

Curriculum: AP Physics B

Curricular Unit: Optics

Instructional Unit: A. Analyze how light interacts with lenses, mirrors and slits

- **Analyze how images are formed with mirrors and lenses**
- Analyze destructive and constructive interference with slits

Standard Alignments (Section 2)

SCCLE: N/A Knowledge: (SC) 1,7 CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9 NETS: 1c,d; 2d; 4c Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

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| <ul style="list-style-type: none">• Apply the principles of interference to coherent sources oscillating in phase in order to:<ul style="list-style-type: none">• describe the conditions under which the waves reaching an observation point from two or more sources will all interfere constructively, or under which the waves from two sources will interfere destructively• determine locations of interference maxima or minima for two sources or determine the frequencies or wavelengths that can lead to constructive or destructive interference at a certain point• relate the amplitude and intensity produced by two or more sources that interfere constructively to the amplitude and intensity produced by a single source• Apply the principles of interference and diffraction to waves that pass through a single or double slit or through a diffraction grating so they can:<ul style="list-style-type: none">• sketch or identify the intensity pattern that results when monochromatic waves pass through a single slit and fall on a distant screen, and describe how this pattern will change if the slit width or the wavelength of the waves is changed• calculate, for a single-slit pattern, the angles or the positions on a distant screen where the intensity is zero• sketch or identify the intensity pattern that results when monochromatic waves pass through a double-slit, and identify which features of the pattern result from single-slit diffraction and which from two slit interference• Apply the principles of interference to light reflected by thin films so they can:<ul style="list-style-type: none">• state under what conditions a phase reversal occurs when light is reflected from the interface between two media of different indices of refraction• determine whether rays of monochromatic light reflected from two such interfaces would interfere constructively or destructively, and thereby account for Newton's rings and similar phenomena, and explain how glass may be coated to minimize the reflection of visible light |
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Board Approved 8-3-15

- Apply the principles of reflection and refraction to:
 - determine how the speed and wavelength of light change when light passes from one medium into another
 - show on a diagram the directions of reflected and refracted rays
 - use Snell's Law to relate the directions of the incident ray and the refracted ray, and the indices of refraction of the media
 - identify conditions under which total internal reflection will occur
- Apply image formation by plane or spherical mirrors to:
 - relate the focal point of a spherical mirror to its center of curvature
 - given a diagram of a mirror with the focal point shown, locate by ray tracing the image of a real object and determine whether the image is real or virtual, upright or inverted, enlarged or reduced in size
- Apply image formation by converging or diverging lenses to:
 - determine whether the focal length of a lens is increased or decreased as a result of a change in the curvature of its surface or in the index of refraction of the material of which the lens is made or the medium in which it is immersed
 - determine by ray tracing the location of the image of a real object located inside or outside the focal point of the lens, and state whether the resulting image is upright or inverted, real or virtual
 - use the thin lens equation to relate to object distance, image distance and focal length for a lens, and determine the image size in terms of the object size
 - analyze simple situations in which the image formed by one lens serves as the object for another lens

Instructional Strategies:

- Students will:
 - complete worksheets which will require them to:
 - apply Snell's Law
 - determine focal points of mirrors and lenses
 - sketch light ray diagrams which show how images are formed with mirrors and lenses
 - analyze constructive and destructive interference with slits and thin films
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative – students will:
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- A beam of light from a light source on the bottom of a swimming pool 3.0 meters deep strikes the surface of the water 2.0 meters to the left of the light source, as shown above. The index of refraction of the water in the pool is 1.33.
 - (a) What angle does the reflected ray make with the normal to the surface?
 - (b) What angle does the emerging ray make with the normal to the surface?
 - (c) What is the minimum depth of water for which the light that strikes the surface of the water 2.0 meters to the left of the light source will be refracted into the air?
- A thin double convex lens of focal length $f_l = +15$ centimeters is located at the origin of the x-axis, as shown above. An object of height 8 centimeters is placed 45 centimeters to the left of the lens. Calculate (do not measure) each of the following.
 - i. The position of the image formed by the lens
 - ii. The size of the image formed by the lens

Instructional Resources/Tools:

- iPad
- Class website
- LabQuest2
- Traditional physics lab equipment

Cross Curricular Connections:

- ELA: Reading is emphasized with written lab instructions and word problems
- Math:
 - Algebra II
 - Trigonometry

Depth of Knowledge (Section 5)

DOK: 3

Curriculum: AP Physics B

Curricular Unit: Atomic and Nuclear Physics

Instructional Unit: B. Analyze the physics of matter at an atomic scale

- **Analyze the photon effect**
- Analyze the Compton effect and DeBroglie's wavelength
- Analyze radioactive decay and Mass-Energy equivalence

Standard Alignments (Section 2)

SCCLE: N/A

Knowledge: (SC) 1,6,7

CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9

NETS: 1c,d; 2d; 3d; 4c; 6c,d

Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Apply the properties of photons and the photoelectric effect to:
 - relate the energy of a photon in joules or electron-volts to its wavelength or frequency
 - relate the linear momentum of a photon to its energy or wavelength, and apply linear momentum conservation to simple processes involving the emission, absorption, or reflection of photons
 - calculate the number of photons per second emitted by a monochromatic source of specific wavelength and power
 - describe a typical photoelectric effect experiment, and explain what experimental observations provide evidence for the photon nature of light
 - describe qualitatively how the number of photoelectrons and their maximum kinetic energy depend on the wavelength and intensity of the light striking the surface, and account for this dependence in terms of a photon model of light
 - determine the maximum kinetic energy of photoelectrons for a different photon energy or wavelength when given the maximum kinetic energy of photoelectrons ejected by photons of one energy or wavelength
 - sketch or identify a graph of stopping potential versus frequency for a photoelectric effect experiment, determine from such a graph the threshold frequency and work function, and calculate an approximate value of h/e
- Apply energy levels of atoms to:
 - calculate the energy or wavelength of the photon emitted or absorbed in a transition between specified levels, or the energy or wavelength required to ionize an atom
 - explain qualitatively the origin of emission or absorption spectra of gases
 - calculate the wavelength or energy for a single-step when given the wavelengths or energies of photons emitted or absorbed in a two-step transition between energy levels

- write an expression for the energy levels of hydrogen in terms of the ground-state energy, draw a diagram to depict these levels, and explain how this diagram accounts for the various “series” in the hydrogen spectrum
- Apply DeBroglie wavelength to:
 - calculate the wavelength of a particle as a function of its momentum
 - describe the Davisson-Germer experiment and explain how it provides evidence for the wave nature of electrons
- Apply the nature and production of x-rays to:
 - calculate the shortest wavelength of x-rays that may be produced by electrons accelerated through a specific voltage
- Apply Compton scattering to:
 - describe Compton’s experiment, and state what results were observed and by what sort of analysis these results may be explained
 - account qualitatively for the increase of photon wavelength that is observed, and explain the significance of the Compton wavelength
- Analyze that the atomic model describes the electrically neutral atom:
 - Describe the atom as having a dense, positive nucleus surrounded by a cloud of negative electrons
 - Calculate the number of protons, neutrons, and electrons of an element (or isotopes) given its atomic mass (or mass number) and atomic number
 - Describe the information provided by the atomic number and the mass number (i.e., electrical charge, chemical stability)
- Analyze how nuclear energy is a major source of energy throughout the universe:
 - Describe how changes in the nucleus of an atom during a nuclear reaction (i.e., nuclear decay, fusion, fission) result in emission of radiation
 - Identify the role of nuclear energy as it serves as a source of energy for the Earth, stars, and human activity (e.g., source of electromagnetic radiation, thermal energy within mantle, nuclear power plants, fuel for stars)
 - Energy can change from one form to another within and between systems, but the total amount remains the same
 - Compare the efficiency of simple machines (recognizing that, as work is done, the amount of usable energy decreases with each transformation as it is transferred as heat due to friction)
 - Classify the different forms of energy (i.e., chemical, nuclear, thermal, mechanical, electromagnetic) that can be observed as energy is transferred and transformed within a system when given a scenario (e.g., dynamite explosion, solar radiation interacting with the Earth, electromagnetic motor doing work, energy generated by nuclear reactor)
 - Explain how energy can be transferred (absorbed or released) or transformed between and within systems as the total amount of energy remains constant (i.e., Law of Conservation of Energy)

<p>Instructional Strategies:</p> <ul style="list-style-type: none"> Students will: <ul style="list-style-type: none"> complete worksheets which will require them to: <ul style="list-style-type: none"> analyze: <ul style="list-style-type: none"> the relationship between the energy of a photon and the light hitting the surface of an object Compton scattering determine the: <ul style="list-style-type: none"> Debroglie wavelength of a particle amount of mass converted to energy when an atom decays wavelength of a photon based on the emitting atom's energy spectra complete a quiz for each of the worksheets. They can retake a quiz as often as they wish design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results
<p>Assessments/Evaluations:</p> <ul style="list-style-type: none"> Formative – students will: <ul style="list-style-type: none"> complete lab reports for each lab in the unit take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish Summative: District developed unit test
<p>Sample Assessment Questions:</p> <ul style="list-style-type: none"> The sun is a yellow star and emits most of its radiation in the yellow portion of the spectrum. If the sun's radiation peaks at a frequency of 5.20×10^{14} Hz, how much energy is emitted by one photon of this visible yellow light? Roy is making holograms with his helium-neon laser. In a helium-neon laser, excited helium atoms collide with neon atoms, raising the neon to an excited state where its energy is 20.66 eV. Stimulated emission then causes electrons in the neon to drop to a lower energy level where $E=18.7$ eV. What is the wavelength and color of the light given off by a helium-neon laser?
<p>Instructional Resources/Tools:</p> <ul style="list-style-type: none"> iPad Class website LabQuest2 Traditional physics lab equipment
<p>Cross Curricular Connections:</p> <ul style="list-style-type: none"> ELA: Reading is emphasized with written lab instructions and word problems Math: <ul style="list-style-type: none"> Algebra II Trigonometry

Depth of Knowledge (Section 5)

DOK: 4

Curriculum: AP Physics B

Curricular Unit: Electricity

Instructional Unit: C. Electrostatics and electric current

- Analyze an electric field due to a static charge
- Analyze electric potential
- **Analyze electric circuits**

Standard Alignments (Section 2)

SCCLE: N/A

Knowledge: (SC) 1,2,7

CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9

NETS: 1c,d; 2d; 3d; 4c; 6c,d

Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Defining electric field:
 - Define it in terms of the force on a test charge
 - Calculate the magnitude and direction of a force on a positive or negative charge placed in a specified field
 - Given a diagram on which an electric field is represented by flux lines, determine the direction of the field at a given point, identify locations where the field is strong and where it is weak, and identify where positive or negative charges must be present
 - Analyze the motion of a particle of specified charge and mass in a uniform electric field
- Apply the concept of electric potential to:
 - calculate the electrical work done on a positive or negative charge that moves through a specific potential difference
 - determine the direction and approximate magnitude of the electric field at various positions when given a sketch of equipotentials for a charge configuration
 - apply conservation of energy to determine the speed of a charged particle that has been accelerated through a specific potential difference
 - calculate the potential difference between two points in a uniform electric field, and state which has the higher potential
- Apply Coulomb's Law and the principle of superposition to:
 - determine the force that acts between specified point charges, and describe the electric field of a single point charge
 - determine the electric field produced by two or more point charges using vector addition

- Apply the behavior of series and parallel combinations of resistors to:
 - identify on a circuit diagram resistors that are in series or in parallel
 - determine the ratio of the voltages across resistors connected in series of the ratio of the currents through resistors connected parallel
 - calculate the equivalent resistance of two or more resistors that can be broken down into series and parallel combinations
 - calculate the voltage, current, and power dissipation for any resistor in such a network or resistors connected to a single battery
 - design a simple series-parallel circuit that produces a given current and terminal voltage for one specified component, and draw a diagram for the circuit using conventional symbols
- Apply Ohm's Law and Kirchoff's rules to direct-current circuits in order to determine a single unknown current, voltage, or resistance
- Apply the behavior of capacitors connected in series or in parallel to:
 - calculate the equivalent capacitance of a series or parallel combination
 - describe how stored charge is divided between two capacitors connected in parallel
 - determine the ratio of voltages for two capacitors connected in series
- Analyze the behavior of circuits containing several capacitors and resistors to determine voltages and currents immediately after:
 - a switch has been closed and steady-state conditions have been established

Instructional Strategies:

- Students will complete worksheets which will require them to:
 - determine the:
 - electric field due to a static charge
 - force on a static charge in an electric field
 - equivalent capacitance for multiple capacitors
 - equivalent resistance for multiple resistors
 - analyze:
 - the potential difference due to multiple charges
 - a DC circuit
- Students will:
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative:
 - Students will
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- As Ben switches on the TV set to watch the Simpsons, the electron beam in the TV tube is steered across the screen by the field between the two charged plates. If the electron experiences a force of 3.0×10^{-6} N, how large is the field between the deflection plates?
- Timmy is playing with a new electronic kit he has received for his birthday. He takes out four resistors with resistances of 15Ω , 20Ω , 20Ω , and 30Ω . A) How would Timmy have to wire the resistors so that they would allow the maximum amount of current to be drawn? Calculate the total resistance in this circuit. B) How must he wire the resistors so that they draw a minimum amount of current? Calculate the total resistance in this circuit.

Instructional Resources/Tools:

- iPad
- Class website
- LabQuest2
- Traditional physics lab equipment

Cross Curricular Connections:

- ELA: Reading is emphasized with written lab instructions and word problems
- Math:
 - Algebra II
 - Trigonometry

Depth of Knowledge (Section 5)

DOK: 4

Curriculum: AP Physics B

Curricular Unit: Magnetism and Electromagnetism

Instructional Unit: D. Analyze magnetostatics and electromagnetism

- Analyze forces on charged particles in a magnetic field
- Analyze forces on a current in a magnetic field
- Analyze the magnetic field produced by a current
- **Analyze the relationship between magnetic flux and emf**

Standard Alignments (Section 2)

SCCLE: N/A

Knowledge: (SC) 1,2,7

CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9

NETS: 1c,d; 2d; 3d; 4c; 6c,d

Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Apply the force experienced by a charged particle in a magnetic field to:
 - calculate the magnitude and direction of the force in terms of q , v , and B , and explain why the magnetic force can perform no work
 - deduce the direction of a magnetic field from information about the forces experienced by charged particles moving through the field
 - state and apply the formula for the radius of the circular path of a charge that moves perpendicular to a uniform magnetic field, and derive this formula from Newton's Second Law and the magnetic force law
 - describe the most general path possible for a charged particle moving in a uniform magnetic field, and describe the motion of a particle that enters a uniform magnetic field moving with specified initial velocity describe quantitatively under what conditions particles will move with constant velocity through crossed electric and magnetic fields
- Apply force experienced by a current in a magnetic field to:
 - calculate the magnitude and direction of the force on a straight segment of current carrying wire in a uniform magnetic field
 - indicate the direction of magnetic forces on a current carrying loop of wire in a magnetic field, and determine how the loop will tend to rotate as a consequence of these forces
- Apply magnetic field produced by a long, straight current-carrying wire to:
 - calculate the magnitude and direction of the field at a point in the vicinity of such a wire
 - use superposition to determine the magnetic field produced by two long wires and calculate the force of attraction or repulsion between two long current carrying wires

- Apply the concept of magnetic flux to calculate the flux of a uniform magnetic field through a loop of arbitrary orientation
- Apply Faraday's Law and Lenz's Law to:
 - recognize situations in which changing flux through a loop will cause an induced emf or current in the loop
 - calculate the magnitude and direction of the induced emf and current in a:
 - a) square loop of wire pulled at a constant velocity into or out of a uniform magnetic field
 - b) loop of wire placed in a spatially uniform magnetic field whose magnitude is changing at a constant rate
 - c) loop of wire that rotates at a constant rate about an axis perpendicular to a uniform magnetic field
 - d) conducting bar moving perpendicular to a uniform magnetic field

Instructional Strategies:

- Students will complete worksheets which will require them to:
 - determine the:
 - strength of a magnetic field
 - force on a current-carrying wire in a magnetic field
 - magnetic flux generated by a changing current
 - current generated by a changing magnetic field
 - analyze the effect of Lenz's Law
- Students will:
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative – students will:
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- A hydroelectric plant in Niagara Falls sends 3000 V to the transformer in a substation that steps it up to 120,000 V for transmission to homes in New York City. If the primary coil contains 2000 turns, how many turns are there in the secondary coil of the step-up transformer?
- Captain Kirk is sailing due north, as indicated by his compass needle, in a location where the earth's magnetic field is 2.0×10^{-5} T. The captain inadvertently places his radio near the compass, allowing the wire from his radio to align in a north-south direction. The 0.80 m long wire carries a current of 5.0 A and produces a magnetic force on the compass needle of 2.8×10^{-4} N. To what angle will the compass needle turn while the wire is over it?

Instructional Resources/Tools:

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| <ul style="list-style-type: none">• iPad• Class website• LabQuest2• Traditional physics lab equipment |
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Cross Curricular Connections:

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|---|
| <ul style="list-style-type: none">• ELA: Reading is emphasized with written lab instructions and word problems• Math:<ul style="list-style-type: none">• Algebra II• Trigonometry |
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Depth of Knowledge (Section 5)

DOK: 4

Curriculum: AP Physics B

Curricular Unit: Fluid mechanics

Instructional Unit: E. Analyze fluid mechanics

- Analyze hydrostatic pressure
- Analyze buoyancy
- Analyze fluid flow continuity
- **Analyze Bernoulli's Equation**

Standard Alignments (Section 2)

SCCLE: N/A

Knowledge: (SC) 1,2,6,7

CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9

NETS: 1c,d; 2d; 3d; 4c; 6c,d

Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Hydrostatic pressure:
 - Explain that a fluid exerts pressure in all directions
 - Apply the concept that a fluid at rest exerts pressure perpendicular to any surface that it contacts
 - Explain and be able to use the relationship between pressure and depth in a liquid, $\Delta p = \rho g \Delta h$
- Buoyancy:
 - Explain that the difference in the pressure on the upper and lower surfaces of an object immersed in liquid results in an upward force on the object
 - Apply Archimedes's principle: the buoyant force on a submerged object is equal to the weight of the liquid it displaces
- Fluid flow continuity:
 - Explain that for laminar flow, the flow rate of a liquid through its cross section is the same at any point along the path
 - Apply the equation of continuity $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$
- Bernoulli's Equation:
 - Explain that the pressure of a flowing liquid is low where the velocity is high, and vice versa
 - Apply Bernoulli's equation, $p + \frac{1}{2} \rho v^2 + \rho g y = \text{constant}$

Instructional Strategies:

- Students will complete worksheets which will require them to determine the:
 - hydrostatic pressure in a given location
 - buoyant force on an object
 - velocity of a fluid using fluid flow continuity
 - velocity of a fluid using Bernoulli's equation
- Students will:
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative:
 - Students will:
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- A water tower sits on the top of a hill and supplies water to the citizens below. The difference in pressure between the water tower and the Brown's house is 1.1×10^5 Pa, while the difference in pressure between the tower and the Miller's house is 3.2×10^5 Pa.
 - a) What house sits at a higher elevation, the Brown's or the Miller's?
 - b) What is the difference in elevation between the two houses?
- Nancy is floating on her back in the beautiful blue Caribbean during her spring vacation. If Nancy's density is 980 kg/m^3 and she has a volume of 0.060 m^3 , what is the buoyant force that supports her in the seawater of density of 1025 kg/m^3 ?

Instructional Resources/Tools:

- iPad
- Class website
- LabQuest2
- Traditional physics lab equipment

Cross Curricular Connections:

- ELA: Reading is emphasized with written lab instructions and word problems
- Math:
 - Algebra II
 - Trigonometry

Depth of Knowledge (Section 5)

DOK: 4

Curriculum: AP Physics B

Curricular Unit: Thermodynamics and Ideal Gases

Instructional Unit: F. Analyze thermodynamics and ideal gases

- Analyze the kinetic theory model of an ideal gas
- Analyze the relationships of pressure, volume and temperature of an ideal gas using the combined gas law
- **Analyze a P-V diagram**

Standard Alignments (Section 2)

SCCLE: N/A

Knowledge: (SC) 1,2,6,7

CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9

NETS: 1c,d; 2d; 3d; 4c; 6c,d

Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Apply the kinetic theory model of an ideal gas to:
 - state the assumptions of the model
 - state the connection between temperature and mean translational kinetic energy, and apply it to determine mean speed of gas molecules as a function of their mass and the temperature of the gas
 - state the relationship among Avogadro's number, Boltzmann's constant, and the gas constant R , and express the energy of a mole of monatomic ideal gas as a function of its temperature
 - explain qualitatively how the model explains the pressure of a gas in terms of collisions with the container walls, and explain how the model predicts that, for fixed volume, pressure must be proportional to temperature
- Apply the ideal gas law; and thermodynamics principles to:
 - relate the pressure and volume of a gas during an isothermal expansion or compression
 - relate the pressure and temperature of a gas during constant-volume heating or cooling, or the volume and temperature during constant pressure heating or cooling
 - calculate the work performed on or by a gas during an expansion or compression at constant pressure
 - describe the process of adiabatic expansion or compression of a gas
 - identify or sketch on a pV diagram the curves that represent each of the above processes

Instructional Strategies:

- Students will complete worksheets which will require them to determine the:
 - temperature of an ideal gas using the combined gas law
 - pressure of an ideal gas using the combined gas law
 - volume of an ideal gas using the combined gas law
 - work, input heat, and output heat of a process from a P-V diagram
- Students will:
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative – students will:
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- The caloric value of food is measured with a device called a bomb calorimeter. Oxygen is forced into this sealed container and kept at a constant volume. Once the internal pressure is increased to 1.50×10^5 Pa, a small piece of food inside the calorimeter is ignited with a spark. As the food burns, the temperature inside the sealed vessel rapidly increases from 293 K to 523 K. What is the new pressure of the gas inside the chamber when the temperature rises?
- Brandon takes Sally on a surprise hot-air balloon ride for her birthday. However, once the pair is airborne Sally announces that she is afraid of heights. The 2200 m^3 balloon is filled to capacity with 350.0 K air at a height where the surrounding air pressure is 1.01×10^5 Pa. When Brandon turns off the heating unit, the air in the balloon begins to cool and the balloon descends.
 - a) Why do both the pressure and volume of the air in the balloon remain constant, even though the balloon's air cools to a temperature of 300.0 K?
 - b) Hot-air balloons are always made so that the bottom remains open throughout the flight. By how much would the balloon's volume change if the balloon could be manually closed as the temperature dropped to 300.0K? (Assume atmospheric pressure remains constant)

Instructional Resources/Tools:

- iPad
- Class website
- LabQuest2
- Traditional physics lab equipment

Cross Curricular Connections:

- ELA: Reading is emphasized with written lab instructions and word problems
- Math:
 - Algebra II
 - Trigonometry

Depth of Knowledge (Section 5)

DOK: 4

Curriculum: AP Physics B

Curricular Unit: Relativity and Cosmology

Instructional Unit: G. Analyze relativity and cosmology

- Analyze special relativity
- Analyze general relativity
- **Analyze the big bang theory of cosmology**

Standard Alignments (Section 2)

SCCLE: N/A
Knowledge: (SC) 1,2,6,7
CCSS: 11-12.RST.3; 11-12.RST.4; 11-12.RST.9
NETS: 1c,d; 2d; 3d; 4c; 6c,d
Performance: 3.1, 3.5

Unit (Section 3)

Learning Targets:

- Apply the postulates of special relativity to:
 - state and apply the basic assumptions about the equivalence of inertial frames and about the speed of light
 - describe the Michelson-Morley experiment and explain its significance
- Apply kinematic effects produced by special relativity to:
 - relate the lifetime of a fast moving elementary particle or other “clock,” as times by two stationary clocks, to the lifetime of such a particle in its rest frame
 - describe quantitatively the effect of Lorentz contraction on the dimensions of a fast moving object
 - when given two objects moving at high speeds along the same line, describe the limits on the speed of one object in a frame of reference where the other is at rest
- Apply the relationship between mass, momentum and energy to:
 - sketch or identify a graph of the total energy or kinetic energy of a particle as a function of its velocity
 - calculate the total energy, kinetic energy, or momentum of a moving particle in terms of its rest mass and speed
 - describe briefly one physical process in which kinetic energy is converted to rest energy and one in which rest energy is converted to kinetic energy, and apply the relationship $E = mc^2$ in analyzing such processes
 - describe verbally or graphically, the behavior of the velocity, acceleration, linear momentum and energy of a particle that is accelerated close to the speed of light by a constant force

- Apply the basic ideas of general relativity and how it can be used to describe gravitational effects to:
 - describe the meaning of mass energy equivalence, and explain how it is still correct to say that mass is conserved and that energy is conserved
 - explain why the equivalence of mass and energy is not noticed for everyday events such as the throwing of a baseball
 - explain how the correspondence principle is a good test of the validity of any new theory
 - explain what is meant by the principle of equivalence
 - describe the effect of gravity on the motion of light and time
 - explain how gravity affects the space-time continuum
 - explain how Einsteinian gravity differs from Newtonian gravity
- Apply the basic features of modern cosmology to:
 - explain the basic features of the Big Bang theory for the creation of the universe
 - explain the importance of the "search for dark matter"
 - explain how the universe can continue to expand into apparently nothingness
 - discuss the factors that determine the direction of the "arrow of time"
 - support or argue against cosmological theories according to observations that have been made about our universe

Instructional Strategies:

- Students will complete worksheets which will require them to determine the:
 - mass of an object as it approaches the speed of light
 - effect of gravity on space and time
 - reason for postulating dark energy and dark matter
- Students will:
 - complete a quiz for each of the worksheets. They can retake a quiz as often as they wish
 - design a lab to analyze principles covered in the worksheets. They will then perform the lab and write up the results

Assessments/Evaluations:

- Formative – students will:
 - complete lab reports for each lab in the unit
 - take a quiz based on the worksheet associated with each lab in the unit. The students may retake each quiz as often as they wish
- Summative: District developed unit test

Sample Assessment Questions:

- Of all the planets, why is Mercury the best candidate for our finding evidence of the relationship of gravitation in space?
- We readily note the bending of light by reflection and refraction, but why is it we do not ordinarily notice the bending of light by gravity?

Instructional Resources/Tools:

- iPad
- Class website
- LabQuest2
- Traditional physics lab equipment

Cross Curricular Connections:

- ELA: Reading is emphasized with written lab instructions and word problems
- Math:
 - Algebra II
 - Trigonometry

Depth of Knowledge (Section 5)

DOK: 4