Elizabethtown Area School District

AP Physics 2

Course Number:	335B	Length of Course:	2 semesters
Grade Level:	11-12	Total Clock Hours:	
Length of Period:	80 minutes	Date Written:	Course adopted 2014/2015
Periods/Week:	5 periods/week	Written By:	David Cherry
Credits (if app.):	1.0	Weighting: 1.2	

Prerequisite: Calculus, AP Physics I

Course Description:

This weighted course covers topics in fluids, thermodynamics, electricity and magetism, optics, and modern physics that are included in introductory college physics courses. The course will also allow students to explore these topics in a laboratory setting, with the emphasis on solving calculus based physics problems. This course would be benefical for those who plan to major in physics, mathematics, chemistry or engineering in college. Upon successful completion of this course students may choose to take the Advanced Placement Physics II exam. Students scoring three or above may receive college credit from participating colleges and universities.

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I. Overall Course/Grade Level Standards

Students will know and be able to do the following as a result of taking this course.

A. The student will be able to discuss the meaning and significance of the basic principles of physics.

B. The student will be able to analyze technical problems, organize technical information, create a labeled sketch, develop a logical approach to problem solving, arrive at a solution, and ascertain the reasonableness of the solution.

C. The student will be able to interpret graphs (graphs constructed on paper and Microsoft Excel), and will be able to correctly present laboratory and classroom data in a graphical format.

D. The student will be able to synthesize new approaches to problems by considering skills, knowledge, and experiences gained in prior units of study or other courses.

E. The student will be able to collect, statistically analyze, and interpret data taken from computers, mechanical, or electrical equipment in the laboratory, as well as prepare written lab reports detailing important points of the lab and the significance of the results.

F. The student will recognize the role of the computer as a data collection and analysis instrument in the modern laboratory setting.

G. The student will know how to analyze problems in electrostatics in different coordinate systems, and electrical circuits (using Kirchhoff's voltage and current laws).

H. Students know how to use Ohm's laws and how to calculate equivalent resistances for basic resistive circuits as well as draw and interpret basic schematic diagrams.

I. The students will know the fundamental principles of magnetostatics, magnetic fields, sources of magnetic fields, and electromagnetism.

J. The student will know the properties of light waves and the electromagnetic spectrum, including the nature of color and the dual nature of light.

K. The student will know the thermodynamic systems, methods of heat transfer, kinetic theory, laws of thermodynamics and how to interpret PV diagrams.

L. The students will know the basic characteristics of optical systems, reflection, refraction and interference of light, and be able to predict image characteristics mathematically, or through construction of ray diagrams.

M. The student will know the basic vocabulary of each physics discipline, including fundamental SI units, variables, and equations.

N. The student will know the basic concepts of modern physics including wave-particle duality, quantum mechanics, photoelectric effect, energy level transitions, nuclear physics, and decay processes.

O. The students will know the basic properties of fluids including buoyancy, hydrostatics, continuity equation, and Bernoulli's equation.

P. Students will be able to analyze a basic RC circuit, identify the time constant and calculate voltages, currents, and charges during times of charging, discharging, and steady state conditions. Students will also be able to understand the electrostatic properties of capacitors.

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II. Content

Major Areas of Study

Unit	Estimated Time	Materials
1. Electricity and Magnetism		Textbook, Prepared Notes, PASCO Science Workshop 750 Computer Interfaces and Probes, Computers, Prepared Problems, Free Response Problems, Thermodynamics Lab Equipment, College Board Released MC Exams
2. Heat, Kinetic Theory, Thermodynamics		Textbook, Prepared Notes, PASCO Science Workshop 750 Computer Interfaces and Probes, Computers, Prepared Problems, Free Response Problems, Thermodynamics Lab Equipment, College Board Released MC Exams
3. Waves and Optics		Textbook, Prepared Notes, PASCO Science Workshop 750 Computer Interfaces and Probes, Computers, Prepared Problems, Free Response Problems, Waves and Optics Lab Equipment, College Board Released MC Exams
4. Modern Physics		Textbook, Prepared Notes, Prepared Problems, Free Response Problems, College Board Released MC Exams

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Name of Course: AP Physics 2
Name of Unit: Electricity and Magnetism

Essential Question: How are the basic principles of electricity and magnetism incorporated into products we use in our everyday lives?

Unit Objectives	Priority	Aligned to Course Standard	Aligned to PA Standard
A) Vectors **1.** Students will be able to identify all quantities in electricity and magnetism as either a vector or a scalar quantity. **2.** Students will be able to resolve vectors into their vector components. **3.** Students will be able to perform vector addition (graphically and mathematically), vector dot product, and vector cross product. Students will be able to recognize the dot product of two vectors is a scalar, and the cross product of two vectors is a vector. **4.** Students will be able to utilize unit vector notation and recognize that vector quantities exist in orthogonal, cylindrical, and spherical coordinate systems.	E	V O I D B A	3.2.12A 3.2.12D
B) Electrostatics **1.** Electric Charge **a)** Students should be able to identify the two types of electric charge. **b)** Students should understand that charges can be isolated. **c)** Students will be able to determine the direction of the force on a charged particle brought near an uncharged or grounded conductor. **d)** Students will be able to describe qualitatively how to charge an object by induction. **2.** Electric Field **a)** Students will be able to define electric field in terms of the amount of force experienced by a test charge. **b)** Students will be able to calculate the magnitude and direction of the force exerted on a positive or negative charge placed in a uniform electric field. **c)** Students will be able to determine the magnitude and direction of the net force on a collection of charges placed in an electric field. **d)** Students will be able to determine from a diagram on which an electric field is represented by electric flux lines 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 exist. **e)** Students will be able to analyze the motion of a particle of specified charge and mass in a uniform electric field. **f)** Students should be able to describe and draw the electric field configuration for parallel charged plates, a long uniformly charged wire or thin cylindrical shell, a thin spherical shell, and a point charge. **g)** Students should know why the electric field inside a conductor is zero. **h)** Students will know that excess free charge will reside on the surface of a conductor. **i)** Students will understand that the electric field outside of a conducting	E	V Y O D C B A	3.1.12B 3.1.12C 3.2.12A 3.2.12D 3.4.12A 3.4.10C

surface must be perpendicular to its surface.

3. Electric Potential

a) Students will be able to calculate the electrical work done on a positive or negative charge that moves through a specified potential difference.

b) Given a sketch of equipotential surfaces for a charge configuration, students will be able to determine the direction and approximate magnitude of the electric field at various positions.

c) Students will be able to apply conservation of energy to determine the speed of a charged particle that has been accelerated through a specified potential difference.

d) Students will be able to calculate the potential difference between two points in a uniform electric field and state which is at a higher electric potential.

e) Students will be able to determine the electric potential in the vicinity of one or more point charges.

f) Students will be able to calculate how much work is required to move a test charge from one location to another in the field of fixed point charges.

g) Students will be able to calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is required to move a set of charges into a new configuration.

h) Students will understand the importance of treating electric potential as a scalar quantity.

4. Coulomb's Law

a) Students will be able to understand Coulomb's Law as an important inverse square law.

b) Students should be able to determine the force that acts between specified point charges, and describe the electric field of an isolated point charge.

c) Students will be able to use vector addition to determine the electric field produced by two or more point charges (principle of superposition).

5. Gauss's Law

a) Students will understand that Gauss's law is most easily used in cases where either planar, cylindrical, or spherical symmetry exists.

b) Students will understand the importance of choosing an appropriate Gaussian surface.

c) Students should be able to calculate the electric flux of a uniform electric field through an arbitrary closed surface.

d) Students should be able to calculate the electric flux of a uniform electric field through a curved, closed surface when the electric field is uniform in magnitude and directed perpendicular to the surface.

e) Students should have enough of an understanding of Gauss's law in the integral form to know why and under what conditions the equation may reduce to simply $EA = q_{enc}/\varepsilon_o$

f) Students should have the ability to apply Gauss's Law to determine the electric field in the following situations: near a large uniformly charged plane, inside or outside a uniformly charged long cylinder of cylindrical shell, and inside or outside a uniformly charged sphere or spherical shell.

g) Students will understand that the electric field outside of a closed conducting surface only depends upon the charge enclosed within the conducting surface and not upon its precise location.

6. Conductors

a) Students should be able to explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are connected by wires.

b) Students will be able to calculate the surface charge density on a

conductor. **7.** Capacitors **a)** Students should know the definition of capacitance so they can relate stored charge and voltage for a capacitor. **b)** Students will be able to relate voltage, charge, and stored energy for a capacitor. **c)** Students will recognize situations in which energy stored in a capacitor is converted to other forms. **d)** Students will be able to describe the electric field inside a parallel plate capacitor. **e)** Students will be able to relate the strength of the electric field inside a parallel plate capacitor to the potential difference between the plates and the plate separation. **f)** Students will be able to determine how changes in dimensions of a parallel plate capacitor will affect the value of the capacitance. **g)** Students will be able to calculate the energy stored in a parallel plate capacitor. **8.** Dielectrics **a)** Students will be able to understand how the insertion of a dielectric between the plates of a charged parallel-plate capacitor influences its capacitance, field strength, and the voltage between the plates. **b)** Students will know what materials are commonly used as dielectrics.			
C) Electric Circuits **1.** Current, Resistance, Voltage, Power **a)** Students should understand that the convention universally adopted for current flow is the movement of positive charges. **b)** Students should understand the definition of electric current. **c)** Students will be able to define conductivity, resistivity, and resistance. **d)** Students will be able to use Ohm's Law to relate current and voltage for a resistor. **e)** Students will be able to describe how the resistance of a resistor depends upon its length and cross sectional area. **f)** Students will be able to apply the relationships for the rate of heat production in a resistor. **2.** Steady-State Direct Current Circuits with Voltage Sources and Resistors Only **a)** Students should be able to identify on a circuit diagram whether a circuit is a series circuit, a parallel circuit, or a series-parallel circuit. **b)** Students will be able to find equivalent resistances of series circuits, parallel circuits, and series-parallel circuits. **c)** Students will be able to determine the ratio of the voltages across resistors connected in series, parallel, or series-parallel. **d)** Students will be able to calculate the voltage, current, and power dissipated for any resistor in a network connected to a voltage source. **e)** Students will be able to design series-parallel circuits that produce a given current and voltage for one specified component, and draw a diagram for the circuit using conventional circuit symbols. **f)** Students will be able to calculate the terminal voltage of a battery of specified EMF and internal resistance from which a known current is flowing. **g)** Students will be able to apply Kirchhoff's rules to direct-current, series series-parallel, and parallel circuits. **h)** Students will be able to apply Kirchhoff's rules to set up and solve systems of simultaneous equations to determine unknown currents. **i)** Students should understand that the resistance of an ammeter is low and the resistance of a voltmeter is high.	E	V P Y O F E D C B A	3.1.12B 3.1.12D 3.1.12E 3.2.12A 3.2.12B 3.2.12C 3.2.12D 3.4.12A 3.4.10B 3.4.10C 3.7.12B

j) Students will be able to demonstrate correct methods of connecting meters (or computer probes) in order to measure voltage or current. **3.** Capacitors in Direct Current Circuits **a)** Students will be able to calculate the equivalent capacitance of a series or parallel combination of capacitors. **b)** Students will be able to describe how stored charge is divided between two capacitors connected in parallel. **c)** Students will be able to determine the ratio of voltages for two capacitors connected in a series. **d)** Students will be able to relate voltage, charge, and stored energy for a capacitor. **e)** Students will be able to explain the meaning of an RC time constant and be able to calculate its value. **f)** Students will be able to recognize situations in which energy stored in a capacitor is converted to other forms. **g)** Students should be able to calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected in an RC circuit. **h)** Students will be able to sketch and identify graphs of charge, current, and voltage vs. time for a capacitor that is charging or discharging. **i)** Students will be able to utilize expressions to calculate stored charge, voltage, and current as a capacitor is charging or discharging. **j.** Students will be able to determine voltages, currents, and charges immediately after a switch has been closed and also after steady-state conditions have been established.			
D) Magnetostatics **1.** Forces on Moving Charges in a Magnetic Field **a)** Students will understand that a charged particle in a magnetic field experiences a force. **b)** Students will be able to calculate the magnitude and direction (using the right hand rule) of the force a charged particle experiences in terms of q, **v**, and **B** using a vector cross product. **c)** Students should be able to explain why a magnetic force can perform no work on a charged particle. **d)** Students should be able to deduce the direction of a magnetic field from information provided about the forces experienced by charged particles moving through that field. **e)** Students will be able to calculate the radius of the circular path of a charged particle that moves perpendicular to a uniform magnetic field, and derive this relationship from Newton's Second Law and the magnetic force equation. **f)** Students will be able to describe the path of a charged particle moving in a uniform magnetic field, which starts from rest, and which enters a uniform magnetic field moving with a specified initial velocity. **g)** Students will be able to describe the conditions needed for a particle to move with a constant velocity through crossed electric and magnetic fields. **2.** Forces on Current-Carrying Wires (segments) in Magnetic Fields **a)** Students will be able to calculate the magnitude and direction (using the right-hand rule) of the force experienced by a straight segment of current-carrying wire in a uniform magnetic field. **b)** Students will be able to calculate the magnetic force experienced by a curved segment of current-carrying wire in a uniform magnetic field, and understand that the net force on a closed loop of wire is zero. **c)** Students will be able to indicate the direction of magnetic forces on a current-carrying loop of wire in a magnetic field, and determine how the loop	E	V Q F E D C B A	3.1.12C 3.2.12A 3.2.12D 3.4.10C 3.7.12B

will tend to rotate as a result of these forces. **d)** Students will be able to calculate the magnitude and direction of the torque experienced by a rectangular loop of wire carrying a current in a magnetic field. **3.** Magnetic Fields of Long Current-Carrying Wires **a)** Students will understand how to calculate the magnitude and direction of the magnetic field at a point near a long current-carrying wire. **b)** Students will be able to use the superposition principle to determine the net magnetic field produced by two long current-carrying wires. **c)** Students will be able to determine if two long, parallel, current-carrying wires will attract or repel one another based on current directions. Students will also be able to calculate the force of attraction or repulsion. **4.** Biot-Savart Law and Ampere's Law **a)** Students will gain exposure to the Biot-Savart Law and it uses as well as its limitations. **b)** Students will be able to apply Ampere's Law to find the magnitude and direction of the magnetic field for common shapes of high symmetry. **c)** Students will understand that when applying Ampere's Law they should only consider the current enclosed within their Amperian loop.			
E) Electromagnetism **1.** Electromagnetic Induction **a)** Students will be able to calculate the magnetic flux of a uniform magnetic field through a loop of arbitrary orientation to the field. **b)** Students will be able to use Faraday's Law and Lenz's Law **c)** Students will be able to recognize situations in which changing magnetic flux through a loop will cause an induced EMF or current in the loop. **d)** Students will be able to calculate the magnitude and direction of the induced EMF and current in a square loop of wire pulled at a constant velocity into or out of a uniform magnetic field. **e)** Students will be able to calculate the magnitude and direction of the induced EMF and current in a loop of wire placed in a uniform magnetic field whose magnitude is changing at a constant rate. **f)** Students will be able to calculate the magnitude and direction of the induced EMF and current in a loop of wire that rotates at a constant rate about an axis perpendicular to a uniform magnetic field. **g)** Students will be able to calculate the magnitude and direction of the induced EMF and current in a conducting bar moving perpendicular to a uniform magnetic field.	E	V D C B A	3.1.12C 3.2.12A 3.2.12D 3.4.10C

Unit: Electricity and Magnetism

Unit Essential Question: How are the basic principles of electricity and magnetism incorporated into products we use in our everyday lives?

Unit Key Questions:

1. What is the algebraic relationship between voltage, current, and resistance?
2. What is the flow of charge?
3. What is EMF?
4. What device offers resistance to the flow of electrons?
5. How is power calculated in a resistive network?
6. What characterizes a series circuit?
7. What characterizes a parallel circuit?
8. What characterizes a series/parallel circuit?
9. How do resistive devices combine in a series circuit?
10. How do resistive devices combine in a parallel circuit?
11. How do resistive devices combine in a series/parallel circuit?
12. How does current behave in a series circuit?
13. How does current behave in a parallel circuit?
14. How does voltage across resistive devices behave in a series circuit?
15. How does voltage across resistive devices behave in a parallel circuit?
16. How do we break a resistive network down into an equivalent resistance?
17. How is electricity generated and sent to our homes?
18. What are the main types of electric power production in the United States?
19. What type of electricity comes into our homes?
20. What are the two types of electronic circuits?
21. What are the two main branches of study in electronics?
22. What type of circuitry do most of our modern electronic devices use?
23. What is an integrated circuit?
24. What are the three basic building blocks of digital electronic circuitry?
25. How do we apply Kirchhoff's current law to a resistive network?
26. How do we apply Kirchhoff's voltage law to a resistive network?
27. What are the four categories we can classify materials into with regards to their electrical properties?
28. What reference charge to we use to determine direction of electric field?
29. How much force is necessary to assemble a group of point charges?
30. How does the right hand rule determine the direction of the magnetic force that acts on a charge?
31. How does current direct influence the force felt between two parallel conductors?
32. How does electric potential energy relate to gravitational potential energy?
33. What factors influence the force felt by a charged particle next to another charged particle?
34. How is current induced in a conductor?
35. Can a magnetic monopole exist?
36. Can there be an electric field within a conductor?
37. Where will charge concentrate on a conductor?
38. How is the establishment of an electric potential influence the movement of charge?
39. How did Maxwell unify the ideas of electric field and magnetic field?
40. How does Gauss's Law simplify the calculation of electric field for situations of high symmetry?

Critical Vocabulary: alternating current, ampere, analog circuitry, branch, charge, circuit, conductor, coulomb, digital circuitry, direct current, EMF, electron, electric field, electric potential, electrodynamics, electrostatics, equivalent resistance, generator, insulator, integrated circuit, magnetic field, node, Ohm's law, Ohm, parallel circuit, potential, potential difference, power, resistor, semiconductor, series circuit, superconductor, transformer, volt, voltage, watt

Elizabethtown Area School District

Name of Course: AP Physics 2
Name of Unit: Heat, Kinetic Theory, Thermodynamics

Essential Question: How did the understanding and application of thermodynamic principles contribute to our industrialized society?

Unit Objectives	Priority	Aligned to Course Standard	Aligned to PA Standard
A. Fluid Mechanics **1.** Hydrostatics **a)** Students should understand that a fluid exerts pressure in all directions. **b)** Students will understand that a fluid at rest exerts pressure perpendicular to any surface that it contacts. **c)** Students should understand and be able to use the relationship between pressure and depth in a liquid, $\Delta p = \rho g \Delta h$. **2.** Buoyancy **a)** Students will understand that the difference in the pressure on the upper and lower surfaces of an object immersed in a liquid results in an upward force on the object. **b)** Students should understand that the buoyant force on a submerged object is equal to the weight of the liquid it displaces. **c)** Students will be able to calculate the buoyant force acting on an object when it is fully submerged or partially submerged. **3.** Fluid Flow Continuity **a)** Students should understand the difference between laminar and turbulent flow of fluids. **b)** Students should understand that for laminar flow, the flow rate of a liquid through its cross section is the same at any point along its path. **c)** Students should understand and be able to apply the continuity equation. **d)** Students will be able to represent fluid flow in terms of streamlines. **4.** Bernoulli's Equation **a)** Students should understand that the pressure of a flowing liquid is low where the velocity is high, and vice versa. **b)** Students should be able to apply Bernoulli's equation.	E	V X F E D C B A	3.1.12B 3.1.12D 3.2.12A 3.2.12B 3.2.12D 3.4.12A 3.4.10C
B) Temperature and Heat **1.** Students should understand the mechanical equivalent of heat, and be able to calculate how much a substance will be heated as it performs a specified quantity of mechanical work. **2.** Students should understand the concepts of specific heat, heat of fusion, and heat of vaporization. **3.** Students will be able to identify, given a graph relating the quantity of heat added to a substance and its temperature, the melting point, the boiling point, and will be able to determine the heat of fusion, heat of vaporization and the specific heat of each phase. **4.** Students will be able to determine how much heat must be added to a sample of a substance to raise its temperature from one specified value to another, or to cause melting or vaporization of the substance. **5.** Students will be able to determine the final temperature achieved when	E	V T F E D C B A	3.1.12B 3.1.12D 3.2.12B 3.2.12D 3.4.10A 3.4.12A 3.4.12B 3.7.12B

substances, at different temperatures, are mixed together and allowed to come to thermal equilibrium. **6.** Students will be able to calculate how the flow of heat through a slab of material is affected by changes in the thickness or cross sectional area of the slab, or temperature difference between the two faces of the slab. **7.** Students will be able to determine the change in length, area, or volume of a solid when heated (this includes holes within plates or cavities within solids).			
C) Kinetic Theory and Thermodynamics **1.** Ideal Gases **a)** Students should have an understanding of the kinetic theory model of an ideal gas, and be able to state the assumptions made in the model. **b)** Students will be able to state the connection between temperature and mean translational kinetic energy, and apply it to determine the RMS speed of gas molecules as a function of mass and temperature of a gas. **c)** Students will be able to state the relationship among Avogadro's number n, Boltzmann's constant k, and the ideal gas constant R, and express the energy of a monatomic ideal gas as a function of its temperature. **d)** Students will be able to explain, in terms of the kinetic theory model, the pressure of a gas in terms of collisions with the container walls, and explain how the model predicts that, for a gas at a fixed volume, pressure must be proportional to its temperature. **e)** Students will be able to apply the ideal gas law to relate the pressure and volume of a gas during an isothermal expansion or compression. **f)** Students will be able to relate the pressure and temperature of an ideal gas during constant-volume heating or cooling, or the volume and temperature during constant pressure heating or cooling. **g)** Students will be able to calculate the work performed on or by a gas during an expansion or compression at a constant pressure. **h)** Students will understand the process of adiabatic expansion or compression of a gas. **i)** Students will be able to identify and draw on a PV diagram an isobaric process, adiabatic process, isothermal process, and an isovolumetric process. **2.** Laws of Thermodynamics **a)** Students will have an understanding of the "zeroth" law of thermodynamics. **b)** First Law of Thermodynamics **(1)** Students will be able to relate the heat absorbed by a gas, the work performed by the gas, and the internal energy change of the gas for the major thermodynamic processes. **(2)** Students will be able to relate the work performed by a gas in a cyclic process to the area enclosed by a curve on a PV diagram. **(3)** Students will understand the sign conventions for heat and work in the first law of thermodynamics. **c)** Second Law of Thermodynamics, Entropy, Heat Engines, Carnot Cycle **(1)** Students will be able to determine whether entropy will increase, decrease, or remain the same during a particular thermodynamic process. **(2)** Students will be able to calculate the maximum possible efficiency of a heat engine operating between two given temperatures. **(3)** Students will be able to calculate the actual efficiency of a heat engine. **(4)** Students will be able to relate the heats exchanged at each thermal reservoir in a Carnot cycle to the temperatures of the reservoir. **(5)** Students will be able to draw a basic schematic diagram of a heat engine or a refrigerator.	E	V T L D C B A	3.1.12C 3.2.12A 3.2.12D 3.4.10A 3.4.12A 3.4.12B

Unit: Thermodynamics

Unit Essential Question: How did the understanding and application of thermodynamic principles contribute to our industrialized society?

Unit Key Questions:

1. Is heat a form of energy?
2. What are three different temperature scales, and how are they interrelated?
3. What is the lowest theoretical temperature that could ever be achieved?
4. What is latent heat of fusion?
5. What is latent heat of vaporization?
6. Can a substance lose (gain) heat energy and not incur a temperature drop (rise)?
7. What are the four states of matter?
8. What is specific heat of a substance, and how is it calculated?
9. What is the basic relationship between pressure, temperature, and volume?
10. Most materials, when heated, will expand or contract?
11. How do we calculate heat energy lost or gained in a system?
12. Is heat energy gained in a system considered to be positive or negative?
13. What is an isovolumetric process, and how would it be represented on a PV diagram?
14. What is an isochoric process, and how would it be represented on a PV diagram?
15. What is an isobaric process, and how would it be represented on a PV diagram?
16. What is an isothermal process, and how would it be represented on a PV diagram?
17. What is an adiabatic process, and how would it be represented on a PV diagram?
18. What is entropy, and how does it relate to the natural order of our universe?
19. What experimental process could be used to determine the specific heat of an unknown substance?
20. Why is it that some substances feel colder than others if they are maintained at the same temperature?
21. What are three main heat transfer mechanisms?
22. What factors affect the absorption or radiation of heat energy?
23. What is the lowest possible temperature?
24. How does the specific heat of water compare with the specific heat of other common materials?
25. Which expand more for increases in temperature, solids or liquids?
26. Why does water ice water contract as its temperature is increased?
27. At what temperature is water densest?
28. Why do molecules of warm air move upward?
29. Do collisions between molecules in a gas increase the temperature of the gas?
30. Why does the direction of coastal winds change from day to night?
31. Since all bodies are absorbing thermal energy from their surroundings, why doesn't the temperature of all bodies continually increase?
32. Does Newton's law of cooling apply to cold bodies being warmed in a hot environment?
33. Why does warmer air support a greater amount of water vapor?
34. Why does water vapor in the air condense when the air is chilled?

Critical Vocabulary: absolute zero, adiabatic, calorie, Celsius, entropy, conduction, convection, Fahrenheit, gas, heat, isobaric, isochoric, isothermal, isovolumetric, Joule, Kelvin, latent heat of fusion, latent heat of vaporization, liquid, Pascal, plasma, pressure, radiation, solid, specific heat, temperature, thermal equilibrium, volume

Elizabethtown Area School District

Name of Course: AP Physics 2
Name of Unit: Waves and Optics

Essential Question: How has mankind's curiosity about our solar system and the distant stars led to developments and advancements in the field of optics?

Unit Objectives	Priority	Aligned to Course Standard	Aligned to PA Standard
A) Waves **1.** Wave Motion **a)** Traveling Waves **(1)** Students will be able to sketch and identify graphs that represent traveling waves and determine the amplitude, wavelength, and frequency of a wave from such a graph. **(2)** Students will be able to state and apply the relationship among wavelength, frequency, and velocity of a wave. **(3)** Students will be able to sketch and identify graphs that describe reflection of a wave from the fixed or free end of a string. **(4)** Students will be able to understand what factors determine the speed of waves on a string. **(5)** Students will be able to determine what factors influence the speed of sound in air, solids, and liquids. **b)** Standing Waves **(1)** Students will be able to sketch possible standing wave modes for a stretched string that is fixed at both ends, and determine the amplitude, wavelength, and frequency of such standing waves. **(2)** Students will be able to describe possible standing waves in a pipe or tube that has either open or closed ends, and determine the wavelength and frequency of standing waves. **2.** Doppler Effect **a)** Students will be able to explain the mechanism that gives rise to a frequency shift in both the moving-source and moving observer, and derive an expression for the frequency heard by an observer. **b)** Students will be able to write and apply the equations (with appropriate sign conventions) that describe the moving-source and moving-observer Doppler effect. **3.** Students will be able to use the principle of superposition so they can apply it to traveling waves moving in opposite directions, and describe how a standing wave may be formed by superposition.	E	V R F E D C B A	3.1.12C 3.2.12A 3.2.12C 3.2.12D 3.4.12C 3.4.10C
B) Physical Optics **1.** Interference and Diffraction **a)** Students will be able to describe the conditions under which the waves reaching an observation point from two sources will interfere constructively, or destructively. **b)** Students will be able to mathematically determine locations of interference maxima or minima for two point sources or determine the frequencies or	E	V U S F E D C	3.1.12B 3.1.12C 3.1.12D 3.2.12D 3.2.12B 3.2.12C 3.2.12D

wavelengths that can lead to constructive or destructive interference at a certain point. **c)** Students will be able to relate the amplitude and intensity produced by two or more sources that interfere constructively to the amplitude and intensity produced by a single source. **2.** Double Slit Interference, Single Slit Interference, and Diffraction Gratings **a)** Students should be able to sketch and 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. **b)** Students will be able to calculate, for a single-slit pattern, the angles or the positions on a distant screen where the intensity is zero. **c)** Students will be able to sketch or identify the intensity pattern that results when monochromatic waves pass through a double slit. **d)** Students will be able to calculate, for a double-slit interference pattern, the angles or the positions on a distant screen at which intensity minima or maxima occur. **e)** Students will be able to describe and identify the interference pattern formed by a grating of many equally spaced narrow slits (diffraction grating), calculate the location of intensity maxima, and explain qualitatively why a multiple-slit grating is better than a two-slit grating for making accurate determinations of wavelength. **3.** Thin Film Interference **a)** Students will be able to state under what conditions a phase reversal occurs when light is reflected from the interface between two media of different indices of refraction. **b)** Students will be able to determine whether rays of monochromatic light reflected from two such interfaces will interfere constructively or destructively. **4.** Chromatic Dispersion and the Electromagnetic Spectrum **a)** Students will be able to understand that chromatic dispersion takes place because index of refraction varies with wavelength. **b)** Students will understand which ray deviates the most from the normal as light passes from higher to lower index of refraction, or vice-versa. **c)** Students will know the names associated with the different portions of the electromagnetic spectrum and will be able to arrange them in order of increasing wavelength. **5.** Students will be able to understand the transverse nature of light waves so they can explain qualitatively why light can exhibit polarization. **6.** Students should be able to understand the inverse-square law so they can calculate the intensity of light at a given distance from a source of specified power and compare the intensity of light at different distances from the source.		B A	3.4.12C 3.4.10C 3.7.12B
C) Geometric Optics **1.** Reflection and Refraction **a)** Students will be able to determine how the speed and wavelength of light change when light passes from one medium into another. **b)** Students will be able to show on a diagram the directions of reflected and refracted rays as light passes from one medium to another. **c)** Students will be able to use Snell's Law to relate the directions of the incident ray and the refracted ray, and the indices of refraction of the media. **d)** Students will be able to identify conditions under which total internal reflection will occur. **2.** Plane and Spherical Mirrors **a)** Students will know the mathematical relationship between the focal point	E	V U F E D C B A	3.1.12B 3.1.12D 3.2.12A 3.2.12B 3.2.12D 3.4.12C 3.7.12B

of a spherical mirror to its center of curvature. **b)** Given a diagram of a mirror with the focal point shown, students will be able to perform a ray tracing diagram (using three principle rays) to locate the image of a real object to determine if the image is real or virtual, upright or inverted, enlarged or reduced in size. Students will also be able to confirm this information with proper mathematical relationships. **c)** Students will be able to locate the image formed of a real object in a plane mirror, and do a proper ray tracing to show this image. **3.** Converging and Diverging Lenses **a)** Students will be able to determine whether the focal length of a lens is increased or decreased as a result of a change in the curvature of its surfaces or in the index of refraction of the material of which the lens is made or the medium in which it is immersed. **b)** Students will be able to 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. **c)** Students will be able to use the thin lens equation to relate the object distance, image distance, and focal length for a lens, and determine the image size in terms of the object size. **d)** Students will be able to analyze simple situations in which the image formed by one lens serves as the object for another lens.			

Unit: **Geometric Optics and Waves**

Unit Essential Question: How has mankind's curiosity about our solar system and the distant stars led to developments and advancements in the field of optics?

Unit Key Questions:

1. What is reflection?
2. How are images formed in a mirror by the process of reflection?
3. What is refraction?
4. How are images formed in lenses by the process of refraction?
5. What is interference?
6. What is chromatic dispersion?
7. Under what conditions is a real image formed in a mirror?
8. Under what conditions is a virtual image formed in a mirror?
9. What is a real image?
10. What is a virtual image?
11. Under what conditions is a real image formed in a lens?
12. Under what conditions is a virtual image formed in a lens?
13. Where does visible light fall in the electromagnetic spectrum?
14. What wavelengths of light fall in the visible spectrum?
15. What frequencies of light fall in the visible spectrum?
16. What is the vertex of a mirror or lens?
17. What is the radius of curvature of a mirror or lens?
18. What is the focal point of a mirror or lens?
19. How do we perform a ray tracing to locate images for objects in a mirror?
20. How do we perform a ray tracing to locate images for objects in a lens?
21. How do we apply Snell's Law to refracted rays as light passes from one medium to another?
22. What is the speed of light in a vacuum?
23. Does the speed of light vary from one medium to another?
24. How do we define index of refraction?
25. What is the difference between light that is chromatic and light that is monochromatic?
26. What is total internal reflection, and how does this principle apply to modern communications?
27. What is Doppler shift?
28. How does film thickness influence the interference pattern?
29. How does slit spacing change the position of maximum and minimum interference?
30. How is resonance established in a tube or pipe?
31. What conditions are necessary for complete constructive or destructive interference?
32. How does slit spacing in a diffraction grating influence positions of maximums?

Critical Vocabulary: aberration, angle of incidence, angle of reflection, beats, coherent light, converging lens, critical angle, diffraction, diffraction grating, diffuse reflection, dispersion, diverging lens, Doppler effect, electromagnetic spectrum, electromagnetic wave, focal length, focus, frequency, hertz, incoherent light, infrared, interference, laser, lens, longitudinal wave, monochromatic, node, opaque, period, pitch, polarization, real image, reflection, refraction, spectrum, standing wave, total internal reflection, transverse wave, trough, vibration, virtual image, wavelength, white light

Elizabethtown Area School District

Name of Course: AP Physics 2
Name of Unit: Modern Physics

Essential Question: How do modern physics principles allow us to explain physics phenomena that contemporary physics principles cannot?

Unit Objectives	Priority	Aligned to Course Standard	Aligned to PA Standard
A) Atomic and Quantum Physics Effects **1.** Students should be able to describe the Rutherford scattering experiment and explain how it provides evidence for the existence of the atomic nucleus. **2.** Photoelectric Effect and Properties of Photons **a)** Students will be able to relate the energy of a photon (in Joules or ev) to its wavelength or frequency. **b)** Students will be able to 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. **c)** Students will be able to calculate the number of photons per second emitted by a monochromatic source of a specified wavelength and power. **d)** Students will be able to describe a typical photoelectric effect experiment, and explain what experimental observations provide evidence for the photon nature of light. **e)** Students will be able to describe how the number of photoelectrons and their maximum kinetic energy depends upon the wavelength and intensity of the light striking the surface, and account for this dependence in terms of a photon model of light. **f)** When given the maximum kinetic energy of photoelectrons ejected by photons of one energy or wavelength, students will be able to determine the maximum kinetic energy of photoelectrons for a different photon energy or wavelength. **g)** Students will be able to identify a graph of stopping potential vs. 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. **h)** Students will be able to understand the physical significance of a work function and determine its value from a graph. **3.** Energy Levels for Atoms **a)** Students will be able to calculate the energy or wavelength of a photon emitted or absorbed in a transition between specified energy levels, or the energy or wavelength required to ionize an atom. **b)** Students will be able to explain qualitatively the origin of emission or absorption spectra of gasses. **c)** Given the wavelengths or energies of photons emitted or absorbed in a two-step transition between levels, students will be able to calculate the wavelength or energy for a single-step transition between the same levels. **d)** Students will be able to write an expression for the energy levels of hydrogen in terms of the ground state energy, draw an energy level diagram to	E	W V S D C B A	3.1.12E 3.2.12A 3.2.12D 3.4.12A 3.4.10B

depict the levels, and explain how the diagram accounts for the various series in the hydrogen spectrum. **e)** Students will be able to state the assumptions and conclusions for the Bohr model for the hydrogen atom. **4.** DeBroglie Wavelength **a)** Students will be able to calculate the wavelength of a particle as a function of its momentum. **b)** Students will be able to describe the Davisson-Germer experiment, and explain how it provides evidence for the wave nature of electrons. **5.** Compton Scattering **a)** Students should be able to describe the Compton Scattering experiment, and state what results were observed and by what sort of analysis these results may be explained. **b)** Students will be able to account qualitatively for the increase in photon wavelength that is observed, and explain the significance of the Compton wavelength.			
B) Nuclear Physics **1.** Half-Life in Radioactive Decay **a)** Students will recognize that half-life is independent of the number of nuclei present or of external conditions. **b)** Students will be able to sketch or identify a graph to indicate what fraction of a radioactive sample remains as a function of time, and indicate the half-life on such a graph. **c)** Students will be able to determine, for an isotope of specified half-life, what fraction of the nuclei have decayed after a given time has elapsed. **2.** Atomic Nuclei **a)** Students will be able to interpret symbols for nuclei that indicate these quantities. **b)** Students will be able to use conservation of mass number and charge to complete nuclear reactions. **c)** Students will be able to determine the mass number and charge of a nucleus after it has undergone specified decay process. **d)** Students will be able to describe the process of alpha, beta, and gamma decay and write a reaction to describe each. **e)** Students will be able to explain why the existence of the neutrino had to be postulated in order to reconcile experimental data from beta decay with fundamental conservation laws. **3.** Students should know the nature of the nuclear force so they can compare its strength and range with those of the electromagnetic force within the atom. **4.** Students should be able to understand nuclear fission so they can describe a typical neutron-induced fission. **5.** Mass-Energy Equivalence **a)** Students should be able to qualitatively relate the energy released in nuclear processes to the change in mass. **b)** Students will be able to apply the relationship $E = mc^2$ in analyzing nuclear processes.	E	W V L D C B A	3.1.12E 3.2.12A 3.2.12D 3.4.12A 3.4.10B

Unit: Modern Physics

Unit Essential Question: How do modern physics principles allow us to explain physics phenomena that contemporary physics principles cannot?

Unit Key Questions:

1. Does the amount of photoelectrons ejected from a metal depend upon the intensity of the source?
2. What are the major experiments that show that light has particle properties?
3. What are the major experiments that show that light has wave properties?
4. What is the equivalence of mass and energy?
5. What is the significance of the work function of a metal?
6. What do electrons undergo discrete transitions to lower energy states?
7. How do we apply conservation principles to nuclear reactions?
8. What is an alpha particle?
9. What is the significance of the threshold frequency in the photoelectric effect experiment?
10. What role does electrical force play in nuclear fission?
11. What is nuclear fission?
12. What is nuclear fusion?
13. Which type of radiation results in the least change in mass number, atomic number, and charge?
14. Why are larger nuclei more unstable than smaller nuclei?
15. What is meant by radioactive half-life?

Critical Vocabulary: Alpha Particle, anode, atomic number, beta particle, cathode, decay, duality, electron, energy level, fission, fusion, gamma-particle, half-life, mass equivalence, mass number, neutron, nucleon, nucleus, photocurrent, photo emission, proton, threshold frequency, work function

Elizabethtown Area School District

III. Course Assessments

Check types of assessments to be used in the teaching of the course.
(Provide examples of each type.)

__X_ Objective Tests/Quizzes
____ Constructed Responses
____ Essays
__X_ Reports
____ Projects
____ Portfolios
__X_ Presentations
__X_ Performance tasks
__X_ Lab Activities
____ Response Journals
____ Logs
__X_ Computer Simulations
____ Research Papers
__X_ Class Participation
__X_ Notetaking
__X_ Daily Assignments
____ Writing Samples
____ __________________

Provide copies of common assessments that will be utilized for all students taking this course. Overall course/grade level standards will be measured by a common course assessment. Unit objectives will be measured on an ongoing basis as needed by the classroom teacher to assess learning and plan for instruction. List common assessements below and recommended date/time frame for administration (at least quarterly).

	Name of Assessment	When given?
1.	Unit Tests	At the conclusion of each major unit
2.	Final Exam	At the conclusion of the semester
3.	Lab Reports and Analysis	At the conclusion of a lab