student is able to use mathematics to describe the electric force that results from the interaction of several separated point charges (generally 2 to 4 point charges, though more are permitted in situations of high symmetry).

3.C.4: Contact forces result from the interaction of one object touching another object and they arise from interatomic electric forces. These forces include tension, friction, normal, spring (Physics 1), and buoyant (Physics 2).

LO 3.C.4.1: The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.

LO 3.C.4.2: The student is able to explain contact forces (tension, friction, normal,

buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.

Enduring Understanding 3.G: Certain types of forces are considered fundamental.

3.G.1: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.

LO 3.G.1.2: The student is able to connect the strength of the gravitational force between two objects to the spatial scale of the situation and the masses of the objects involved and compare that strength to other types of forces.

3.G.2: Electromagnetic forces are exerted at all scales and can dominate at the human scale.

LO 3.G.2.1: The student is able to connect the strength of electromagnetic forces with the spatial scale of the situation, the magnitude of the electric charges, and the motion of the electrically charged objects involved.

3.G.3: The strong force is exerted at nuclear scales and dominates the interactions of nucleons.

LO 3.G.3.1: The student is able to identify the strong force as the force that is responsible for holding the nucleus together.

BIG IDEA 4: Interactions between systems can result in changes in those systems.

4.C.3: Energy is transferred spontaneously from a higher temperature system to a lower temperature system. The process through which energy is transferred between systems at different temperatures is called heat.

LO 4.C.3.1: The student is able to make predictions about the direction of energy transfer due to temperature differences based on interactions at the microscopic level.

4.C.4: Mass can be converted into energy and energy can be converted into mass.

LO 4.C.4.1: The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale.

Enduring Understanding 4.E: The electric and magnetic properties of a system can change presence of, or changes in, other objects or systems.

4.E.1: The magnetic properties of some materials can be affected by magnetic fields at the s focus on the underlying concepts and not the use of the vocabulary.

LO 4.E.1.1: The student is able to use representations and models to qualitatively describe the magnetic properties of some materials that can be affected by magnetic properties of other objects in the system.

4.E.2: Changing magnetic flux induces an electric field that can establish an induced emf in a system.

LO 4.E.2.1: The student is able to construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux 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.

4.E.3: The charge distribution in a system can be altered by the effects of electric forces produced by a charged object.

LO 4.E.3.1: The student is able to make predictions about the redistribution of charge during charging by friction, conduction, and induction.

LO 4.E.3.2: The student is able to make predictions about the redistribution of charge

caused by the electric field due to other systems, resulting in charged or polarized objects.

LO 4.E.3.3: The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors.

LO 4.E.3.4: The student is able to construct a representation of the distribution of fixed and mobile charge in insulators and conductors that predicts charge distribution in processes involving induction or conduction.

LO 4.E.3.5: The student is able to plan and/or analyze the results of experiments in which electric charge rearrangement occurs by electrostatic induction, or is able to refine a scientific question relating to such an experiment by identifying anomalies in a data set or procedure.

4.E.4: The resistance of a resistor, and the capacitance of a capacitor, can be understood from the basic properties of electric fields and forces, as well as the properties of materials and their geometry.

LO 4.E.4.1: The student is able to make predictions about the properties of resistors and/or capacitors when placed in a simple circuit, based on the geometry of the circuit element and supported by scientific theories and mathematical relationships.

LO 4.E.4.2: The student is able to design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors.

LO 4.E.4.3: The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors.

4.E.5: The values of currents and electric potential differences in an electric circuit are determined by the properties and arrangement of the individual circuit elements such as sources of emf, resistors, and capacitors.

LO 4.E.5.1: The student is able to 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.

LO 4.E.5.2: The student is able to make and justify a qualitative prediction of the effect of a change in values or arrangements of one or two circuit elements on currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel.

LO 4.E.5.3: The student is able to plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors.

BIG IDEA 5: Changes that occur as a result of interactions are constrained by conservation laws.

5.B.2: A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy. [Physics 1: includes mass-spring oscillators and simple pendulums. Physics 2: includes charged object in electric fields and examining changes in internal energy with changes in configuration.]

LO 5.B.2.1: The student is able to calculate the expected behavior of a system using the

object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system.

5.B.4: The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.

LO 5.B.4.1: The student is able to describe and make predictions about the internal energy of systems.

LO 5.B.4.2: The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.

5.B.5: Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system. [A piston filled with gas getting compressed or expanded is treated in Physics 2 as a part of thermodynamics.]

LO 5.B.5.4: The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy).

LO 5.B.5.5: The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance.

5.B.6: Energy can be transferred by thermal processes involving differences in temperature; the amount of energy transferred in this process of transfer is called heat.

LO 5.B.6.1: The student is able to describe the models that represent processes by which energy can be transferred between a system and its environment because of differences in temperature: conduction, convection, and radiation.

5.B.7: The first law of thermodynamics is a specific case of the law of conservation of energy involving the internal energy of a system and the possible transfer of energy through work and/or heat. Examples should include P-V diagrams — isovolumetric process, isothermal process, isobaric process, adiabatic process. No calculations of heat or internal energy from temperature change; and in this course, examples of these relationships are qualitative and/or semi-quantitative.

LO 5.B.7.1: The student is able to predict qualitative changes in the internal energy of a thermodynamic system involving transfer of energy due to heat or work done and justify those predictions in terms of conservation of energy principles.

LO 5.B.7.2: The student is able to create a plot of pressure versus volume for a thermodynamic process from given data.

LO 5.B.7.3: The student is able to use a plot of pressure versus volume for a thermodynamic process to make calculations of internal energy changes, heat, or work, based upon conservation of energy principles (i.e., the first law of thermodynamics).

5.B.8: Energy transfer occurs when photons are absorbed or emitted, for example, by atoms or nuclei.

LO 5.B.8.1: The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the

atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.

5.B.9: Kirchhoff's loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff's laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors.

LO 5.B.9.4: The student is able to analyze experimental data including an analysis of experimental uncertainty that will demonstrate the validity of Kirchhoff's loop rule.

LO 5.B.9.5: The student is able to use conservation of energy principles (Kirchhoff's loop rule) to describe and make predictions regarding electrical potential difference, charge, and current in steady-state circuits composed of various combinations of resistors and capacitors.

LO 5.B.9.6: The student is able to mathematically express the changes in electric potential energy of a loop in a multiloop electrical circuit and justify this expression using the principle of the conservation of energy.

LO 5.B.9.7: The student is able to refine and analyze a scientific question for an experiment using Kirchhoff's Loop rule for circuits that includes determination of internal resistance of the battery and analysis of a non-ohmic resistor.

LO 5.B.9.8: The student is able to translate between graphical and symbolic representations of experimental data describing relationships among power, current, and potential difference across a resistor.

5.B.10: Bernoulli's equation describes the conservation of energy in fluid flow.

LO 5.B.10.1: The student is able to use Bernoulli's equation to make calculations related to a moving fluid.

LO 5.B.10.2: The student is able to use Bernoulli's equation and/or the relationship between force and pressure to make calculations related to a moving fluid.

LO 5.B.10.3: The student is able to use Bernoulli's equation and the continuity equation to make calculations related to a moving fluid.

LO 5.B.10.4: The student is able to construct an explanation of Bernoulli's equation in terms of the conservation of energy.

5.B.11: Beyond the classical approximation, mass is actually part of the internal energy of an object or system with $E = mc^2$.

LO 5.B.11.1: The student is able to apply conservation of mass and conservation of energy concepts to a natural phenomenon and use the equation $E = mc^2$ to make a related calculation.

5.C.1: Electric charge is conserved in nuclear and elementary particle reactions, even when elementary particles are produced or destroyed. Examples should include equations representing nuclear decay.

LO 5.C.1.1: The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge.

5.C.2: The exchange of electric charges among a set of objects in a system conserves electric charge.

LO 5.C.2.1: The student is able to predict electric charges on objects within a system by application of the principle of charge conservation within a system.

LO 5.C.2.2: The student is able to design a plan to collect data on the electrical charging of objects and electric charge induction on neutral objects and qualitatively analyze that data.

LO 5.C.2.3: The student is able to justify the selection of data relevant to an investigation

of the electrical charging of objects and electric charge induction on neutral objects.

5.C.3: Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit. Examples should include circuits that combine resistors in series and parallel. [Physics 1: covers circuits with resistors in series, with at most one parallel branch, one battery only. Physics 2: includes capacitors in steady-state situations. For circuits with capacitors, situations should be limited to open circuit, just after circuit is closed, and a long time after the circuit is closed.]

LO 5.C.3.4: The student is able to predict or explain current values in series and parallel arrangements of resistors and other branching circuits using Kirchhoff's junction rule and relate the rule to the law of charge conservation.

LO 5.C.3.5: The student is able to determine missing values and direction of electric current in branches of a circuit with resistors and NO capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.

LO 5.C.3.6: The student is able to determine missing values and direction of electric current in branches of a circuit with both resistors and capacitors from values and directions of current in other branches of the circuit through appropriate selection of nodes and application of the junction rule.

LO 5.C.3.7: The student is able to determine missing values, direction of electric current, charge of capacitors at steady state, and potential differences within a circuit with resistors and capacitors from values and directions of current in other branches of the circuit.

Enduring Understanding 5.D: The linear momentum of a system is conserved.

5.D.1: In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.

LO 5.D.1.6: The student is able to make predictions of the dynamical properties of a system undergoing a collision by application of the principle of linear momentum conservation and the principle of the conservation of energy in situations in which an elastic collision may also be assumed.

LO 5.D.1.7: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values.

5.D.2: In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.

LO 5.D.2.5: The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values.

LO 5.D.2.6: The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy.

5.D.3: The velocity of the center of mass of the system cannot be changed by an interaction within the system. [Physics 1: includes no calculations of centers of mass; the equation is not provided until Physics 2. However, without doing calculations, Physics 1 students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or

two spheres of equal mass.]

LO 5.D.3.2: The student is able to make predictions about the velocity of the center of mass for interactions within a defined one-dimensional system.

LO 5.D.3.3: The student is able to make predictions about the velocity of the center of mass for interactions within a defined two-dimensional system.

Enduring Understanding 5.F: Classically, the mass of a system is conserved..

5.F.1: The continuity equation describes conservation of mass flow rate in fluids. Examples should include volume rate of flow, mass flow rate.

LO 5.F.1.1: The student is able to make calculations of quantities related to flow of a fluid, using mass conservation principles (the continuity equation).

Enduring Understanding 5.G: Nucleon number is conserved.

5.G.1: The possible nuclear reactions are constrained by the law of conservation of nucleon number.

LO 5.G.1.1: The student is able to apply conservation of nucleon number and conservation of electric charge to make predictions about nuclear reactions and decays such as fission, fusion, alpha decay, beta decay, or gamma decay.

BIG IDEA 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Enduring Understanding 6.A: A wave is a traveling disturbance that transfers energy and momentum.

6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal.

LO 6.A.1.3: The student is able to analyze data (or a visual representation) to identify patterns that indicate that a particular mechanical wave is polarized and construct an explanation of the fact that the wave must have a vibration perpendicular to the direction of energy propagation.

6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum.

LO 6.A.2.2: The student is able to contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation.

Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.

6.B.3: A simple wave can be described by an equation involving one sine or cosine function involving the wavelength, amplitude, and frequency of the wave.

LO 6.B.3.1: The student is able to construct an equation relating the wavelength and amplitude of a wave from a graphical representation of the electric or magnetic field value as a function of position at a given time instant and vice versa, or construct an equation relating the frequency or period and amplitude of a wave from a graphical representation of the electric or magnetic field value at a given position as a function of time and vice versa.

Enduring Understanding 6.C: Only waves exhibit interference and diffraction.

6.C.1: When two waves cross, they travel through each other; they do not bounce off each other. Where the waves overlap, the resulting displacement can be determined by adding the displacements of the two waves. This is called superposition.

LO 6.C.1.1: The student is able to make claims and predictions about the net disturbance that occurs when two waves overlap. Examples should include standing waves.

LO 6.C.1.2: The student is able to construct representations to graphically analyze situations in which two waves overlap over time using the principle of superposition.

6.C.2: When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed.

LO 6.C.2.1: The student is able to make claims about the diffraction pattern produced when a wave passes through a small opening, and to qualitatively apply the wave model to quantities that describe the generation of a diffraction pattern when a wave passes through an opening whose dimensions are comparable to the wavelength of the wave.

6.C.3: When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples should include monochromatic double-slit interference.

LO 6.C.3.1: The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small compared to the wavelength of the waves.

6.C.4: When waves pass by an edge, they can diffract into the "shadow region" behind the edge. Examples should include hearing around corners, but not seeing around them, and water waves bending around obstacles.

LO 6.C.4.1: The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light.

Enduring Understanding 6.E: The direction of propagation of a wave such as light may be changed when the wave encounters an interface between two media.

6.E.1: When light travels from one medium to another, some of the light is transmitted, some is reflected, and some is absorbed. (Qualitative understanding only.)

LO 6.E.1.1: The student is able to make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed.

6.E.2: When light hits a smooth reflecting surface at an angle, it reflects at the same angle on the other side of the line perpendicular to the surface (specular reflection); and this law of reflection accounts for the size and location of images seen in plane mirrors.

LO 6.E.2.1: The student is able to make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.

6.E.3: When light travels across a boundary from one transparent material to another, the speed of propagation changes. At a non-normal incident angle, the path of the light ray bends closer to the perpendicular in the optically slower substance. This is called refraction.

LO 6.E.3.1: The student is able to describe models of light traveling across a boundary from one transparent material to another when the speed of propagation changes, causing a change in the path of the light ray at the boundary of the two media.

LO 6.E.3.2: The student is able to plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell's law).

LO 6.E.3.3: The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation.

6.E.4: The reflection of light from surfaces can be used to form images.

LO 6.E.4.1: The student is able to plan data collection strategies, and perform data analysis and evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors.

LO 6.E.4.2: The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces.

6.E.5: The refraction of light as it travels from one transparent medium to another can be used to form images.

LO 6.E.5.1: The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses.

LO 6.E.5.2: The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses.

Enduring Understanding 6.F: Electromagnetic radiation can be modeled as waves or as fundamental particles.

6.F.1: Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves.

LO 6.F.1.1: The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation.

6.F.2: Electromagnetic waves can transmit energy through a medium and through a vacuum.

LO 6.F.2.1: The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present.

6.F.3: Photons are individual energy packets of electromagnetic waves, with $E_{photon} = hf$, where h is

Planck's constant and f is the frequency of the associated light wave.

LO 6.F.3.1: The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect.

6.F.4: The nature of light requires that different models of light are most appropriate at different scales.

LO 6.F.4.1: The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter.

Enduring Understanding 6.G: All matter can be modeled as waves or as particles.

6.G.1: Under certain regimes of energy or distance, matter can be modeled as a classical particle.

LO 6.G.1.1: The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate.

6.G.2: Under certain regimes of energy or distance, matter can be modeled as a wave. The behavior in these regimes is described by quantum mechanics.

LO 6.G.2.1: The student is able to articulate the evidence supporting the claim that a wave model of matter is appropriate to explain the diffraction of matter interacting with a crystal, given conditions where a particle of matter has momentum corresponding to

a de Broglie wavelength smaller than the separation between adjacent atoms in the crystal.

LO 6.G.2.2: The student is able to predict the dependence of major features of a diffraction pattern (e.g., spacing between interference maxima), based upon the particle speed and de Broglie wavelength of electrons in an electron beam interacting with a crystal. (de Broglie wavelength need not be given, so students may need to obtain it.)

BIG IDEA 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems.

Enduring Understanding 7.A: The properties of an ideal gas can be explained in terms of a small number of macroscopic variables including temperature and pressure.

7.A.1: The pressure of a system determines the force that the system exerts on the walls of its container and is a measure of the average change in the momentum or impulse of the molecules colliding with the walls of the container. The pressure also exists inside the system itself, not just at the walls of the container.

LO 7.A.1.1: The student is able to make claims about how the pressure of an ideal gas is connected to the force exerted by molecules on the walls of the container, and how changes in pressure affect the thermal equilibrium of the system.

LO 7.A.1.2: Treating a gas molecule as an object (i.e., ignoring its internal structure), the student is able to analyze qualitatively the collisions with a container wall and determine the cause of pressure, and at thermal equilibrium, to quantitatively calculate the pressure, force, or area for a thermodynamic problem given two of the variables.

7.A.2: The temperature of a system characterizes the average kinetic energy of its molecules.

LO 7.A.2.1: The student is able to qualitatively connect the average of all kinetic energies of molecules in a system to the temperature of the system.

LO 7.A.2.2: The student is able to connect the statistical distribution of microscopic kinetic energies of molecules to the macroscopic temperature of the system and to relate this to thermodynamic processes.

7.A.3: In an ideal gas, the macroscopic (average) pressure (P), temperature (T), and volume (V), are related by the equation $PV = nRT$.

LO 7.A.3.1: The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero.

LO 7.A.3.2: The student is able to design a plan for collecting data to determine the relationships between pressure, volume, and temperature, and amount of an ideal gas, and to refine a scientific question concerning a proposed incorrect relationship between the variables.

LO 7.A.3.3: The student is able to analyze graphical representations of macroscopic variables for an ideal gas to determine the relationships between these variables and to ultimately determine the ideal gas law $PV = nRT$.

Enduring Understanding 7.B: The tendency of isolated systems to move toward states with higher disorder is described by probability.

7.B.1: The approach to thermal equilibrium is a probability process.

LO 7.B.1.1: The student is able to extrapolate from pressure and temperature or volume and temperature data to make the prediction that there is a temperature at which the pressure or volume extrapolates to zero.

7.B.2: The second law of thermodynamics describes the change in entropy for reversible and irreversible processes. Only a qualitative treatment is considered in this course.

LO 7.B.2.1: The student is able to connect qualitatively the second law of thermodynamics in terms of the state function called entropy and how it (entropy) behaves in reversible and irreversible processes.

Enduring Understanding 7.C: At the quantum scale, matter is described by a wave function which leads to a probabilistic description of the microscopic world.

7.C.1: The probabilistic description of matter is modeled by a wave function, which can be assigned to an object and used to describe its motion and interactions. The absolute value of the wave function is related to the probability of finding a particle in some spatial region. (Qualitative treatment only, using graphical analysis.)

LO 7.C.1.1: The student is able to use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region.

7.C.2: The allowed states for an electron in an atom can be calculated from the wave model of an electron.

LO 7.C.2.1: The student is able to use a standing wave model in which an electron orbit circumference is an integer multiple of the de Broglie wavelength to give a qualitative explanation that accounts for the existence of specific allowed energy states of an electron in an atom.

7.C.3: The spontaneous radioactive decay of an individual nucleus is described by probability.

LO 7.C.3.1: The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay.

7.C.4: Photon emission and absorption processes are described by probability.

LO 7.C.4.1: The student is able to construct or interpret representations of transitions between atomic energy states involving the emission and absorption of photons. [For questions addressing stimulated emission, students will not be expected to recall the details of the process, such as the fact that the emitted photons have the same frequency and phase as the incident photon; but given a representation of the process, students are expected to make inferences such as figuring out from energy conservation that since the atom loses energy in the process, the emitted photons taken together must carry more energy than the incident photon.]

20. Course Outline

UNIT 1. ELECTROSTATICS [CR2c] (3 weeks)
- Electric force
- Electric field
- Electric potential

Big Ideas 1, 2, 3, 4, 5

UNIT 2. ELECTRIC CIRCUITS [CR2d] (3 weeks)
- Electric resistance
- Ohm's Law
- DC circuits with resistors only
- Kirchhoff's Laws

• Series, parallel, and series-parallel circuits
• Capacitance
• DC circuits with resistors and capacitors
Big Ideas 1, 4, 5

UNIT 3. MAGNETISM AND ELECTROMAGNETIC INDUCTION [CR2e] (3 weeks)
• Magnetic field
• Magnetic force on a charged particle
• Magnetic force on a current-carrying wire
• Magnetic flux
• Electromagnetic induction: Faraday's Law
• Lenz's Law
• Motional emf
Big Ideas 1, 2, 3, 4

UNIT 4. THERMODYNAMICS [CR2a] (4 weeks)
• Kinetic theory
• Ideal gases
• First law of thermodynamics
• Thermodynamic processes and PV diagrams
• Heat engines
• Carnot cycle
• Efficiency
• Second law of thermodynamics: entropy
Big Ideas 1, 4, 5, 7

UNIT 5. FLUIDS [CR2b] (3 weeks)
• Density
• Pressure: atmospheric and fluid pressure
• Pascal's principle
• Buoyant force
• Archimedes' principle
• Flow rate
• Continuity equation
• Bernoulli's principle
Big Ideas 1, 3, 5

UNIT 6. GEOMETRIC AND PHYSICAL OPTICS [CR2f] (3 weeks)
• Reflection
• Image formation by flat and curved mirrors
• Refraction and Snell's Law
• Image formation by thin lenses
• Interference and diffraction
• Double slit, single slit, and diffraction grating interference
• Thin film interference
Big Idea 6

UNIT 7. QUANTUM PHYSICS, ATOMIC AND NUCLEAR PHYSICS [CR2g] (4 weeks)

- Atoms, atomic mass, mass number, and isotopes
- Atomic energy levels
- Absorption and emission spectra
- Models of light: wave and particle
- Photoelectric effect
- DeBroglie wavelength
- Wave function graphs
- Mass-energy equivalence
- Radioactive decay: alpha, beta and gamma decay
- Half life
- Conservation of nucleon number: fission and fusion

Big Ideas 1, 3, 4, 5, 6, 7

21. Instructional Materials:

Required Text(s):

Title: College Physics
Publisher: Serway and Vuille
Edition/Copyright Date: 9th Edition 2012

Supplementary materials (include Title, Publisher, Edition/Copyright Date if appropriate): Verneir Lab Equipment, including dynamics carts, photo-gates, force sensors, motion sensors, ect.

22. Key Assignments

UNIT 1.
ELECTROSTATICS Lab
Students will use an electroscope, rods, cloths, pith balls, balloons, and a Van de Graph generator to study the phenomenon of charge.

UNIT 2.
ELECTRIC CIRCUITS lab
Students will assemble several simple circuits out of wires, resistors, batteries and capacitors. They will use volt meters and ammeters to measure the voltage and current throughout the circuits.

UNIT 3.
MAGNETISM AND ELECTROMAGNETIC INDUCTION lab
Students will construct simple motors. Students will use probes to measure magnetic field strength. Students will use solenoids and magnets to generate alternating current and carryout electromagnetic induction.

UNIT 4.
THERMODYNAMICS lab
Students will test the Ideal Gas law by measuring the pressure, volume and temperature changes of a gas as the sample is heated, cooled, compressed, and expanded.

UNIT 5.

FLUIDS Lab
Students will measure density and the buoyant forces on various objects submerged in water. The will devise several demonstrations of Bernoulli's principle

UNIT 6.
OPTICS Lab
Students will work with curved mirrors and lenses to determine how these objects form images. Students will measure the index of refraction of water and plastic. Students will determine the line spacing of a diffraction grating. Students will perform the classic double slit experiment.

UNIT 7.
Solar Panel Lab
Students will explore the function of photovoltaic cells.

23. Instructional Methods and/or Strategies

This course focuses on the application of mathematics in the field of physical science. It is aligned with the Next Generation Science Standards teaching cross-cutting patterns, science practices, and disciplinary core ideas. Class time consists of lecture, demonstration, lab work, and problem solving. Lab work makes up a minimum of 25% of class time. Labs are inquiry based whenever possible. Laboratory work is an integral part of physics and students are introduced to a variety of different laboratory experiences. Some labs are expected to develop a specific skill. Others are open ended; based on a given objective and an equipment list, the students are required to design their own procedure, data gathering, and analysis. Class time is used to introduce the lab; students can design the lab in their own time and then more class time is given to conduct the experiment and record data. The analyses and report generation are completed as homework. Students perform labs either to discover a fundamental concept or to apply a concept previously discussed. Most laboratory experiences are designed to encourage students to develop their own hypothesis, experiments, and conclusions. Labs also provide the opportunity to gather and analyze data, and to hone critical thinking skills. Part of the lab experience will require students to present their findings to their peers for a peer review and critique. Students must use the evidence they found in the lab to defend their conclusions. Students are evaluated by their performance on weekly problem sets, weekly lab reports, bi-weekly quizzes, unit exams, and a semester final exam.

24. Assessment Methods/Tools: Students will be assessed on problem sets, laboratory reports, quizzes, tests, projects, and final exam.

25. GRADING POLICY

Grading will follow the San Leandro Unified School District's policy. It is expected that assignments will be turned in on time. Late assignments will be accepted if students have communicated to teacher the reasons and actions taken to complete the work in a timely manner.

SECTION C

26. Context for Course (optional)

This course will add another opportunity for high school students to get a head start on college-level work, hence broaden their intellectual horizons and stand out in the college admissions process. This course will give them an opportunity to explore the natural world. This is an ideal course for students considering careers in science or engineering.