

APS DISTRICT HIGH SCHOOL SCIENCE CURRICULUM FRAMEWORK

Course Title: Physics C AP CEC Course Number: 445C2

Department: Science ADS Number: 17384944

Prerequisites: Co-requisite of Calculus

Length of Course: One Year Credit/PRI Area: 1.0 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 formulate physical principles of electricity and magnetism to solve problems 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 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 assessment, 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).

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, and interpret data and observations and to design and conduct scientific and communicate 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.

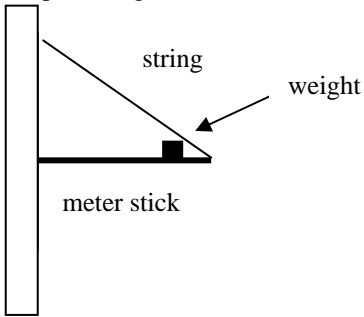
GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<ol style="list-style-type: none"> 1. Describes the essential components of an investigation, including appropriate methodologies, proper equipment, and safety precautions (NM-I.I.I.1). 2. Designs and conducts scientific investigations that include (NM-I.I.I.2): <ul style="list-style-type: none"> • 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. 3. Uses appropriate technologies to collect, analyze, and communicate scientific data (e.g., computers, calculators, balances, microscopes) (NM-I.I.I.3). 4. Conveys results of investigations using scientific concepts, methodologies, and expressions, including (NM-I.I.I.4): <ul style="list-style-type: none"> • 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. 	<p>NOTE: Illustrations include suggested activities for attaining each performance standard. A check (✓) refers to a key feature to look for while assessing student performance.</p> <ol style="list-style-type: none"> 1. The student applies centrifugal acceleration and Newton’s Second Law of Motion to the problem in soaring birds circling in thermals and calculates the lift to mass ratio. He/She discusses the implication it has in the field of low power flight. (See “The Amateur Scientist,” <i>Scientific American</i>, March 1985.) <ul style="list-style-type: none"> ✓ correct calculation of the lift to mass ratio of a bird ✓ realization that this ratio is an order of magnitude greater than that of most airplanes ✓ correct conclusion (i.e. high lift to mass ratios are desirable for low power flight) <p>1-7, 11, 13-16. 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 launch speed of the car is calculated. 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 students are expected to discuss and conclude that energy conservation is appropriate to predict the final velocity of the car.</p> <ul style="list-style-type: none"> ✓ Hot Wheels™ land on expected target area (correct calculations)

	<p>5. Understands how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atom) (NM-I.I.I.5).</p> <p>6. Understands how scientific processes produce valid, reliable results, including (NM-I.I.II.1):</p> <ul style="list-style-type: none"> • 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. <p>7. Uses scientific reasoning and valid logic to recognize (NM-I.I.II.2):</p> <ul style="list-style-type: none"> • faulty logic, • cause and effect, • the difference between observation and unsubstantiated inferences and conclusions, and • potential bias. <p>8. Understands how new data and observations can result in new scientific knowledge (NM-I.I.II.3).</p> <p>9. Critically analyzes an accepted explanation by reviewing current scientific knowledge (NM-I.I.II.4).</p> <p>10. Examines investigations of current interest in science (e.g., superconductivity, molecular machines, age of the universe) (NM-I.I.II.5).</p> <p>11. Examines the scientific processes and logic used in investigations of past events (e.g., using data from crime scenes, fossils), investigations that can be planned in advance but are only done once (e.g., expensive or time-consuming experiments such as medical clinical trials), and investigations of phenomena that can be repeated easily and frequently (NM-I.I.II.6).</p> <p>12. Creates multiple displays of data to analyze and explain the relationships in scientific investigations (NM-I.I.III.1).</p> <p>13. Uses mathematical models to describe, explain, and predict natural phenomena (NM-I.I.III.2).</p>	<ul style="list-style-type: none"> ✓ conceptual understanding of physics ✓ correct conclusion (i.e., that energy is appropriate to predict the final velocity of the car) <p>1-7, 13, 15, 16. 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 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.</p> <ul style="list-style-type: none"> ✓ 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 <p>9. The student describes the acceleration of 1 m from the black hole and 3m from the black hole depending on size of the black hole after listening to a discussion on black hole formation. 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).</p> <ul style="list-style-type: none"> ✓ use of Newton's Universal Law of Gravity to calculate acceleration ✓ appreciation of the lethality of black holes ✓ analysis ✓ effective communication <p>13, 16. 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</p>
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	<p>14. Uses technologies to quantify relationships in scientific hypotheses (e.g., calculators, computer spreadsheets and databases, graphing software, simulations, modeling) (NM-I.I.III.3).</p> <p>15. Identifies and applies measurement techniques and considers possible effects of measurement errors (NM-I.I.III.4).</p> <p>16. Uses mathematics to express and establish scientific relationships (e.g., scientific notation, vectors, dimensional analysis) (NM-I.I.III.5).</p>	<p>sheet of paper (river). What angle should they point upstream to go straight across?</p> <ul style="list-style-type: none"> ✓ use of sheet of paper as one reference frame and classroom as the other ✓ use of vector diagrams for calculations
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STRAND II: THE CONTENT OF SCIENCE-PHYSICAL SCIENCE**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
	<p>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).</p> <p>2. Understands that electromagnetic waves carry energy that can be transferred when they interact with matter (NM-II.I.II.7).</p>	<p>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 students are expected to discuss and conclude that energy is appropriate to predict the final velocity of the car.</p> <ul style="list-style-type: none">✓ 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) <p>2, 3, 7, 8, 12. 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).</p> <ul style="list-style-type: none">✓ conclusion that the fields could sustain each other✓ when given that the only speed that this can happen is 3×10^8 m/s (speed of light) conclusion that light is made out of electric and magnetic fields

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<p>3. Understands the concept of equilibrium (i.e., thermal, mechanical, and chemical) (NM-II.I.II.11).</p> <p>4. Knows that there are four fundamental forces in nature: gravitation, electromagnetism, weak nuclear force, and strong nuclear force (NM-II.I.III.1).</p> <p>5. 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).</p>	<p>3, 8-10. In each case the student:</p> <ul style="list-style-type: none"> • 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. <p>4. 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 students are asked to predict the tension on the string using Newton's 2nd 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.</p>  <p>The diagram shows a vertical wall on the left. A horizontal meter stick is attached to the wall at its left end. A string is attached to the right end of the meter stick and extends upwards and to the left, where it is attached to the wall. A weight is suspended from the string near the right end of the meter stick. Labels with arrows point to the 'string', 'weight', and 'meter stick'.</p> <ul style="list-style-type: none"> ✓ correct prediction for tension on the string ✓ use of Newton's 2nd Law as applied to equilibrium conditions <p>5. The student describes the acceleration of 1m from the black hole and 3m 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).</p>

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<p>6. Knows that materials containing equal amounts of positive and negative charges are electrically neutral, but a small excess or deficit of negative charges produces significant electrical forces (NM-II.I.III.3).</p> <p>7. Explains how electric currents cause magnetism and how changing magnetic fields produce electricity.</p> <p>8. Represents the magnitude and direction of forces by vector diagrams (NMII.I.III.6).</p> <p>9. 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).</p> <p>10. Applies Newton's Laws to describe and analyze the behavior of moving objects, including (NM-II.I.III.8):</p> <ul style="list-style-type: none"> • 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. <p>11. Describes relative motion using frames of reference (NM-II.I.III.9).</p> <p>12. Describes wave propagation using amplitude, wavelength, frequency, and speed (NM-II.I.III.10).</p>	<ul style="list-style-type: none"> ✓ use of Newton's Universal Law of Gravity to calculate acceleration ✓ appreciation of the lethality of black holes <p>5, 7. 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.</p> <ul style="list-style-type: none"> ✓ realization that some types of charge attract and some repel ✓ sees electrostatic force in action <p>6. The student calculates the gravitational force of attraction between one student and another based on their masses and separation distance and Newton's Universal Law of Gravity. A discussion is held on whether or not this force could be responsible for the physical attraction that some people feel for each other.</p> <ul style="list-style-type: none"> ✓ correct calculation of the miniscule force that results ✓ conclusion that this small force probably isn't responsible for physical attraction between humans <p>6, 9-11. 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.</p> <ul style="list-style-type: none"> ✓ correct calculation ✓ use of centripetal acceleration in Newton's 2nd Law ✓ application of the Law of Gravity to each planet <p>9,12. 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?</p> <ul style="list-style-type: none"> ✓ use of sheet of paper as one reference frame and classroom as the other ✓ use of vector diagrams for calculations

STRAND III: THE CONTENT OF SCIENCE-EARTH AND SPACE

CONTENT STANDARD: The student understands the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

BENCHMARKS:

- A. The student examines the scientific theories of the origin, structure, contents, and evolution of the solar system and the universe, and their interconnections.
 B. The student examines the scientific theories of the origin, structure, energy, and evolution of Earth and its atmosphere and their interconnections.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<ol style="list-style-type: none"> Predicts changes in the positions and appearances of objects in the sky (e.g., moon, sun) based on knowledge of current positions and patterns of movements (e.g., lunar cycles, seasons) (NM-II.III.I.2). Explains plate tectonic theory and understands the evidence that supports it (NM-II.III.II.5). Describes how stars are powered by nuclear fusion, how luminosity and temperature indicate their age, and how stellar processes create heavier and stable elements that are found throughout the universe (NM-II.III.I.6). 	<ol style="list-style-type: none"> Using Kepler's Third Law of Planetary Motion, the student calculates the altitude of a satellite orbiting the Earth based on its orbital period (this time may be estimated with a stop watch if the satellite can be observed moving through the sky). The lunar cycle and orbital radius may be used in the ratio form of Kepler's Third Law or to find the constant of proportionality in the equation form of Kepler's Third Law. <ul style="list-style-type: none"> ✓ correct prediction of satellite orbit ✓ correct use of either form of Kepler's Third Law The student discusses magnetic pole shifting by earth's magnetic field resulting from the circulation of electric charges under the earth's crust and describes sea floor spreading and the evidence that the magnetic field has shifted in the past. The student is given information about these shifts including the fact that they may be associated with mass extinctions. He/She discusses implication on society. <ul style="list-style-type: none"> ✓ correctly associates moving charge with magnetic field ✓ describes how sea floor spreading can record Earth's magnetic field ✓ describes Earth's magnetic field role as a shield against solar wind The student describes the acceleration of 1m from the black hole and 3m from the black hole, depending on size of the black hole, after listening to a discussion on black hole formation. <ul style="list-style-type: none"> ✓ description of the competing processes of gravity driving nuclear fusion and fusion expanding outward from stellar cores ✓ indication of black hole formation occurs when the fusion process stops and gravity wins ✓ description of black hole formation as resulting from the compact size of a collapsed star and not an increase in mass

STRAND IV: SCIENCE AND SOCIETY**CONTENT STANDARD:** The student understands how scientific discoveries, inventions, practices, and knowledge influence and are influenced by individuals and societies.**BENCHMARK:** The student examines and analyze how scientific discoveries and their applications affect the world and explains how societies influence scientific investigations and applications.

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<ol style="list-style-type: none"> <li data-bbox="268 467 1129 581">1. Knows how science enables technology but also constrains it, and recognizes the difference between real technology and science fiction (e.g., rockets vs. antigravity machines, nuclear reactors vs. perpetual-motion machines, medical X-rays vs. Star-Trek tricorders) (NM-III.I.1). <li data-bbox="268 800 1129 881">2. Understands how advances in technology enable further advances in science (e.g., microscopes and cellular structure, telescopes and understanding of the universe) (NM-III.I.2). <li data-bbox="268 1133 1129 1279">3. Evaluates the influences of technology on society (e.g., communications, petroleum, transportation, nuclear energy, computers, medicine, genetic engineering) including both desired and undesired effects, and including some historical examples (e.g., the wheel, the plow, the printing press, the lightning rod) (NM-III.I.3). 	<ol style="list-style-type: none"> <li data-bbox="1157 467 1976 768">1. In a group project the student receives assorted motors, gears, switches, and structural materials and builds a robot to perform a specific activity (e.g., robot basketball, pull the limbs off other robots, robot soccer). At the end, robots are evaluated in head to head competition to see which groups were successful in applications. Response questions: What is possible with electric motors and what is not? What are the practical applications of lever arms and pulleys? <ul style="list-style-type: none"> ✓ robot control system works ✓ robot is mobile and can manipulate its surroundings ✓ robot can perform indicated task <li data-bbox="1157 800 1976 1101">2. The student applies centrifugal acceleration and Newton’s Second Law of Motion to the problem of soaring birds circling in thermals and calculates the lift to mass ratio. He/She discusses the implication it has in the field of low power flight. (See “The Amateur Scientist,” <i>Scientific American</i>, March 1985) <ul style="list-style-type: none"> ✓ correct calculation of the lift to mass ratio of a bird ✓ realization that this ratio is an order of magnitude greater than that of most airplanes ✓ correct conclusion (i.e. high lift to mass ratios are desirable for low power flight) <li data-bbox="1157 1133 1976 1404">3. The student receives a mass on a spring and vibrates the spring at various frequencies to find its resonance frequency. In a discussion the student presents implications of Tacoma Narrows Bridge and Mexico City earthquake where some buildings of a certain length fell down. <ul style="list-style-type: none"> ✓ associates resonance with a particular frequency for a particular object ✓ explains the selective destruction in Mexico City in terms of resonance ✓ discusses damping as a form of earthquake and bridge safety

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<p>4. Understands the scientific foundations of common technologies (e.g., kitchen appliances, radio, television, aircraft, rockets, computers, medical X-rays, selective breeding, fertilizers and pesticides, agricultural equipment) (NM-III.I.4).</p> <p>5. Describes how scientific knowledge helps decision makers with local, national, and global challenges [e.g., Waste Isolation Pilot Project (WIPP), mining, drought, population growth, alternative energy, climate change] (NM-III.I.9).</p>	<p>3, 6, 8. The student discusses magnetic pole shifting by earth's magnetic field resulting from the circulation of electric charges under the earth's crust and describes sea floor spreading and the evidence that the magnetic field has shifted in the past. Given that the shift may be associated with mass extinctions, he/she discusses the implications on society.</p> <ul style="list-style-type: none"> ✓ correctly associates moving charge with magnetic field ✓ describes how sea floor spreading can record Earth's magnetic field ✓ describes Earth's magnetic field role as a shield against solar wind <p>4. 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 up stream to go straight across?</p> <ul style="list-style-type: none"> ✓ use of sheet of paper as one reference frame and classroom as the other ✓ use of vector diagrams for calculations <p>5. 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, 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 kinematic 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.</p> <ul style="list-style-type: none"> ✓ 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)

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<p>6. Describes major historical changes in scientific perspectives (e.g., atomic theory, germs, cosmology, relativity, plate tectonics, evolution) and the experimental observations that triggered them (NM-III.I.I.10).</p> <p>7. Knows that societal factors can promote or constrain scientific discovery (e.g., government funding, laws and regulations about human cloning and genetically modified organisms, gender and ethnic bias, AIDS research, alternative-energy research) (NM-III.I.I.11).</p> <p>8. Identifies how science has produced knowledge that is relevant (NM-III.I.I.9).</p> <p>9. Understands that scientists have characteristics in common with other individuals (e.g., employment and career needs, curiosity, desire to perform public service, greed, preconceptions and biases, temptation to be unethical, core values including honesty and openness) (NM-III.I.I.18).</p> <p>10. Knows that science plays a role in many different kinds of careers and activities (e.g., public service, volunteers, public office holders, researchers, teachers, doctors, nurses, technicians, farmers, ranchers) (NM-III.I.I.19).</p>	<p>6. The student participates in a brainstorming lab to practice coming up with ideas and not being critical of others. With three pieces of paper and two meters of string, tape and plastic straw, the student brainstorms ideas to building the tallest freestanding structure possible. After the session the student picks the best idea and builds it.</p> <ul style="list-style-type: none"> ✓ discussion on this activity in reference to orbital towers, orbital tethers, and space elevators ✓ comments on the problems in constructing a 36,000 km tower and the advantages of orbital tethers <p>7. Using work and conservation of energy, the student compares braking distance with initial speed and driver reaction time and discusses the implications of defensive driving and DUI or DWI. He/She calculates the initial speed of a laboratory car based on the distance it skids to a stop and discusses the implications of skid mark calculation for vehicle accident investigation.</p> <ul style="list-style-type: none"> ✓ correct calculation of braking distance vs. initial speed ✓ conclusion that twice the speed takes four times as far to stop ✓ conclusion that skid mark tests are not very accurate <p>8. The student listens to an interactive narrative about Tycho Brahe and Johann Kepler, their discoveries and personal interactions, and roles in the development in the theory of gravity.</p> <ul style="list-style-type: none"> ✓ relates incidents in Tycho's colorful life ✓ knows what Tycho's nose was made out of and how he lost the original one ✓ knows that Kepler was a son of a witch (she was tried and convicted for witchcraft) ✓ appreciates the uneasy relationship between Tycho and Kepler <p>9. The student applies centrifugal acceleration and Newton's Second Law of Motion to the problem of soaring birds circling in thermals and calculates the lift to mass ratio. He/She discusses the implication it has in the field of low power flight. Burt Rutan who went on to found Areoenvironment Aviation did this calculation. (See "The Amateur Scientist," <i>Scientific American</i>, March 1985.)</p> <ul style="list-style-type: none"> ✓ correct calculation of the lift to mass ratio of a bird ✓ realization that this ratio is an order of magnitude greater than that of most airplanes ✓ correct conclusion (i.e. high lift to mass ratios are desirable for low power flight)

STRAND V: 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
	<p>1. Develops and demonstrates proficiency with the following strategies to approach reading for information across content areas: (APS – LA I.1):</p> <ul style="list-style-type: none"> • 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. <p>2. Identifies and uses roots, prefixes, and suffixes to determine meaning of words (APS – LA I.4).</p> <p>3. Uses textual evidence to develop and support an interpretation of a scientific process or concept (APS – LA II.2).</p> <p>4. Develops increased competence in using the writing process to create a final product (APS – LA III.1).</p> <p>5. Develops increased competence in using elements of effective writing (APS – LA III.2).</p>	<p>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:</p> <p>Step 1:</p> <ul style="list-style-type: none"> • 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)? <p>Step 2: Read the article and take notes.</p> <p>Step 3: Write a summary including why the article is interesting or important</p> <p>Step 4: Present findings to the group.</p> <ul style="list-style-type: none"> ✓ completion of the steps ✓ proper use of referencing author’s thoughts ✓ use of bibliographic format for each article <p>(Based on <i>Questioning The Author: An Approach For Enhancing Student Engagement With Text</i> by I. Beck, et. al., International Reading Association, Newark, DE)</p> <p>2. The student maintains a glossary of important vocabulary including correct spelling of word, etymology, and definition.</p> <ul style="list-style-type: none"> ✓ completion of tasks <p>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 will indicate mastery of the projectile equations.</p>

GRADE 11-12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	<p>6. Supports an informed opinion: (APS – LA III.6):</p> <ul style="list-style-type: none"> • 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. <p>7. Responds to a variety of written, electronic, and other media (APS – LA III.7).</p> <p>8. Develops increased competence with speaking and language conventions (APS – LA IV.3).</p> <p>9. Listens to and analyzes a presentation or discussion (APS – LA V.1).</p> <p>10. Conducts research and collects data from in-depth field studies (APS – LA VI.1).</p> <p>11. Obtains and sends information electronically to support advanced research (APS – LA VI.2).</p> <p>12. Uses a variety of technology (APS – LA VI.5).</p> <p>13. Synthesizes and organizes information from a variety of sources to inform and persuade an audience (APS – LA VI.9).</p>	<p>The student is then asked to take data and see how well a Nerf™ gun conforms to the projectile equations for various angles of elevation and to compile his/her findings into a brief written summary using tables or graphs. The student is asked to comment on the accuracy and reproducibility of his/her findings and defend his/her measurements to the teacher or class. Finally, using his/her report data the students participate in Nerf™ gun shoot-outs where he/she compete against each other to hit targets at various ranges.</p> <ul style="list-style-type: none"> ✓ 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 <p>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 is also asked to move in a way that will reproduce sample graphs.</p> <ul style="list-style-type: none"> ✓ correctly correlates graphs of motion with the motion itself ✓ reproduction of sample graphs by actually moving in front of the sonic ranger <p>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 a 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 kinematic 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</p> <ul style="list-style-type: none"> ✓ correct prediction for the time to roll down the long ramp ✓ use of regression analysis for prediction ✓ graphs made in Excel