



Kutztown Area School District Curriculum (Unit Map)

Grade 12 AP Physics

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Course Description: AP Physics I course is for students who have demonstrated exceptional achievement in prior science courses and have met the established criteria for Honors/AP selection as stated in this course selection guide. This introductory course is for students with an aptitude and interest in the field of science. The course covers Newtonian mechanics (including rotational dynamics and angular momentum); work, energy, and power; and mechanical waves and sound. It will also introduce electric circuits. AP Physics is an intense, problem-solving, lab based curriculum that is strongly recommended for students intending to pursue an education in the sciences, engineering, or medicine.

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Unit #/Title	1/Introduction, Measurement & Estimating	Time Frame	1 Week
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Standards	
M11.A.1.1.2 Express numbers and/or simplify expressions using scientific notation (including numbers less than 1).	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> Measurements of physical quantities are only as accurate as allowable by the precision of the measuring device itself. Expressing numbers/measurements to the correct number of significant digits is a statement regarding the accuracy and the precision of the data itself. 	<ul style="list-style-type: none"> How can the precision of a given measuring tool and/or instrument be determined? How can the determined precision of a measuring tool/instrument be used to determine error analysis in a class laboratory setting?
Content	Skills
<ul style="list-style-type: none"> Classroom rules/norms setting and expectations of the classroom Course syllabus & general course overview Introduction, measurement, & estimating as a review of previous knowledge Rules for significant figures Dimensional Analysis Basic unit conversions 	<ul style="list-style-type: none"> Demonstrate knowledge of measurement and uncertainty Utilize significant figures in expressing physical quantities Recognize and demonstrate a working knowledge of units, standards and the SI System of measurement Perform basic unit conversions between the English System and the SI System and vice versa

Unit #/Title	2/Kinematics - One Dimensional	Time Frame	3 Weeks
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Standards	
<p>3.3.12.B Evaluate experimental information for relevance and adherence to science processes. Judge that conclusions are consistent and logical with experimental conditions.</p> <p>3.2.P.B.1 Differentiate among translational motion, simple harmonic motion and rotational motion in terms of position, velocity and acceleration.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> Graphical representations of motion are universal - information can be transmitted without words. Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values. Distance traveled and change in velocity for an object can be obtained by determining the area under the curves of a velocity vs. time and an acceleration vs. time graphs, respectively. 	<ul style="list-style-type: none"> How can the motion of an object moving at constant velocity be described and represented? How can the motion of an object that is accelerating be described and represented? How do I use my basic skill set to conduct labs and solve problems?
Content	Skills
<ul style="list-style-type: none"> Kinematics parameters: position, speed, velocity, acceleration Uniformly accelerated motion Falling bodies Graphical analysis of motion 	<ul style="list-style-type: none"> Distinguish between distance and displacement and speed and velocity Create graphs using motion detectors and written or oral descriptions Interpret displacement vs. time and velocity vs. time graphs Interpret and solve 1D kinematics problems

Unit #/Title	3/Vectors and Projectile Motion	Time Frame	3 Weeks
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Standards	
<p>CC.2.3.HS.A.7 Apply trigonometric ratios to solve problems involving right triangles.</p> <p>3.2.10.B1. Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's Second Law of Motion.</p> <p>3.2.P.B1 Differentiate among translational motion, simple harmonic motion and rotational motion in terms of position, velocity and acceleration.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> • Forces are described by vectors. • Displacement, velocity, and acceleration are all vector quantities. • Force and acceleration are both vectors, with acceleration in the same direction as the net force. • Horizontal and vertical components of the velocity may be considered separately in order to perform calculations as long as it is understood that both components occur simultaneously. 	<ul style="list-style-type: none"> • What information can be gathered from motion graphs? • What are the characteristics of the motion of a projectile launched horizontally? • What are the characteristics of the motion of a projectile launched at an angle?
Content	Skills
<ul style="list-style-type: none"> • Trigonometric ratios are applied to vector variables. • Vectors can be broken down into components. • All the information in one component direction (x or y) can be analyzed separately i.e. <i>vector components are independent of one another.</i> 	<ul style="list-style-type: none"> • Apply trigonometric ratios to real world applications (projectile motion, cable tension, etc.) • Solve physics problems involving relative velocity, projectile motion, and force vectors • Demonstrate advanced problem solving skills (break down a complex problem, analyze the parts of the problem, recombine parts)

Unit #/Title	4/Newton's 1 st , 2 nd , & 3 rd Laws	Time Frame	4.5 Weeks
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Standards

3.2.10.B1. Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's Second Law of Motion.

3.2.P.B.1 Use force and mass to explain translational motion or simple harmonic motion of objects.

CC.3.6.11-12.A. Write arguments focused on discipline-specific content; Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing; Provide a concluding statement or section that follows from or supports the argument presented.

CC.3.6.11-12.B Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes; Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g. headings), graphics (e.g. figures, tables), and multimedia when useful to aiding comprehension; Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic; Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts; Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers; Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

Big Ideas	Essential Questions
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- All forces share certain common characteristics when considered by observers in inertial reference frames.
- Forces have magnitude and direction.
- Even though an object is at rest, there may be forces exerted on that object by other objects.
- Forces are detected by their influence on the motion of an object
- If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.
- The acceleration of the center of mass of a system is related to the net force exerted on the system, where

$$a = \frac{\sum \vec{F}}{m}$$
- The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects.
- Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.
- Objects in contact experience a frictional force and that the coefficient of friction is a property of the surfaces in contact only.

- How can the forces acting on an object be represented?
- How can a free-body diagram be used to create a mathematical representation of the forces acting on an object?
- How do Newton's laws apply to interactions between objects at rest and in motion?
- How do Newton's laws apply to systems of two or more objects?

Content	Skills
<ul style="list-style-type: none"> ● The motion of objects can be analyzed using a free body diagram ● The effects of the net force acting on a body ● With no net force acting that equilibrium (static or translational) exists ● "Weight" as measured on a scale is not a "real" value, mass is the actual measurement of an object's inertia ● Freefall is an example of net force changing over time 	<ul style="list-style-type: none"> ● Interpret data using analysis software ● Predict the effects of force and acceleration on an object ● Applying Newton's Second Law (a mathematical equation), determine the position, velocity, acceleration, force, mass, coefficient of friction, etc. of a given object ● Write appropriate dynamics equations of motion based on the free body diagram

Unit #/Title	5/Circular Motion & Gravitation	Time Frame	2 Weeks
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Standards

- 3.2.10.B1** Analyze the relationships among the net forces acting on a body, the mass of the body and the resulting acceleration using Newton's Second Law of Motion.
- 3.2.10.B1** Apply Newton's Law of Universal Gravitation to the forces between two objects.
- 3.2.12.B6** Compare and contrast motions of objects using forces and conservation laws.
- 3.2.P.B2** Explain how gravitational forces give rise to rotational motion.
- 3.2.P.B6** Use Newton's laws of motion and gravitation to describe and predict the motion of objects ranging from atoms to the galaxies.
- 3.2.P.B.1.** Relate the torque and rotational inertia to explain rotational motion AND differentiate among translational motion and rotational motion in terms of position, velocity and acceleration.
- 3.2.12.B1.** Analyze the principles of rotational motion to solve problems relating to angular momentum and torque.

Big Ideas	Essential Questions
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- Forces are described by vectors.
- Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.
- A torque exerted on an object can change the angular momentum of an object.
- The angular momentum of a system is conserved.

- What force or combination of forces keeps an object in circular motion?
- How can net force and gravitational force be applied to predict rotational and orbital motion?
- How is the motion of the moon around the Earth like the motion of a falling apple?
- How does the effect of Earth's gravitational field on an object change as the object's distance from Earth changes?

Content	Skills
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- Gravitational forces always occur between two objects with mass
- Circular motion is the result of the net inward acting force acting on an object rather than a fundamental force
- Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis
- Angular momentum is affected by the rotational inertia and angular speed of an object

- Identify/describe circular orbits as they relate to force, acceleration, and velocity
- Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
- Explain the difference between rotational inertia and angular momentum
- Calculate the linear and rotational velocity for a spinning object
- Solve problems involving centripetal force
- Solve problems involving torque

Unit #/Title	6/Work, Energy & Simple Machines	Time Frame	2.5 Weeks
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Standards	
<p>3.2.12.B1 Describe the work-energy theorem. Explain the relationships between work and power.</p> <p>3.2.12.B2 Demonstrate how the law of conservation of energy provides an alternate approach to predict and describe the motion of objects.</p> <p>3.2.C.B3 Describe the law of conservation of energy.</p> <p>3.2.P.B2 Explain the translation and simple harmonic motion of objects using conservation of energy and conservation of momentum.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> • Energy can change form or be transferred from one form to another, but it is never “used up” or created or destroyed. • A machine can increase or decrease force/distance but cannot increase/decrease the work. • Energy is conserved, in the sense that the changes of energy in a given system are always equal to the transfer of energy to or from the system by all possible interactions with other systems. 	<ul style="list-style-type: none"> • How are the different modes of energy storage transformed within a system and transferred between a system and the environment? • How can energy be represented with graphs and equations? • What does it mean for energy to be conserved?
Content	Skills
<ul style="list-style-type: none"> • The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted • The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy; Examples should include gravitational potential energy, elastic potential energy, and kinetic energy • Since energy is constant in a closed system, changes in a system’s potential energy will result in changes to the system’s kinetic energy 	<ul style="list-style-type: none"> • Use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged • Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system • Calculate changes in kinetic energy and potential energy of a system, using information from representations of that system

Unit #/Title	7/Newton's 3 rd Law & Linear Momentum	Time Frame	2.5 Weeks
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Standards	
3.2.10.B1. Use Newton's Third Law to explain forces as interactions between bodies; Describe how interactions between objects conserve momentum.	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> • A force exerted on an object is always due to the interaction of that object with another object. • An object cannot exert a force on itself. • If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction. • Momentum is always conserved in the absence of outside forces. • Impulse is the application of Newton's Third Law. 	<ul style="list-style-type: none"> • Why do objects respond differently when they collide? • When can you determine what happens to the motion of objects after they collide?
Content	Skills
<ul style="list-style-type: none"> • Newton's Third Law (equal and opposite forces) • Momentum is conserved • Outside factors (forces) acting on the system negate momentum conservation • The time over which an impulse occurs affects the amount of force felt by an object 	<ul style="list-style-type: none"> • Calculate the speed of an object after a collision • Determine the type of collision that occurred • Analyze the impulse equation to determine how a change in one factor will affect other factors • Analyze/interpret integrals using software as a calculation tool

Unit #/Title	8/Electricity	Time Frame	3-4 Weeks
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Standards	
<p>3.2.P.B4 Explain how stationary and moving particle result it electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connections among them. Explain how electrical induction is applied in technology.</p> <p>3.2.12.B4 Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> The electric charge of a system is conserved. For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. 	<ul style="list-style-type: none"> How are electric charge, electrostatic forces, electric field, and electric potential (voltage), and potential difference related? What are the relationships between voltage, current and resistance? What is electric power?
Content	Skills
<ul style="list-style-type: none"> Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge The electric field inside of a conductor is always zero Electric field lines are similar to gravitational field lines Electric force results from the interaction of one object that has an electric charge with another object that has an electric charge Matter has a property called resistivity Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in the circuit Kirchhoff's loop rule describes conservation of energy in electrical circuits 	<ul style="list-style-type: none"> Apply the concepts of conservation of charge Describe and apply the phenomenon of induced charge Use Coulomb's Law to calculate electrostatic forces. Describe the similarities between gravitational potential energy and electric potential energy Understand the operation of an electric battery Use Ohm's law to solve V-I-R problems Calculate the electric power transformed by an electric device Calculate equivalent resistance in series and parallel

Unit #/Title	9/Magnetism	Time Frame	3 Weeks
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Standards	
<p>3.2.P.B4 Explain how stationary and moving particles result in electricity and magnetism.</p> <p>3.2.10.B4 Describe the relationship between electricity and magnetism as two aspects of a single electromagnetic force.</p> <p>3.2.P.B2 Explain how gravitational, electrical and magnetic forces and torques give rise to rotational motion.</p> <p>3.2.P.B4 Explain how electrical induction is applied in technology.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> Electricity and magnetism are two components of the same force (electromagnetism). Magnetic properties are the result of the subatomic structure of a material. Electromagnetic forces underlie alternating current power. 	<ul style="list-style-type: none"> How are magnets formed? What is a magnetic field and how is one created? Can you create current without a battery?
Content	Skills
<ul style="list-style-type: none"> Electric current creates a magnetic field and a changing magnetic field creates a current Domains align to form both temporary and permanent magnets The right hand rule is used to determine the direction of a magnetic field, current force on a current-carrying wire Motors and generators use electromagnetic forces to function Transformers, which work only with alternating current, allow electric power to be transmitted over large distances 	<ul style="list-style-type: none"> Identify the conditions under which a magnetic field and/or current are present Analyze the effect that heating, cooling, or the presence of another magnetic field has on a temporary or permanent magnet Use the right hand rule to analyze forces or field directions Describe the similarities and differences between motors and generators Explain why transformers only work with alternating current Determine the cost of electricity given the wattage and time used for a device (such as a light bulb)

Unit #/Title	10/Vibrations, Waves & Sound	Time Frame	3-4 Weeks
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Standards	
<p>3.2.P.B5 Explain how waves transfer energy without transferring matter. Explain how waves carry information from remote sources that can be detected and interpreted; Describe the cause of wave frequency, speed and wavelength.</p> <p>3.2.10.B5 Describe the difference between sound and light waves. Compare and contrast the wave nature of light and sound.</p>	
Big Ideas	Essential Questions
<ul style="list-style-type: none"> • A wave is a traveling disturbance that transfers energy and momentum. • A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy. • Interference and superposition lead to standing waves and beats. 	<ul style="list-style-type: none"> • How are waves and harmonics related to one another? • How are waves energy transport phenomena? • How do the relative velocities of the source of a wave and of the observer affect the frequency of the observed wave? • How do waves from more than one source interfere to make waves of smaller or larger amplitude, depending on the location where the waves meet? • How can wave boundary behavior be used to derive and apply relationships for calculating the characteristic frequencies for standing waves in strings, open pipes, and closed pipes? • How does human perception affect our understanding of loudness? Pitch? Music vs. noise?
Content	Skills
<ul style="list-style-type: none"> • Waves can propagate via different oscillation modes such as transverse and longitudinal • Sound waves require a medium to propagate • Wave properties such as wavelength, frequency, and amplitude determine the characteristics of the wave • Waves interact to produce amplitude and frequency variations • Standing waves only occur at specific wavelengths/frequencies 	<ul style="list-style-type: none"> • Distinguish between transverse and longitudinal waves by focusing on the vibration that generates the wave and the movement of the wave • Explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example • Identify wave properties and their effect on the wave type • Determine the type of interference that will occur based on the frequency of interfering waves • Using properties of reflection and interference, determine what harmonics or standing waves will be present.

Unit #/Title	11/Optics	Time Frame	2 Weeks
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Stage 1 - Identify Desired Results
Standards

3.2.P.B5 Explain how waves transfer energy without transferring matter, carry information from remote sources that can be interpreted and detected; Describe the causes of wave frequency, speed, and wavelength.

3.2.10.B5 Describe the difference between sound and light waves. Compare and contrast the wave nature of light and sound.

Big Ideas	Essential Questions
<ul style="list-style-type: none">• Vision is partly based on human perception.• Light is both a wave and a particle. It transfers energy and information with massless particles called photons.	<ul style="list-style-type: none">• How is it possible for one person to see the same thing differently from another person?• How are real and virtual images similar to and different from one another?
Content	Skills
<ul style="list-style-type: none">• Understand what it means for light to be polarized• Light behaves as a ray/particle• Light follows the law of reflection for mirrors and the rules of refraction for changing mediums	<ul style="list-style-type: none">• State the properties of light that make it like a particle and those that make it like a wave• Explain absorption and reflection as they relate to seeing color• Explain how frequency and wavelength are related to color.• Explain why primary paint and light colors are different• Analyze a situation where reflection and absorption alter the colors seen by the viewer• Draw diagrams to predict the size, location, and type of image with either a mirror or a lens.• Identify the primary colors of light