Wilson Area School District
Planned Course Guide

Title of planned course: AP Physics C

Subject Area: Science

Grade Level: 11-12

Course Description: AP Physics C course is equivalent to the first semester of a typical introductory, algebra-based physics course. The course is designed to enable the student to develop the ability to reason about physical phenomena using important science process skills such as explaining causal relationships, applying and justifying the use of mathematical routines, designing experiments, analyzing data, and making conclusions across multiple topics within the course.

Time/Credit for this Course: One Full Academic Year / 1.0 Credit

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Planned Course Materials

Course Title: AP Physics C

Supplemental Books:
Guided Notes Binder
Giancoli, Douglas C.2009
Physics: Principles with Applications
Upper Saddle River: Pearson Education

Teacher Resources:
AP Prep Books
- 5 Steps to a 5
- Princeton Review
- A-Plus Physics

Curriculum Map

August:	Fundamentals
September:	Fundamentals / Kinematics
October:	Dynamics
November:	Work, Energy and Power
December:	Linear Momentum and Impulse
January:	Circular Motion and Gravitation
February:	Rotational Dynamics
March:	Simple Harmonic Motion
April:	Individual Unit Reviews
May:	Full-Course Recap / AP Exam
June:	Advanced Topics

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Fundamentals

Time Frame: 1-2 weeks

State Standards: 3.1.12.C, D; 3.2.12.A, B, C, D; 3.7.12.B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Express calculated answers within one position of the correct significant figures
- Perform order-of-magnitude estimates
- Use scientific notation in additive, multiplicative, and exponential calculations
- Solve problems requiring unit conversions and dimensional analysis
- Design experiments that minimize relative accuracy and precision errors
- Determine fundamental constants from experimental data using graphical linearization
- Recognize vectors as quantities that: rely on both direction and magnitude; combine with other velocity and acceleration vectors according to specific mathematical rules; allow the formulation of Physical Laws independent of a particular coordinate system; and can be expressed in component and unit vector forms
- Properly execute vector and scalar operations
- Solve dot products and cross products

Core Activities: Students will participate in:
- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments and engage in whole-group and small-group problem solving

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading and problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Individual and whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer or phone
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- In-class and online quizzes
- Lab reports

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Kinematics

Time Frame: 4-5 weeks

AP Physics Big Idea: The interactions of an object with other objects can be described by forces

State Standards: 3.1.12.B, C; 3.2.12.B, C, D; 3.4.10.C; 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Express the motion of an object using narrative, mathematical, and graphical representations
- Design an experimental investigation of the motion of an object
- Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations
- Make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time and velocity is equal to the change in position per unit time
- Create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system
- Model verbally or visually the properties of a system based on its substructure and to relate this to changes in the system properties over time as external variables are changed
- Determine the derivatives of position, velocity, and acceleration functions and explore what they represent

Core Activities: Students will participate in:
- Instructor-led discussions
- Projectile motion laboratory
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Dynamics

Time Frame: 4 - 6 weeks

AP Physics Big Ideas:
- Objects and Systems have properties such as mass and charge, systems may have internal structure
- Fields existing in space can be used to explain interactions
- The interactions of an object with other objects can be described by forces
- Interactions between systems can result in changes in those systems

State Standards: 3.1.12.B, D, E; 3.2.12.B, C, D; 3.4.10.C; 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration
- Design a plan for collecting data to measure gravitational mass and to measure inertial mass, and to distinguish between the two experiments
- Apply F = mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems
- Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation
- Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces
- Challenge a claim that an object can exert a force on itself
- Describe a force as an interaction between two objects and identify both objects for any force
- Construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces
- Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact
- Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces
- Predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension
- Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces
- Re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object
- Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively

- Make claims about various contact forces between objects based on the microscopic cause of those forces
- Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions
- Evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified
- Apply Newton's second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system
- Use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system

Core Activities: Students will participate in:
- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving.

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations.

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Work, Power, and Energy

Time Frame: 2-3 weeks

AP Physics Big Ideas:
- The interactions of an object with other objects can be described by forces
- Interactions between systems can result in changes in those systems
- Changes that occur as a result of interactions are constrained by conservation laws

State Standards: 3.1.12.E; 3.2.12.B, C, D; 3.4.10.B; 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Make predictions about the changes in kinetic energy of an object based on considerations of the direction of the net force on the object as the object moves
- Use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged
- Use force and velocity vectors to determine qualitatively and quantitatively the net force exerted on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged
- Apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object
- Calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy
- Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system
- Make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass
- Apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system
- Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations
- Set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy
- Translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies
- Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy

- Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system
- Apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system
- Describe and make predictions about the internal energy of systems
- Calculate changes in kinetic energy and potential energy of a system, using information from representations of that system
- Design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance
- Design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system
- Predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance
- 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)
- 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
- Determine the calculus definitions of Work, Energy, and Power

Core Activities: Students will participate in:
- Instructor-led discussions
- Work-Energy Theorem Laboratory
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Linear Momentum and Impulse

Time Frame: 3 - 4 weeks

AP Physics Big Ideas:
- Objects and systems have properties such as mass and charge. Systems may have internal structure
- The interactions of an object with other objects can be described by forces
- Interactions between systems can result in changes in those systems
- Changes that occur as a result of interactions are constrained by conservation laws

State Standards: 3.1.12.E; 3.2.12.B; 3.4.10.C; 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations
- Make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions
- Apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations
- Apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy
- Design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome
- 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
- Qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic
- Plan data collection strategies to test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically
- Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy

- Analyze data that verify conservation of momentum in collisions with and without an external friction force
- 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 there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values
- Predict the velocity of the center of mass of a system when there is no interaction outside of the system but there is an interaction within the system (i.e., the student simply recognizes that interactions within a system do not affect the center of mass motion of the system and is able to determine that there is no external force)
- Determine the calculus definition of momentum and impulse

Core Activities: Students will participate in:

- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving

Extensions:

- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:

- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:

- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:

- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:

- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Uniform Circular Motion and Gravitation

Time Frame: 2 weeks

AP Physics Big Ideas:
- Objects and Systems have properties such as mass and charge, systems may have internal structure
- Fields existing in space can be used to explain interactions
- The interactions of an object with other objects can be described by forces
- Interactions between systems can result in changes in those systems

State Standards: 3.1.12.E, 3.2.12B, C, D; 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Apply F = mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems
- Apply Newton's universal law of gravitation to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M
- Approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects
- Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation
- Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively
- Use Newton's law of gravitation to calculate the gravitational force two objects exert on each other and use that force in contexts other than orbital motion
- Discuss centripetal force and acceleration. Determine the direction of those vectors as well as tangential velocity
- Relate circular motion to orbital motion.

Core Activities: Students will participate in:
- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving.

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations.

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving.

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Rotational Kinematics and Dynamics

Time Frame: 5 weeks

AP Physics Big Ideas:
- Objects and systems have properties such as mass and charge, systems may have internal structure
- The interactions of an object with other objects can be described by forces.
- Changes that occur as a result of interactions are constrained by conservation laws

State Standards: 3.1.12.D; 3.4.10.C, 3.4.12.C; 3.7.12.A, B

Essential Content /Objectives: At the end of the unit, students will be able to:
- Use representations of the relationship between force and torque
- Compare the torques on an object caused by various forces
- Estimate the torque on an object caused by various forces in comparison to other situations
- Design an experiment and analyze data testing a question about torques in a balanced rigid system
- Calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction)
- Make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis
- Plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis
- Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum
- In an unfamiliar context or using representations beyond equations, justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object
- Plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object
- Use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively
- Describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system

- Plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data
- Describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems
- Plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems
- Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum
- Plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted
- Make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque
- Make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero
- Derive the moments of inertia for spinning objects using calculus
- Examine the calculus definitions of torque, angular momentum

Core Activities: Students will participate in:
- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Simple Harmonic Motion

Time Frame: 6 weeks

AP Physics Big Ideas:
- Objects and systems have properties such as mass and charge, systems may have internal structure.
- The interactions of an object with other objects can be described by forces
- Changes that occur as a result of interactions are constrained by conservation laws

State Standards: 3.1.12.A, D, E; 3.4.10.B, C; 3.4.12.C; 3.7.12.A

Essential Content /Objectives: At the end of the unit, students will be able to:
- Apply F =mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems
- Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation
- Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties
- Design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force
- Analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown
- Construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force
- Make claims about various contact forces between objects based on the microscopic cause of those forces
- Explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions
- 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, 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

Core Activities: Students will participate in:
- Instructor-led discussions
- Use analog and digital tools for data-collection and analysis in labs
- Run computer-based simulations of experiments
- Engage in whole-group and small-group problem solving

Extensions:
- Current events
- Actual undergraduate problems
- Independent investigations

Remediation:
- One-on-one re-teaching
- Online physics tutorials
- Supplemental reading
- Problem-solving

Instructional Methods:
- Direct instruction
- Demonstrations
- Labs
- Peer-to-peer knowledge sharing
- Whole-group problem-solving

Materials & Resources:
- Guided Notes Binder
- Calculator
- Computer
- Internet
- Lab equipment

Assessments:
- In-class Q & A
- Problem sets
- Quizzes
- Lab reports
- End-of-unit exam

Curriculum Scope & Sequence

Planned Course: AP Physics C

Unit: Review

Time Frame: 3-4 weeks

Essential Content /Objectives: At the end of the unit, students will be able to comprehensively review each of the units above.

Core Activities: Students will participate in the following:
- AP style practice problems for each individual unit
- AP Practice Exams
- AP mix and match questions
- Timed quizzes and Exams

Instructional Methods:
- Instructor-supported activities
- Direct instruction
- Demonstrations
- Peer-to-peer knowledge sharing
- Whole-group problem solving.

Materials & Resources: Varies by topic

Assessments:
- Problems sets
- Quizzes
- Exams