ADVANCED PLACEMENT
PHYSICS C

Revision 1

Course Overview

AP Physics C is a college-level, calculus-based Physics course, with a laboratory component, that addresses topics in *Newtonian Mechanics* as well as *Electricity and Magnetism*. The principal topics considered in the course include:

1. **Kinematics**
2. **Newton's Laws of Motion**
3. **Work, Energy, and Power**
4. **Systems of Particles and Linear Momentum**
5. **Circular Motion & Rotation**
6. **Oscillations and Gravitation**
7. **Electrostatics**
8. **Conductors, capacitors, and dielectrics**
9. **Electric circuits**
10. **Magnetic fields**
11. **Electromagnetism**

Periodic Exams and End-of Term Exams are administered throughout the year to monitor student progress. Data from tests are also used to enhance teaching and student learning.

Throughout the AP Physics C course heavy emphasis is placed upon guided inquiry and developing problem-solving skills. Typically, between fifteen and twenty homework problems (from the text) are assigned weekly, yielding a course total of more than 600 problems. Students write their solutions to these problems in a dedicated notebook and these solutions are reviewed by the instructor on a weekly basis. In addition, one or two problems of greater difficulty (taken from advanced texts) are typically assigned each week to further develop problem-solving skills and to illustrate the application of important physical principles to a broader range of problems than appears in the course text. Detailed solutions for these more challenging problems are provided to the students after their solutions have been submitted and graded. Multiple approaches to solving a given problem are highlighted when appropriate.

The emphasis that is placed on developing problem-solving skills is a key element of the AP Physics C course because it fosters in students an ability to apply physical principles in an innovative and systematic fashion to a broad range of problems. Students are encouraged to approach problem-solving with an open mind, a creative spirit and a willingness to try a variety of approaches. Student experiences with more complex problems allow them to evolve "personal" problem-solving paradigms which grow in sophistication throughout the course as the range and complexity of problems increases.

The AP Physics C course stresses student-centered learning and a college-level laboratory experience (discussed in greater detail later) which provide students with an ability to explore the course material from both a theoretical and an experimental perspective. Students develop an appreciation for the ways in which theory and experiment complement each other and they examine how experimental data are analyzed and results are compared with the predictions of theory.

Text: Fundamentals of Physics, 8th edition
Authors: Halliday, Resnick, Walker

COURSE OUTLINE

Measurement
- Measuring Things
- The International System of Units
- Changing Units
- Length
- Time
- Mass

Motion Along a Straight Line
- Motion
- Position and Displacement
- Average Velocity and Average Speed
- Instantaneous Velocity and Speed
- Acceleration
- Constant Acceleration; A Special Case
- Another Look at Constant Acceleration
- Free-Fall Acceleration

Vectors
- Vectors and Scalars
- Adding Vectors Geometrically
- Components of Vectors

- Unit Vectors
- Adding Vectors by Components
- Vectors and the Laws of Physics
- Multiplying Vectors

Motion in Two and Three Dimensions

- Moving in Two or Three Dimensions
- Position and Displacement
- Average Velocity and Instantaneous Velocity
- Average Acceleration and Instantaneous Acceleration
- Projectile Motion
- Projectile Motion Analyzed
- Uniform Circular Motion
- Relative Motion in One Dimension
- Relative Motion in Two Dimensions

Force and Motion – I

- What Causes an Acceleration?
- Newton's First Law
- Force
- Mass
- Newton's Second Law
- Some Particular Forces
- Newton's Third Law
- Applying Newton's Laws

Force and Motion – II

- Friction
- Properties of Friction
- The Drag Force and Terminal Speed
- Uniform Circular Motion

Kinetic Energy and Work

- Energy
- Work
- Work and Kinetic Energy
- Work Done by a Gravitational Force
- Work Done by a Spring Force
- Work Done by a General Variable Force

- Power

Potential Energy and Conservation of Energy

- Potential Energy
- Path Independence of Conservative Forces
- Determining Potential Energy Values
- Conservation of Mechanical Energy
- Reading a Potential Energy Curve
- Work Done on a System by an External Force
- Conservation of Energy

Systems of Particles

- A Special Point
- The Center of Mass
- Newton's Second Law for a System of Particles
- Linear Momentum
- The Linear Momentum of a System of Particles
- Conservation of Linear Momentum
- Systems with Varying Mass: A Rocket
- External Forces and Internal Energy Changes

Collisions

- What is a Collision?
- Impulse and Linear Momentum
- Momentum and Kinetic Energy in Collisions
- Inelastic Collisions in One Dimension
- Elastic Collisions in One Dimension
- Collisions in Two Dimensions

Rotation

- Translation and Rotation
- The Rotational Variables
- Are Angular Quantities Vectors?
- Rotation with Constant Angular Acceleration
- Relating the Linear and Angular Variables
- Kinetic Energy of Rotation
- Calculating the Rotational Inertia

- Torque
- Newton's Second Law for Rotation
- Work and Rotational Kinetic Energy

Rolling, Torque, and Angular Momentum
- Rolling
- The Kinetic Energy of Rolling
- The Forces of Rolling
- The Yo-Yo
- Torque Revisited
- Angular Momentum
- Newton's Second Law in Angular Form
- The Angular Momentum of a System of Particles
- The Angular Momentum of a Rigid Body Rotating About a Fixed Axis
- Conservation of Angular Momentum

Equilibrium and Elasticity
- Equilibrium
- The Requirements of Equilibrium
- The Center of Gravity
- Some Examples of Static Equilibrium
- Indeterminate Structures
- Elasticity

Gravitation
- The World and the Gravitational Force
- Newton's Law of Gravitation
- Gravitation and the Principle of Superposition
- Gravitation Near Earth's Surface
- Gravitation Inside Earth
- Gravitational Potential Energy
- Planets and Satellites: Kepler's Laws
- Satellites: Orbits and Energy
- Einstein and Gravitation

Oscillations
- Oscillations
- Simple Harmonic Motion
- The Force Law for Simple Harmonic Motion
- Energy in Simple Harmonic Motion
- An Angular Simple Harmonic Oscillator
- Pendulums

- Simple Harmonic Motion and Uniform Circular Motion
- Damped Simple Harmonic Motion
- Forced Oscillations and Resonance

<u>Electric Charge</u>

- Electromagnetism
- Electric Charge
- Conductors and Insulators
- Coulomb's Law
- Charge is Quantized
- Charge is Conserved

<u>Electric Fields</u>

- Charges and Forces: A Closer Look
- The Electric Field
- Electric Field Lines
- The Electric Field Due to a Point Charge
- The Electric Field Due to an Electric Dipole
- The Electric Field Due to a Line of Charge
- The Electric Field Due to a Charged Disk
- A Point Charge in an Electric Field
- A Dipole in an Electric Field

<u>Gauss' Law</u>

- A New Look at Coulomb's Law
- Flux
- Flux of an Electric Field
- Gauss' Law
- Gauss' Law and Coulomb's Law
- A Charged Isolated conductor
- Applying Gauss' Law: Cylindrical Symmetry
- Applying Gauss' Law: Planar Symmetry
- Applying Gauss' Law: Spherical Symmetry

Electric Potential

- Electric Potential Energy
- Electric Potential
- Equipotential Surfaces
- Calculating the Potential from the Field
- Potential Due to a Point Charge
- Potential Due to a Group of Point Charges
- Potential Due to an Electric Dipole
- Potential Due to a Continuous Charge Distribution
- Calculating the Field from the Potential
- Electric Potential Energy of a System of Point Charges
- Potential of a Charged Isolated Conductor

Capacitance

- The Uses of Capacitors
- Capacitance
- Calculating the Capacitance
- Capacitors in Parallel and in Series
- Energy Stored in an Electric Field
- Capacitor with a Dielectric
- Dielectrics: An Atomic View
- Dielectrics and Gauss' Law

Current and Resistance

- Moving Charges and Electric Currents
- Electric Current
- Current Density
- Resistance and Resistivity
- Ohm's Law
- A Microscopic View of Ohm's Law
- Power in Electric Circuits
- Semiconductors
- Superconductors

Circuits

- "Pumping" Charges
- Work, Energy, and Emf
- Calculating the Current in a Single-Loop Circuit
- Other Single-Loop Circuits
- Potential Differences
- Multiloop Circuits
- The Ammeter and the Voltmeter

- *RC* Circuits

Magnetic Field
- The Magnetic Field
- The Definition of B
- Crossed Fields: Discovery of the Electron
- Crossed Fields: The Hall Effect
- A Circulating Charged Particle
- Cyclotrons and Synchrotrons
- Magnetic Force on a Current-Carrying Wire
- Torque on a Current Loop
- The Magnetic Dipole Moment

Magnetic Fields Due to Currents
- Calculating the Magnetic Field Due to a Current
- Force Between Two Parallel Currents
- Ampere's Law
- Solenoids and Toroids
- A Current-Carrying Coil as a Magnetic Dipole

Induction and Inductance
- Two Symmetric Situations
- Two Experiments
- Faraday's Law of Induction
- Lenz's Law
- Induction and Energy Transfers
- Induced Electric Fields
- Inductors and Inductance
- Self-Induction
- *RL* Circuits
- Energy Stored in a Magnetic Field
- Energy Density of a Magnetic Field
- Mutual Induction

Magnetism of Matter: Maxwell's Equations

- Magnets
- Gauss' Law for Magnetic Fields
- The Magnetism of Earth
- Magnetism and Electrons
- Magnetic Materials
- Diamagnetism
- Paramagnetism
- Ferromagnetism
- Induced Magnetic Fields
- Displacement Current
- Maxwell's Equations

AP Physics C Laboratory Activities

The laboratory experience represents an integral part of the overall AP Physics C course and hands-on laboratory work comprises at least 20 percent of the total instructional time of the course. Students typically conduct a total of 20 experiments throughout the course, with 10 of these experiments addressing principles of mechanics and 10 involving electricity and magnetism. The majority of the experiments are relatively straightforward and utilize approximately one laboratory session. However, a number of the experiments are more complex in nature and require several sessions in the laboratory to complete. For these experiments the student must not only collect and analyze the appropriate data, but must also plan the manner in which the experiment will be conducted and choose the majority of the equipment that will be utilized. Such laboratory experiences dramatically broaden the student's appreciation for the creativity that is involved in a good experiment and emphasize the importance of careful planning and attention to detail.

All of the data collected for each of the approximately 20 experiments conducted during the AP Physics C course are entered into the student's laboratory notebook, which is dedicated to this course. For each experiment, the student prepares a detailed laboratory report which contains (but is not limited to) the following elements:

- Abstract
- Introduction
- Approach
- Results

- Analysis
- Conclusions

These laboratory reports are read, graded and returned to the student with appropriate comments. Students are encouraged to discuss data analysis procedures and laboratory techniques among themselves and with the instructor.

The 20 laboratory experiments (equally divided between mechanics and electricity and magnetism) that are typically conducted during the AP Physics C course are chosen from the following list:

- Using a Micrometer
- Measurement and Significant Figures
- Accuracy, Precision and Error
- Graphing Data
- Graphical Analysis of Data: The Simple Pendulum
- Histograms and the Measurement Process
- One-dimensional Kinematics
- Reaction Time
- Two-dimensional Kinematics
- Freely-falling Objects
- Work and Power in Mechanical Systems
- Projectile Motion
- The Ballistic Pendulum

- Faraday's Law
- Lenz's law
- Power in DC Circuits
- Using an Oscilloscope
- The Electroscope
- Operation of a Cathode Ray Tube
- D'Arsonval Galvanometer
- Ohm's Law
- Measuring Current and Voltage in a DC Circuit
- Measuring RC Circuits Using an Oscilloscope
- Ammeters, Voltmeters and Multimeters
- Leyden Jar

The majority of these experiments are taken directly from college laboratory manuals and the equipment is the same as that utilized in these college laboratories.