APS DISTRICT HIGH SCHOOL SCIENCE CURRICULUM FRAMEWORK

Course Title: Physics C AP **Course Number:** 44134

Department: Science **ADS Number:** 17384944

Prerequisites: Co-requisite of Calculus

Length of Course: One Year **Credit/PRI Area:** 0.5 per Sem/Elective **Grade Level(s):** 11-12

Important Notes:

COURSE DESCRIPTION:
This laboratory course is designed as a rigorous introductory college level physics course with laboratory activities. The student examines mechanics, electricity and magnetism at a level appropriate for college majors in the physical sciences and engineering. It is recommended as a second-year physics course for the student interested in the physical science and/or engineering. The student uses calculus to solve problems in mechanics and electricity and magnetism and applies inquiry to the study of matter and energy and their interaction. The student is encouraged, but is not required, to take the AP Physics-C exam at the end of the school year.

* Lab Courses: A minimum of 250 minutes per week of directed class activity for 36 weeks, 40% of which must be lab oriented, for a total of 150 clock hours (90 hours of class plus 60 hours of lab) shall be required for one (1) unit of credit, excluding passing period. [APS Procedural Directives, Section I – Instruction, Basis for offering credit]

References in parentheses following each performance standard align with the State of New Mexico Science Standards (NM) and the Albuquerque Public Schools Language Arts Standards (APS - LA).

STRATEGIES:
The "Illustrations" column in the *Program of Studies* provides exemplars of the performance standards, strategies, and best practices suggested by science teachers in the Albuquerque Public Schools (APS).

ASSESSMENTS:
Assessments may include the following: authentic and performance-based assessments, cooperative learning, teacher observations, checklists, tests and exams, formal and informal writing, small group and full class discussions, oral and multimedia presentations, projects, demonstrations, and portfolios. Assessments are based on appropriate rubrics.

SUGGESTED TEXTBOOKS AND INSTRUCTIONAL MATERIALS:

- *Fundamentals of Physics* by David Halliday, et al., (John Wiley, 2002).
- *Physics for Scientists and Engineers* by Paul Stephen Gasiorowicz, et. al., (Prentice Hall, 1996).
- *Physics for Scientists and Engineers* by Douglas Giancoli (Prentice Hall, 2002).
- *Physics for Scientists and Engineers* by Raymond Serway, et al., (Brooks/Cole, 2002).
- *Physics for Scientists and Engineers* by Paul Tipler, et al., (W.H. Freeman, 2003).
- *Physics for Scientists and Engineers* by Richard Wolfson, et al., (Addison Wesley, 1999).
- *Physics Parts I and II* by David Halliday, et al., (John Wiley, 2001).
- *Principles of Physics* by Raymond Serway, et al., (Brooks/Cole, 2002).
- *Sears and Zemansky's University Physics* by Hugh Young, et al., (Addison Wesley, 2000).
- *University Physics* by Reese
- *How to Prepare for the AP Physics C Advanced Placement Examination* by Barron's Educational Series, Inc. , (2002)

SUGGESTED TITLES/AUTHORS WEB SITES:

- www.apcentral.collegeboard.com

Approved by HSCA: ________12/04______

STRAND I: SCIENTIFIC THINKING AND PRACTICE
CONTENT STANDARD: The student understands the processes of scientific investigations and uses inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

BENCHMARKS:

A. The student uses accepted scientific methods to collect, analyze, interpret data and observations, design and conduct scientific experiments, and communicates results.
B. The student understands that scientific processes produce scientific knowledge that is continually evaluated, validated, revised, or rejected.
C. The student uses mathematical concepts, principles, and expressions to analyze data, develop models, understand patterns and relationships, evaluate findings, and draw conclusions.

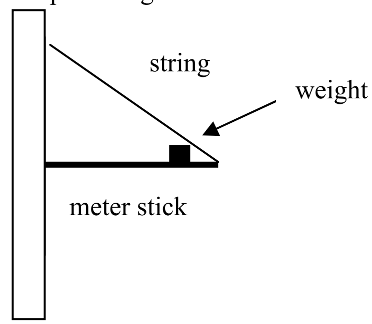
GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Designs and conducts scientific investigations that include (NM-I.I.I.2): • testable hypotheses, • controls and variables, • methods to collect, analyze, and interpret data, • results that address hypotheses being investigated, • predictions based on results, • re-evaluation of hypotheses and additional experimentation as necessary, and • error analysis. 2. Uses appropriate technologies to collect, analyze, and communicate scientific data (e.g., computers, calculators, balances, microscopes) (NM-I.I.I.3). 3. Conveys results of investigations using scientific concepts, methodologies, and expressions, including (NM-I.I.I.4): • scientific language and symbols, • diagrams, charts, and other data displays, • mathematical expressions and processes (e.g., mean, median, slope, proportionality), • clear, logical, and concise communication, and • reasoned arguments.	**NOTE: Illustrations include suggested activities for attaining each performance standard. A check (√) refers to a key feature to look for while assessing student performance**. 1-8. The student sets up Hot Wheels™ on a U-shaped track. He/She starts the car on one side of the U and measures how high it goes on the other side. The initial and final potential energies are calculated and the energy lost due to friction is estimated based on their difference. The student then turns the U shape ramp into a launch ramp by taking part of the U off so the car has a 15 – 20 degree launch angle. Using conservation of energy and the energy lost to friction, the student calculates the launch speed of the car. He/She uses kinematics equations to predict where the car lands. In addition he/she uses carbon paper to record the impact and calculates percentage error to evaluate the effectiveness of physics. The student is expected to discuss and conclude that energy conservation is appropriate to predict the final velocity of the car. ✓ Hot Wheels™ land on expected target area (correct calculations) ✓ conceptual understanding of physics ✓ correct conclusion (i.e., that energy is appropriate to predict the final velocity of the car) 1-5, 7-8. The student needs the following supplies: an 8 ft. long ramp, a 4 ft. ramp, and a one inch steel ball. The student collects data on short ramp using the steel ball and predicts the time it takes for the steel ball to go down the 8 ft. long ramp at a 30-degree incline. He/She predicts results solely on experimental results, not on the use of kinematics equations.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	4. Understands how scientific processes produce valid, reliable results, including (NM-I.I.II.1): • consistency of explanations with data and observations, • openness to peer review, • full disclosure and examination of assumptions, • testability of hypotheses, and • repeatability of experiments and reproducibility of results. 5. Uses mathematical models to describe, explain, and predict natural phenomena (NM-I.I.III.2). 6. Uses technologies to quantify relationships in scientific hypotheses (e.g., calculators, computer spreadsheets and databases, graphing software, simulations, modeling) (NM-I.I.III.3). 7. Identifies and applies measurement techniques and considers possible effects of measurement errors (NM-I.I.III.4). 8. Uses mathematics to express and establish scientific relationships (e.g., scientific notation, vectors, dimensional analysis) (NM-I.I.III.5).	The student discusses and concludes that graphical analysis and regression analysis is the most accurate way to predict the time for the long range ramp. At the end of the class, the actual time is measured using a photo-gate timer. The student uses Excel for graphing the results. ✓ correct prediction for the time to roll down the long ramp ✓ use of regression analysis for prediction ✓ graphs made in Excel ✓ applications of scientific process ✓ active participation in discussions ✓ representation of data 5, 8. The student is given this scenario. A river flows due south 3 miles an hour and you have a boat that can go 4 miles an hour in still water. If you point the boat due east and run at 4 mph relative to the river, how fast will the boat be going relative to the bank or shore? Set up a demonstration using a wind-up toy or battery-operated car (boat) and a sheet of paper (river). What angle should they point upstream to go straight across? ✓ use of sheet of paper as one reference frame and classroom as the other ✓ use of vector diagrams for calculations

STRAND II: THE CONTENT OF SCIENCE-PHYSICAL SCIENCE-MECHANICS
CONTENT STANDARD: The student understands the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy.

BENCHMARKS:
A. The student understands the transformation and transmission of energy and how energy and matter interact.
B. The student understands the motion of objects and waves and the forces that cause them.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Understands that the ability of energy to do something useful (work) tends to decrease (and never increases) as energy is converted from one form to another (NM-II.I.II.6).	1. The student sets up Hot Wheels™ on a U-shaped track. He/She starts the car on one side of the U to the other side, and calculates the potential energy at the end of the track, and based on the initial and final energy, calculates the energy lost due to friction. The student then turns the U shape ramp into a launch ramp by taking part of the U off so the car has a 15 – 20 degree launch angle using conservation of energy and the energy lost to friction and calculates the launch speed of the car. He/She uses kinematics equations to predict where the car lands In addition he/she uses carbon paper to record the impact and calculates percentage error to evaluate the effectiveness of physics. The student is expected to discuss and conclude that energy is appropriate to predict the final velocity of the car. ✓ Hot Wheels™ land on expected target area (correct calculations) ✓ conceptual understanding of physics ✓ correct conclusion (i.e., that energy is appropriate to predict the final velocity of the car)
	2. Understands the concept of equilibrium (i.e., thermal, mechanical, and chemical) (NM-II.I.II.11).	2, 5-7. In each case the student: • lists the equipment he/she needs and includes a labeled diagram, • writes a brief but concise procedure, describing any measurements he/she would make, assigning each measurement a symbol (e.g., time = t), • shows explicitly using equations how the measured quantities would be used to determine the unknown quantity, and • indicates one possible source of experimental error and discuss how it would affect his/her value for the unknown quantity he/she is ultimately measuring.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	3. Knows that there are four fundamental forces in nature: gravitation, electromagnetism, weak nuclear force, and strong nuclear force (NM-II.I.III.1).	3. The case: A meter stick is taped to the wall so that the tape acts as a hinge. A piece of string is tied to the end of the meter stick as shown and is used to hold the meter stick in a horizontal position. A 200 gram weight is placed near the end of the meter stick and the student is asked to predict the tension on the string using Newton's 2^{nd} Law of Motion and the concept of equilibrium (all forces are balanced since the meter stick does not accelerate). The actual tension on the string is measured using a spring scale and the student calculates his/her percentage error.  ✓ correct prediction for tension on the string ✓ use of Newton's 2^{nd} Law as applied to equilibrium conditions
	4. Knows that every object exerts gravitational force on every other object and how this force depends on the masses of the objects and the distance between them (NM-II.I.III.2).	4. The student describes the acceleration of 1 m from the black hole and 3 m from the black hole depending on size of the black hole after listening to a discussion on black hole formation. The student is then asked to speculate on the fate of a person standing this close to a black hole (his or her head and feet would experience a difference in acceleration of about 10^{24} m/s ^{2}). ✓ use of Newton's Universal Law of Gravity to calculate acceleration ✓ appreciation of the lethality of black holes
	5. Represents the magnitude and direction of forces by vector diagrams (NMII.I.III.6). 6. Knows that when one object exerts a force on a second object, the second object exerts a force of equal magnitude and in the opposite direction on the first object (i.e., Newton's Third Law) (NM-II.I.III.7).	5, 6. The student is given this scenario: A river flows due south 3 miles an hour and you have a boat that can go 4 miles an hour in still water. If you point the boat due east and run at 4 mph relative to the river, how fast will the boat be going relative to the bank or shore? Set up a demonstration using a wind-up toy or battery-operated car (boat) and a sheet of paper river). What angle should you point upstream to go straight across?

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	7. Applies Newton's Laws to describe and analyze the behavior of moving objects, including (NM-II.I.III.8): • displacement, velocity, and acceleration of a moving object, • Newton's Second Law, *F* = *ma* (e.g., momentum and its conservation, the motion of an object falling under gravity, the independence of a falling object's motion on mass), and • circular motion and centripetal force.	✓ use of sheet of paper as one reference frame and classroom as the other ✓ use of vector diagrams for calculations
	8. Describes relative motion using frames of reference (NM-II.I.III.9).	6-8. The student calculates the orbital velocity of two planets that orbit around each other using Newton's 2nd and 3rd Laws of Motion and his Law of Gravity. ✓ correct calculation ✓ use of centripetal acceleration in Newton's 2nd Law ✓ application of the Law of Gravity to each planet

STRAND III: THE CONTENT OF SCIENCE-PHYSICAL SCIENCE – ELECTRICITY & MAGNETISM
CONTENT STANDARD: The student understands the properties and behavior of both electric and magnetic fields and their interactions.

BENCHMARKS:
A. The student understands electrostatics and magnetostatics.
B. The student analyzes electrical circuits containing resistors and capacitors.
C. The student evaluates conductors, capacitors, and dielectrics.
D. The students understands the interaction between electric and magnetic fields (electromagnetism).

GRADE 11–12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Understands that electromagnetic waves carry energy that can only be transferred when they interact with matter (NM-II.I.II.7).	1, 6, 7. By participating in an interactive lecture and reading the text, the student examines the idea that a collapsing electric field induces a magnet field and a collapsing magnet field induces an electric field. He/She discusses the implications (e.g., the process might sustain itself). ✓ conclusion that the fields could sustain each other ✓ when given that the only speed that this can happen is 3 x 10^8 m/s (speed of light) conclusion that light is made out of electric and magnetic fields
	2. Understands the concepts of charge, field, and potential and applies these concepts to point charges and various symmetries (planar, spherical, cylindrical, Gaussian surfaces) (AP Physics C curriculum).	2. The student uses a power supply, semi-conducting paper, metallic pens, and a voltmeter to identify the electric field lines associated with various shapes (e.g., single bar, parallel bars, point charge). ✓ presence of equipotential lines that are labeled and do not cross ✓ presence of field lines perpendicular to equipotential lines
	3. Knows that materials containing equal amounts of positive and negative charges are electrically neutral, but that a small excess or deficit of negative charges produces significant electrical force (NM-II.I.III.3).	3. In a lab the student recreates the Ben Franklin experiment using rubber balloons and glass rods illustrating that like charges repel and unlike charges attract. ✓ realization that some types of charge attract and some repel ✓ sees electrostatic force in action
	4. Evaluates the effect of conductors, capacitors, and dielectrics on charge and electric field (AP Physics C curriculum). 5. Analyzes current, resistance, voltage, and power in steady-state DC circuits and time-variable RC circuits (AP Physics C curriculum). 6. Identifies and quantifies the forces on moving charges and current-carrying wires in magnetic fields (AP Physics C curriculum).	4, 5. The student uses a breadboard, power supply and several 1kΩ resistors to design a simple series circuit and a simple parallel circuit. The student calculates theoretical values for the current through each resistor using Kirchhoff's laws and uses a multimeter to take experimental measurements, and then calculates error and discusses sources of error. The student creates a simple RC circuit using a single resistor (10 kΩ to 100 kΩ) and a large capacitor (1,000μF to 10,000μF). The student calculates the resistor needed for a given capacitor so that the circuit has a

GRADE 11–12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	7. Explains how a changing electric field induces a magnetic field and how a changing magnetic field induces an electric field (electromagnetic induction, including Faraday's law and Lenz's law) (AP Physics C curriculum).	time constant of 100 seconds. The student then takes voltage measurements across the capacitor every 10 seconds, plots the data (V vs. t) on both standard axes and semi-log axes, calculates the slope (-1/RC), and uses this (along with actual resistors measurements) to determine the actual capacitance of their capacitor. ✓ circuit topology correct on breadboard ✓ correct measurement of voltage and current ✓ shape of RC charge/discharge curve on graph
	8. Applies the concept of inductance to electrical circuits (including LR and LC circuits). (AP Physics C curriculum)	8. The student uses a breadboard, power supply and several inductors to design simple LC and LR circuits. The student calculates theoretical values for the time constants for each circuit and uses a comparator and LED set to trigger at 67% of the supply voltage to show when one time constant has passed. The student times the event either with a stopwatch, or, by videotaping and counting frames (each frame is 1/30th of a second). The student calculates error and discusses source of error. The student then performs an experiment, using a known value of inductance, sets up a circuit to measure an unknown resistance and unknown capacitance. When the actual values are revealed the student performs an error analysis. ✓ circuit topology correct on breadboard ✓ correct measurement method of time constant ✓ shape of LR / LC charge/discharge curve on graph

STRAND IV: LITERACY
CONTENT STANDARD: The student communicates physics' principles through reading, writing, and speaking opportunities.

BENCHMARK: The student demonstrates proficiency in reading comprehension, specialized vocabulary, and a variety of writing and speaking requirements.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Develops and demonstrates proficiency with the following strategies to approach reading for information across content areas (APS – LA I.1): • scans reading selection to determine whether a text contains relevant information, • uses the headings and subheadings of the material to make predictions and to validate comprehension of text, • reads and rereads to decode meaning, and • reviews and summarizes essential elements of text for overview.	1, 4, 5, 6, 7, 13. The student selects and reviews a series of current science articles from an appropriate science journal or teacher-approved website and follows the steps outlined below: Step 1: • Identify the author and locate any biographical information that provides insight into who he/she is. • What perspective does the author bring to the book (e.g., university professor, expert in the field, classroom educator)? Step 2: Read the article and take notes. Step 3: Write a summary including why the article is interesting or important Step 4. Present findings to the group. ✓ completion of the steps ✓ proper use of referencing author's thoughts ✓ use of bibliographic format for each article (Based on *Questioning The Author: An Approach For Enhancing Student Engagement With Text* by I. Beck, et. al., International Reading Association, Newark, DE)
	2. Identifies and uses roots, prefixes, and suffixes to determine meaning of words (APS – LA I.4).	2. The student maintains a glossary of important vocabulary including correct spelling of word, etymology, and definition. ✓ completion of tasks
	3. Uses textual evidence to develop and support an interpretation of a scientific process or concept (APS – LA II.2). 4. Develops increased competence in using the writing process to create a final product (APS – LA III.1). 5. Develops increased competence in using elements of effective writing (APS – LA III.2).	3, 4, 5, 8, 9, 10. Working in small groups, the student is given a Nerf™ gun and a meter stick and asked to calculate its muzzle velocity by shooting it horizontally off a table. No other instructions are given. The student is expected to use textbook trajectory equations to figure out what measurements need to be taken. After the muzzle velocity is found, the student is then asked to predict the distance the projectile will go when fired from a new altitude. The accuracy of this prediction indicates mastery of the projectile equations.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	6. Supports an informed opinion (APS – LA III.6): • uses appropriate language, reasoning, and organizational structure for the audience and purpose, • provides relevant and convincing reasons, uses various types of evidence, and • demonstrates an awareness of possible questions, concerns, or counterarguments. 7. Responds to a variety of written, electronic, and other media (APS – LA III.7). 8. Develops increased competence with speaking and language conventions (APS – LA IV.3). 9. Listens to and analyzes a presentation or discussion (APS – LA V.1). 10. Conducts research and collects data from in-depth field studies (APS – LA VI.1).	The student then takes data to see how well a Nerf™ gun conforms to the projectile equations for various angles of elevation and compiles his/her findings into a brief written summary using tables or graphs. The student comments on the accuracy and reproducibility of his/her findings and defends his/her measurements to the teacher or class. Finally, using his/her report data, the student participates in Nerf™ gun shoot-outs where he/she competes against each other to hit targets at various ranges. ✓ correct prediction of projectile range ✓ clear and concise experimental report ✓ organized and convincing oral defense of report ✓ effective criticisms of weaknesses in other reports ✓ experimental data and predictions effective in shoot out
	11. Obtains and sends information electronically to support advanced research (APS – LA VI.2).	11. Using sonic data collectors (sonic rangers and calculator based laboratory interfaces from Texas Instruments™), the student creates distance, speed, and acceleration graphs of moving objects. He/She also moves in a way that reproduces sample graphs. ✓ correctly correlates graphs of motion with the motion itself ✓ reproduction of sample graphs by actually moving in front of the sonic ranger
	12. Uses a variety of technology (APS – LA VI.5). 13. Synthesizes and organizes information from a variety of sources to inform and persuade an audience (APS – LA VI.9).	12. The student needs the following supplies: an 8 ft. long ramp, a 4 ft. ramp, and a one inch steel ball. The student collects data on the short ramp using the steel ball and predicts the time it takes for the steel ball to go down the 8 ft. long ramp at a 30 degree incline. He/She predicts results solely on experimental results, not on the use of kinematics equations. The student discusses and concludes that graphical analysis and regression analysis is the most accurate way to predict the time for the long-range ramp. At the end of the class, the actual time is measured using a photo-gate timer. The student uses Excel for graphing the results. ✓ correct prediction for the time to roll down the long ramp ✓ use of regression analysis for prediction ✓ graphs made in Excel