COURSE OUTLINE

NAME OF COURSE: AP PHYSICS C
LEVEL OF COURSE: ADVANCED PLACEMENT
PRE-REQUISITE: PRECALCULUS, PHYSICS H OR CP PHYSICS A
CO-REQUISITE CALCULUS
COURSE NUMBER: SCI 503
NUMBER OF CREDITS: SIX (6)
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COURSE DESCRIPTION:
This course is a calculus based college physics course designed to prepare the students to take the AP Physics C Mechanics and the AP Physics Electricity & Magnetism Exams in May. This physics course parallels a calculus-based college physics course taken by those majoring in Physics or Engineering.

COURSE OBJECTIVES:
The general objectives of this course include:

1. *Physics Knowledge* – Basic knowledge of the discipline of physics, including phenomenology, theories and techniques, concepts and generalizing principles.
2. *Problem Solving* – Ability to ask physical questions and to obtain solutions to physical questions by use qualitative and quantitative reasoning, and by experimental investigation.
3. *Student Attributes* – Fostering of important student attributes, including appreciation of the physical world and the discipline of physics, curiosity, creativity, and reasoned skepticism.
4. *Connections* – Understanding connections of physics to other disciplines and to societal issues.

ASSIGNMENTS:

1. Web Assign Homework
2. Projects
3. Teacher Generated Questions

EVALUATION:

1. Quizzes & Tests
2. Lab Report
3. Mid-Term & Final Exams

Core Curriculum Content Standards addressed in this course:

5.1 - Scientific Practices
- A. Understanding Scientific Explanations
- B. Generate Scientific Evidence Through Active Investigations
- C. Reflect on Scientific Knowledge
- D. Participate Productively in Science

5.2 – Physical Science
- C. Forms of Energy
- D. Energy Transfer
- E. Forces and Motion

PART I: MECHANICS

Unit 1 – Motion in One Dimension **Time = 2 weeks**

Objectives:

1. Students should understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line.
    a. Given a graph of one of the kinematic quantities, position, velocity or acceleration, as a function of time, they can recognize in what time intervals the other two are positive, negative, or zero, and can identify or sketch a graph of each as a function of time.
    b. Given an expression for one of the kinematic quantities, position, velocity, and acceleration, as a function of time, they can determine the other two as a function of time, and when these quantities are zero or achieve their maximum or minimum values.
2. Students should understand the special case of motion with constant acceleration so that they can:
    a. Write down expressions for velocity and position as functions of time, and identify or sketch graphs of these quantities.
    b. Use the equations to solve problems involving one-dimensional motion with constant acceleration.
3. Students should know how to deal with situations in which acceleration is a specified function of velocity and time so they can write an appropriate differential equation incorporating correctly a given initial value of v.

Unit 2 – Vectors and Motion in Two Dimensions **Time = 2 weeks**

Objectives:

1. Students should be able to calculate the component of a vector along a specified axis, or resolve a vector into components along two unspecified mutually perpendicular axes.
2. Students should be able to add vectors in order to find the net displacement of a particle that undergoes successive straight-line displacements.
3. Students should be able to subtract displacement vectors in order to find the location of one particle relative to another, or calculate the average velocity of a particle.
4. Students should be able to add or subtract velocity vectors in order to calculate the velocity change or average acceleration of a particle, or the velocity of one particle relative to another.
5. Students should understand the general motion of a particle in two dimensions so that, given $x(t)$ and $y(t)$ which describe this motion, they can determine the components, magnitude, and direction of the particle's velocity and acceleration as a function of time.
6. Students should understand the motion of projectiles in a uniform gravitational field so they can:
    a. Write down expressions for the horizontal and vertical components of velocity and position as functions of time, and sketch or identify graphs of these components.
    b. Use these expressions in analyzing the motion of a projectile that is projected above the level ground with a specified initial velocity.
7. Students should understand the uniform circular motion of a particle so they can:

a. Students should be able to relate the radius of a circle and the speed or rate of revolution of a particle undergoing uniform circular motion to the magnitude of the centripetal acceleration.
b. Students should be able to describe the direction of a particle's velocity and acceleration at any instant during uniform circular motion.
c. Students should be able to determine the components of the velocity and acceleration vectors at any instant, and sketch or identify graphs of these quantities, while undergoing uniform circular motion.

Unit 3 – Newton's Laws **Time = 2 weeks**

Objectives:

1. Students should be able to analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces.
2. Students should understand the relationship between the force that acts on a body and the resulting change in the body's velocity.
    a. Calculate, for a body moving in one direction, the velocity change that results when a constant force F acts over a specified time interval.
    b. Calculate, for a body moving in one dimension, that velocity change that results when a force $F(t)$ acts over a specified time interval.
    c. Determine, for a body moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the body.
3. Students should understand how Newton's 2nd Law, $F = ma$, applies to a body subject to forces such as gravity, the pull of strings, or contact forces so they can:
    a. Draw a well-labeled diagram showing all real forces that act on a body.
    b. Write down the vector equation that results from applying Newton's Second Law to the body, and take components of this equation along appropriate axes.
4. Students should be able to analyze situations in which a body moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that make up the net force, in situations such as the following:
    a. Motion up or down motion with constant acceleration in an elevator for example).
    b. Motion in a horizontal circle (e.g. mass on a rotating merry-go-round, or a car rounding a banked curve).
    c. Motion in a vertical circle (e.g., mass swinging on the end of a string, cart rolling down a curved track, rider on a Ferris wheel).
5. Students should understand Newton's Third Law so that, for a given force, they can identify the body on which the reaction force acts and state the magnitude and the direction of this reaction.
6. Students should know that the tension is constant in a light string that passes over a mass less pulley and should be able to use this fact in analyzing the motion of a system of two bodies joined by a string.
7. Students should be able to solve problems in which applications of Newton's Laws lead to two or three simultaneous linear equations involving unknown forces and accelerations.
8. Students should understand the significance of the coefficient of friction so they can:

   a. Write down the relationship between the normal and frictional forces on a surface.
   b. Analyze situations in which a body slides down a rough inclined plane or is pulled or pushed across a rough surface.
   c. Analyze static situations involving friction to determine under what circumstances a body will start to slip, or to calculate the magnitude of the force of static friction.
9. Students should understand the effect of fluid friction on the motion of a body so they can:
   a. Find the terminal velocity of a body moving vertically through a fluid that exerts a retarding force proportional to the velocity.
   b. Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of such a particle when it is released from rest or is projected vertically with specified initial velocity.
10. Students should be able to apply Newton's Third law in analyzing the force of contact between two bodies that accelerate together along a horizontal or a vertical line, or between two surfaces that slide across one another.

Unit 4 – Work and Energy **Time = 2 weeks**
Objectives:

1. Students should understand the definition of work so they can:
   a. Calculate the work done by a specified constant force on a body that undergoes a specified displacement.
   b. Relate the work done by a force to the area under the graph of force as a function of position, and calculate this work in the case where the force is a linear function of position.
   c. Use integration to calculate the work performed by a force $F(x)$ on a body that undergoes a specified displacement in one dimension.
   d. Use the scalar product operation to calculate the work performed by a specified constant force F on a body that undergoes a displacement in a plane.
2. Students should understand the work-energy theorem so they can:
   a. Calculate the change in kinetic energy or speed that results from performing a specified amount of work on a body.
   b. Calculate the work performed by the net force on a body that undergoes a specified change in speed or kinetic energy.
   c. Apply the work energy theorem to determine the change in a body's kinetic energy and speed, that results from the application of specified forces, or to determine the force that is required to bring a body to rest in a specified distance.
3. Students should understand the concept of a conservative force so they can:
   a. State two alternative definitions of "conservative force" and explain why these definitions are equivalent.
   b. Describe two examples of conservative forces and non-conservative forces.
4. Students should understand the concept of potential energy so they can:
   a. State the general relationship between force and potential energy, and explain why potential energy can be associated only with conservative forces.

   b. Calculate a potential energy function associated with a specified one-dimensional force *F(x)*.
   c. Given the potential energy function *U(x)* for a one-dimensional force, calculate the magnitude and direction of the force.
   d. Write an expression for the force exerted by an ideal spring and for the potential energy stored in a stretched or compressed spring.
   e. Calculate the potential energy of a single body in a uniform gravitational field.
   f. Calculate the potential energy of a system of bodies in a uniform gravitational field.
   g. State the generalized work-energy theorem and use it to relate the work done by non-conservative forces on a body to the change in kinetic and potential energy of the body.
5. Students should understand the concepts of mechanical energy and of total energy so they can:
   a. State, prove, and apply the relation between the work performed on a body by a non-conservative force and the change in a body mechanical energy.
   b. Describe and identify situations in which mechanical energy is converted to other forms of energy.
   c. Analyze situations in which a body's mechanical energy is changed by friction or by a specified externally applied force.
6. Students should understand the conservation of energy so they can:
   a. Identify situations in which mechanical energy is or is not conserved.
   b. Apply conservation of energy in analyzing the motion of bodies that are moving in a gravitational field and are subjects to constraints imposed by strings or surfaces.
   c. Apply conservation of energy in analyzing the motion of bodies that move under the influence of springs.
   d. Apply conservation of energy in analyzing the motion of bodies that move under the influence of other specified one-dimensional forces.
7. Students should be able to recognize and solve problems that call for application of both conservation of energy and Newton's Laws.
8. Students should understand the definition of power so they can:
   a. Calculate the power required to maintain the motion of a body with constant acceleration (e.g., to move a body along a level surface, to raise a body at a constant rate, or to overcome friction for a body that is moving at a constant speed).
   b. Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs as specified amount of work.
   c. Prove the relation $P = F^* v$ follows from the definition of work and apply this relation in analyzing particle motion.

Unit 5 – Impulse and Momentum **Time = 2 weeks**

Objectives:

1. Students should understand the technique for finding the center of mass so they can:
   a. Identify by inspection the center of mass of a body that has a point of symmetry.
   b. Locate the center of mass of a system consisting of two such bodies.

    c. Use integration to find the center of mass of a thin rod of non-uniform density, of a plane lamina of uniform density, or a solid of revolution of uniform density.
2. Students should be able to state, prove, and apply the relation between center-of-mass velocity and linear momentum, and between center-of-mass acceleration and net external force for a system of particles.
3. Students should understand impulse and linear momentum so they can:
    a. Relate mass, velocity, and linear momentum for a moving body, and calculate the total linear momentum of a system of bodies.
    b. Relate impulse to the change in linear momentum and the average force acting on a body.
    c. State and apply the relations between linear momentum and center-of-mass motion for a system of particles.
    d. Define impulse, and prove and apply the relation between impulse and momentum.
4. Students should understand linear momentum conservation so they can:
    a. Explain hoe linear momentum conservation follows as a sequence of Newton's Third Law for an isolated system.
    b. Identify situations in which linear momentum, or a component of linear momentum, is conserved.
    c. Apply linear momentum conservation to determine the final velocity when two bodies that are moving along the same lien, or at right angles, collide and stick together, and calculate how much kinetic energy is lost in such a situation.
    d. Analyze collisions of particles in one or dimensions to determine unknown masses or velocities, and calculate how much kinetic energy is lost in a collision.
    e. Analyze situations in which two bodies are pushed apart by a spring or other agency, and calculate how much energy is released in such a process.
5. Students should understand frames of reference so they can:
    a. Analyze the uniform motion of a particle relative to a moving medium such as a flowing stream.
    b. Transform the description of a collision or a decay process to or from a frame of reference in which the center of mass of the system is at rest.
    c. Analyze the motion of particles relative to a frame of reference that is acceleration horizontally or vertically at a uniform rate.

Unit 6 – Rotational Motion and Angular Momentum Time = 2 weeks

Objectives:

1. Students should understand the analogy between translational and rotational kinematics so they can write and apply relations among the angular acceleration, angular velocity, and angular displacement of a body that rotates about a fixed axis with constant angular acceleration.
2. Students should be able to use the right hand rule to associate an angular velocity vector with a rotating body.
3. Students should be able to state and apply the parallel axis theorem.
4. Students should understand the dynamics of fixed axis rotation so they can:

    a. Describe in detail the analogy between fixed-axis rotation and straight-line translation.
    b. Determine the angular acceleration with which a rigid body is accelerated about a fixed axis when subjected to a specified external torque or force.
    c. Apply the conservation of energy to problems of fixed-axis rotation.
    d. Analyze problems involving strings and massive pulleys.
5. Students should develop a qualitative understanding of rotational inertia so they can:
    a. Determine by inspection which of a set of symmetric bodies of equal mass has the greater rotational inertia.
    b. Determine by what factor a body's rotational inertia changes if all its dimensions are increased by the same factor.
6. Students should develop skill in computing rotational inertia so they can find the rotational inertia of:
    a. A collection of point masses lying in a plane about an axis perpendicular to the plane.
    b. A thin rod of uniform density, about an arbitrary axis perpendicular to the rod.
    c. A thin cylindrical shell about its axis, or a body that may be viewed as being made up of coaxial shells.
    d. A solid sphere of uniform density about an axis through its center.
7. Students should be able to use the vector product and the right hand rule so they can:
    a. Calculate the torque of a specified force about an arbitrary origin.
    b. Calculate the angular momentum vector for a moving particle.
    c. Calculate the angular momentum vector for a rotating rigid body in simple cases where the vector lies parallel to the angular velocity vector.
8. Students should understand angular momentum conservation so they can:
    a. Recognize conditions under which the law of conservation is applicable and relate this law to one- and two- particle systems such as satellite orbits.
    b. State the relation between net external torque and angular momentum and identify situations in which angular momentum is conserved.
    c. Analyze problems in which the amount of inertia of a body is changed as it rotates freely about a fixed axis.
    d. Analyze a collision between moving particle and a rigid body that can rotate about a fixed axis or about its center of mass.
9. Students should understand the concept of torque so they can:
    a. Calculate the magnitude and sense of the torque associated with a given force.
    b. Calculate the torque on a rigid body due to gravity.
10. Students should understand the motion of a rigid body along a surface so they can:
    a. Write down, justify, and apply the relation between linear and angular velocity, or between linear or angular acceleration, for a body of circular cross-section that rolls without slipping along a fixed plane, and determine the velocity and acceleration of an arbitrary point on such a body.
    b. Apply the equations of translational and rotational motion simultaneously in analyzing rolling with slipping.
    c. Calculate the total kinetic energy of a body that is undergoing both translational and rotational motion, and apply energy conservation in analyzing such motion.

Unit 7 – Gravitation **Time = 2 weeks**

Objectives:

1. Students should know Newton's Law of Universal Gravitation so they can:
    a. Determine the force that one symmetrical mass exerts on another.
    b. Determine the strength of the gravitational field at a specified point outside of an spherically symmetrical mass.
    c. Determine the gravitational force inside and outside a uniform sphere, and calculate how the field at the surface depends on the radius and density of the sphere.
2. Students should understand the motion of a body in orbit under the influence of gravitational forces so they can for a circular orbit:
    a. Recognize that the motion does not depend on the body's mass; describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and derive expression for the velocity and period of revolution in such an orbit.
    b. Prove that Kepler's Third Law must hold for this special case.
    c. Derive and apply the relations among kinetic energy, potential energy, and total energy for such an orbit.
3. Students should understand the motion of a body in orbit under the influence of gravitational forces so they can for a general orbit:
    a. State Kepler's three laws of planetary motion and use them to describe in qualitative terms the motion of a body in an elliptical orbit.
    b. Apply conservation of angular momentum to determine the velocity and radial distance at any point in the orbit.
    c. Apply angular momentum conservation and energy conservation to relate the speeds of a body at the two extremes of an elliptical orbit.
    d. Apply energy conservation in analyzing the motion of a body that is projected straight up from a planet's surface or that is projected directly toward the planet from far above the surface.

Unit 8 – Oscillations **Time = 2 weeks**

Objectives:

1. Students should understand the kinematics of simple harmonic motion so they can:
    a. Sketch or identify a graph of displacement as a function of time, and determine form such a graph the amplitude, period, and frequency of the motion.
    b. Write down an appropriate expression for displacement of the form *Asinwt* or *Acoswt* to describe the motion.
    c. Identify points in the motion where the velocity is zero or achieves its maximum positive or negative value.
    d. Find an expression for velocity as function of time.
    e. State qualitatively the relation between acceleration and displacement.
    f. Identify points in the motion where the acceleration is zero or achieves its greatest positive or negative value.
    g. State and prove the relation between acceleration and displacement.
    h. State and apply the relation between frequency and period.

i. Recognize that a system that obeys a differential equation of the form $d^2x/dt^2 = -kx$ must execute simple harmonic motion, and determine the frequency and period of such motion.
j. State how the total energy of an oscillating system depend on the amplitude of the motion, sketch or identify a graph of kinetic or potential energy as a function of time, and identify point in the motion where this energy is all potential or all kinetic.
k. Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant.
l. Calculate the maximum displacement or velocity of a particle that moves in simple harmonic motion with specified initial position and velocity.
m. Develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force.

2. Students should be able to apply their knowledge of simple harmonic motion to the case of a mass on a spring, so they can:
    a. Derive the expression for the period of oscillation of a mass on a spring.
    b. Apply the expression for the period of oscillation of a mass on a spring.
    c. Analyze problems in which a mass hangs from a spring and oscillates vertically.
    d. Analyze problems in which a mass attached to a spring oscillates horizontally.
    e. Determine the period of oscillation for systems involving series or parallel combinations of identical spring, or spring of different lengths.
3. Students should be able to apply their knowledge of simple harmonic motion to the case of a pendulum, so they can:
    a. Derive the expression for the period of a simple pendulum.
    b. Apply the expression for the period of a simple pendulum.
    c. State what approximation must be made in deriving the period.
    d. Analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations.

PART II: ELECTRICITY AND MAGNETISM

Unit 9 – Electric Force and Electric Field **Time = 3 weeks**

Objectives:

1. Students should understand Coulomb's Law and the principle of superposition so they can determine the force that acts between specified point charges.
2. Students should understand induced charge and electrostatic shielding so they can:
    a. Describe qualitatively the process of charging by induction.
    b. Determine the direction of the force on a charged particle brought near an uncharged or grounded conductor.
    c. Explain qualitatively why there can be no electric field in a charge-free region completely surrounded by a single conductor, and recognize consequences of this result.
    d. Explain qualitatively why the electric field outside a closed conducting surface cannot depend on the precise location of charge in the space enclosed by the conductor, and identify consequences of this result.

3. Students should be able to differentiate between conducing materials and insulating materials.
4. Students should be able to understand and apply the concept that charge is conserved.
5. Students should understand the concept of electric field so they can:
    a. Define it in terms of the force on a test charge.
    b. Calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field.
    c. Calculate the net force and torque on a collection of charges in an electric field.
    d. Given a diagram on which electric field is represented by flux lines, determine the direction of the field at a given point, identify locations where the field is strong and where it is weak, and identify where positive or negative charges must be present.
    e. Analyze the motion of a particle of a specified charge and mass in a uniform electric field.
2. Students should be able to use the principle of superposition to calculate by integration:
    a. The electric field of a straight, uniformly charged wire.
    b. The electric field and potential of a thin ring of charge on the axis of the ring, or of a semicircle of charge at its center.
    c. The electric potential of a uniformly charged disk on the axis of the disk.
3. Students should know the fields of highly symmetric charge distributions so they can:
    a. Identify situations in which the direction of the electric field produced by a charge distribution can be deduced from symmetry considerations.
    b. Describe the electric field of:
        i. Parallel charged plates.
        ii. A long uniformly charged wire or a thin cylindrical shell.
        iii. A thin spherical shell.
    c. Use superposition to determine the fields of parallel charged planes, coaxial cylinders, or concentric spheres.
    d. Derive expressions for electric potential as a function of position in the above cases.
4. Students should understand the nature of electric fields in and around conductors so they can:
    a. Explain the mechanics responsible for the absence of electric field inside a conductor, and why all excess charges must reside on the surface of the conductor.
    b. Explain why a conductor must be an equi-potential, and apply this principle in analyzing what happens when conductors are connected by wires.
    c. Determine the direction of the force on a charged particle brought near an uncharged or grounded conductor.
    d. Prove that all excess charges on a conductor must reside on its surface and that the field outside the conductor must be perpendicular to its surface.
    e. Prove and apply the relationship between the surface charge density on a conductor and the electric field strength near its surface.
5. Students should understand the relationship between field and flux so they can:

a. Calculate the flux of a uniform electric field *E* through an arbitrary surface.
b. Calculate the flux of *E* through a curved surface when *E* is uniform in magnitude and perpendicular to the surface.
c. Calculate the flux of *E* through a rectangle when *E* is perpendicular to the rectangle and a function of one coordinate only.
d. State and apply the relationship between flux and lines of force.

6. Students should understand Gauss' Law so they can:
    a. State the law in integral form, and apply it qualitatively to relate flux and electric charge for a specified surface.
    b. Apply the law, along with symmetry arguments, to determine the electric field near a large uniformly charged plane, inside or outside a charged long cylinder or cylindrical shell, and inside or outside a uniformly charged sphere or spherical shell.
    c. Apply the law to determine the charge density or total charge on a surface in terms of the electric field near the surface.
    d. Graph the electric field and potential function by the calculus method of finding maxima and minima.

Unit 10 – Electric Potential and Electric Potential Energy Time = 2 weeks
Objectives:

1. Students should understand the concept of electric potential so they can:
    a. Calculate the electrical work done on a positive or negative charge that moves through a specified potential difference.
    b. Given a sketch of equipotentials for a charge configuration, determine the direction and approximate magnitude of the electric field at various positions.
    c. Apply conservation of energy to determine the speed of a charged particle that has been accelerated through a specified potential difference.
    d. Calculate the potential difference between two points in a uniform electric field, and state that is at the higher potential.
    e. Given electric field strength as a function of position along a line, use integration to determine electric potential as a function of position.
    f. State the general relationship between field and potential, and define and apply the concept of a conservative electric field.
2. Students should know the potential function for a point charge so they can:
    a. Determine the electric potential in the vicinity of one or more point charges.
    b. Calculate how much work is required to move a test charge from one location to another in the field of fixed point charges.
    c. Calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is required to move a set of charges into a new configuration.
3. Students should be able to describe and sketch the graph of the electric field and potential inside and outside a charged conducting sphere.
4. Students should know the definition of capacitance so the can relate stored charge and voltage for a capacitor.
5. Students should understand energy storage in a capacitor so they can:
    a. Relate voltage, charge, and stored energy for a capacitor.
    b. Recognize a situation in which energy stored is a capacitor is converted to other forms.

6. Students should understand the physics of the parallel-plate capacitor so they can:
    a. Describe the electric field inside the capacitor, and relate the strength of this field to the potential difference between the plates and plate separation.
    b. Relate the electric field to the density of the charge on the plates.
    c. Derive an expression for the capacitance of a parallel-plate capacitor.
    d. Determine how changes in dimension will affect the value of the capacitance.
    e. Derive and apply expressions for the energy stored in a parallel-plate capacitor and for the energy density in the field between the plates.
    f. Analyze situations in which capacitor plates are moved apart or moved closer together, or in which a conducting slab is inserted between capacitor plates, either with a battery connected between the plates or with the charge on the plates held fixed.
7. Students should understand cylindrical and spherical capacitors so they can:
    a. Describe the electric field inside each.
    b. Derive an expression for the capacitance of each.
8. Students should understand the behavior of di-elelectrics so they can:
    a. Describe how the insertion of a dielectric between the plates of a charged parallel-plate capacitor affects its capacitance and the field strength and voltage between the plates.
    b. Analyze situations in which a dielectric slab is inserted between the plates of a capacitor.

Unit 11 – Electric Circuits **Time = 2 weeks**
Objectives:

1. Students should understand the definition of electric current so they can relate the magnitude and direction of the current in a wire or ionized medium to the rate of flow of positive and negative charge.
2. Students should understand conductivity, resistivity, and resistance so they can:
    a. Relate the current and voltage for a resistor.
    b. Write the relationship between electric field strength and current density in a conductor, and describe qualitatively, in terms of the drift velocity of electrons, why such a relationship is plausible.
    c. Describe how the resistance of a resistor depends upon its length and cross-sectional area.
    d. Derive an expression for the resistance of a resistor of uniform cross-section in terms of its dimensions and the conductivity of the material from which it is constructed, and apply this result in comparing current flow in resistors of different material or different geometry.
    e. Derive expressions that relate the current, voltage, and resistance to the rate at which heat is produced when current passes through a resistor.
    f. Apply the relationships for the rate of heat production in a resistor.
3. Students should understand the behavior of series and parallel combinations of resistors so they can:
    a. Identify on a circuit diagram whether resistors are in series or in parallel.
    b. Determine the ratio of the voltages across resistors connected in series or the ratio of currents through resistors connected in parallel.

    c. Calculate the equivalent resistance of two or more resistors connected in series or parallel, or a network of resistors that can be broken down into series or parallel combinations.
    d. Calculate the voltage, current, and power dissipated for any resistor in such a network of resistors connected to a single battery.
    e. Design a simple series-parallel circuit that produces a given current and terminal voltage for one specified component, and draw a diagram for the circuit using conventional symbols.
4. Students should understand the properties of ideal and real batteries so they can:
    a. Calculate the terminal voltage of a battery of specified *emf* and internal resistance from which a known current is flowing.
    b. Calculate the rate at which a battery is supplying energy to a circuit or is being charged up by a circuit.
    c. State what external resistance draws maximum power from a battery of specified internal resistance, and apply this result to solving problems involving one or more resistors connected to a single battery.
5. Students should be able to apply Ohm's Law and Kirchoff's rules to direct-current circuits in order to:
    a. Determine a single unknown current, resistance, or voltage.
    b. Set up and solve simultaneous equations to determine two unknown currents.
6. Students should understand the properties of voltmeters and ammeters so they can:
    a. State whether the resistance of each is high or low.
    b. Identify correct methods of connecting meters into circuits for the purpose of measuring current or voltage.
    c. Assess qualitatively the effects of finite meter resistance on a circuit into which these meters are connected.
7. Students should understand the behavior of capacitors connected in series or parallel so they can:
    a. Calculate the equivalent capacitance of a series or parallel combination.
    b. Describe how stored charge is divided between two capacitors connected in parallel.
    c. Determine the ratio of voltages for two capacitors connected in series.
8. Students should understand energy storage in capacitors so they can:
    a. Relate voltage, charge, and stored energy for a capacitor.
    b. Recognize situations in which energy stored in a capacitor is converted to other forms.
9. Students should be able to calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected to a circuit consisting of a battery and resistors.
10. Students should understand the charging and discharging of a capacitor through a resistor so they can:
    a. Calculate and interpret the time constant of the circuit.
    b. Sketch or identify graphs of stored charge or voltage for the capacitor, or of current or voltage for the resistor, and indicate on the graph the significance of the time constant.
    c. Write expressions to describe the time dependence of the stored charge or voltage for the capacitor, or of the current or voltage for the resistor.

11. Students should develop skill in analyzing the behavior of circuits containing several capacitors and resistors so they can:
    a. Determine voltages and currents immediately after a switch has been closed and also after steady-state conditions have been established.
    b. Identify graphs that correctly indicate how voltages and currents vary with time.

Unit 12 – Magnetostatics **Time = 2 weeks**

Objectives:

1. Students should understand the force experienced by a charged particle in a magnetic field so they can:
    a. Calculate the magnitude and direction of the force in terms of *q, v,* and *B,* and explain why the magnetic field can do know work.
    b. Deduce the direction of a magnetic field from information about the forces experienced by charged particles moving through the field.
    c. State and apply the formula for the radius of the circular path of a charge that moves perpendicular to a uniform magnetic field, and derive this formula from Newton's Second Law and magnetic force law.
    d. Describe the most general path possible for a charged particle moving in a uniform magnetic field, and describe the motion of a particle that enters a uniform magnetic field moving with a specified initial velocity.
    e. Describe quantitatively under what conditions particle will move with constant velocity through crossed electric and magnetic fields.
2. Students should understand the force experienced by a current in a magnetic field so they can:
    a. Calculate the magnitude and direction of the force on a straight segment of a current carrying wire in a uniform magnetic field.
    b. Indicate the direction of magnetic forces on a current carrying loop of wire in a magnetic field, and determine how the loop will tend to rotate as a consequence of these forces.
    c. Calculate the magnitude and direction of the torque experienced by a rectangular loop of wire carrying a current in a magnetic field.
3. Students should understand the magnetic field produced by a long straight current-carrying wire so they can:
    a. Calculate the magnitude and direction of the field at a point in the vicinity of a current carrying wire.
    b. Use superposition to find the magnetic field produced by two current carrying wires.
    c. Calculate the force of attraction or repulsion between two long current carrying wires.
4. Students should understand the Biot-Savart Law so they can:
    a. Deduce the magnitude and direction of the contributions to the magnetic field made by short straight segments of current carrying wire.
    b. Derive and apply the expression for the magnitude of *B* on the axis of a circular loop of current.
5. Students should understand the statement and the application of Ampere's Law in integral form so they can:
    a. State the law precisely.

    b. Use Ampere's Law plus symmetry arguments and the right-hand rule, to relate magnetic field strength to current for a long straight wire, or for a hollow or solid cylinder.
6. Students develop skill in applying the superposition principle so they can determine the magnetic field produced by combinations of the configurations listed above.

Unit 13 – Electromagnetic Induction **Time = 2 weeks**
Objectives:

1. Students should understand the concept of magnetic flux so they can:
    a. Calculate the flux of a uniform magnetic field through a loop of arbitrary orientation.
    b. Use integration to calculate the flux of a non-uniform magnetic field, whose magnitude is a function of one coordinate, through a rectangular loop perpendicular to the field.
2. Students should understand Faraday's Law and Lenz's Law so they can:
    a. Recognize situations in which changing flux through a loop will cause an induced emf or current in the loop.
    b. Calculate the magnitude and direction of the induced *emf* and current in:
        i. A square loop of wire pulled at constant velocity into or out of a uniform magnetic field.
        ii. General cases of a loop of wire that is pulled into or out of a uniform magnetic field.
        iii. A loop of wire placed in a spatially uniform magnetic field whose magnitude is changing at a constant rate.
        iv. A loop of wire placed in a spatially uniform magnetic field whose magnitude is a specified function of time.
        v. A loop of wire that rotates at a constant rate about an axis perpendicular to a uniform magnetic field.
        vi. A conducting bar moving perpendicular to a uniform magnetic field.
3. Students should develop skill in analyzing the forces that act on induced currents so they can solve simple problems involving the mechanical consequences of electromagnetic induction.
4. Students should understand the concept of inductance so they can:
    a. Calculate the magnitude and sense of the *emf* in an indictor through which a specified changing current is flowing.
    b. Derive and apply the expression for the self-inductance of a long solenoid.
5. Students should develop skill in analyzing circuits containing inductors and resistors so they can write and solve the differential equations that relates current to time.
6. Students should be familiar with Maxwell's equations so they can associate each equation with its implications.

<u>Part III: Prep for AP Physics C Mechanics and Electricity & Magnetism Exams</u>

EVALUATION

a. Tests & Quizzes.	50-55%
b. Homework	20-25%
c. Lab Reports	20-25%

TEACHER RESOURCES

a. Primary Text – Fundamentals of Physics, 7th ed. – Halliday/Resnick/Walker
b. Reference - Little Book of Big Ideas (Physics) – Mooney
c. Reference – AP Advantage (Physics C) – Mooney
d. Workbook – Princeton Review (Cracking the AP Physics C Exam)
e. Lab Resource Manual - Practical Physics Labs – Goodwin
f. Lab Resource Manual – Physics with Calculators – Vernier Lab Pro

High Point Regional High School's curriculum and instruction are aligned to the State's Core Curriculum Content Standards and address the elimination of discrimination by narrowing the achievement gap, by providing equity in educational programs and by providing opportunities for students to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectionate or sexual orientation, gender, religion, disability or socioeconomic status.