AP Physics I

Belleville School District **Grades 11-12, 1 year, 1 credit**

Course Description

This year long course is designed to be the equivalent of a general physics course that is usually taught in one college semester. Students will be prepared to seek credit and/or appropriate placement in a college physics course. Students will experience laboratory experiments equivalent to that of a college course. The course is designed around six big ideas outlined below.

Resources

College Physics: AP Edition by Etkina, Gentle, Van Heuvelen (2014) **[CR1]**

Modeling Curriculum, TIPERs: Sensemaking Tasks for Introductory Physics, Vernier for Physics, POGIL for Chemistry

Supply list: Laboratory notebook, scientific calculator, notebook or loose leaf paper, folder or binder, and writing utensils (pencils, pens, and a 4 color pen is recommended).

Big Ideas for AP Physics 1

Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Big Idea 2: Fields existing in space can be used to explain interactions.

Big Idea 3: The interactions of an object with other objects can be described by forces.

Big Idea 4: Interactions between systems can result in changes in those systems.

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

Big Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Learning Objectives. The learning objectives referenced are provided by the College Board. They are listed within their respective units on the scope and sequence page.

Science Practices. The science practices are provided by the College Board and are designated by SP when applicable. They are listed within their respective units and labs.

Connections to the Real World. One part of each required lab is that students connect what they learned in the unit lab to their everyday lives. An example is that while learning about impulse and momentum that students can make connections between impulse, momentum, Newton's 2nd Law and connect the science to a collision involving an airbag. **[CR4]**

Outside of Classroom Experiences. Students will participate in two fieldtrips during the school year. **1)** One includes all AP science students visiting a large cave. Students will enter the cave by crawling through a narrow area. While in the dark cave the students will be able to observe why bats must use echolocation to move around their surroundings. The students will be required to connect the trip to the lessons on Sound and Waves **(EU: 6A, 6B) 2)** The 2nd includes a snow tubing trip or an amusement park trip (student choice). Both trips will ask students to use their knowledge of physics to solve problems with regards to their speed, acceleration, momentum, and energy **(EU: 3A, 3B, 3D, 3E, 4A-4C)**. **[CR3]**

Laboratory Experiments. Students will complete a number of labs and a minimum of 50% of the labs will acquire data using probeware technology. They will be expected to keep a lab notebook according to the guidelines provided. Lab reports are expected to include a heading, purpose/hypothesis, procedure/materials, data/observations/graphs, calculations, analysis, error, and connections to the real world. I have included the guidelines for the conclusion below. Labs that have the code WB listed after them will require student groups to present their results to the class and defend their results. They will be asked to evaluate the results from other groups and offer suggestions to improve their results. **[CR4], [CR6a], [CR7], [CR8]**

- *Conclusion is logical, it used data and prior knowledge to explain results, and it is easy to follow. The purpose and outcome of the lab is summarized and any questions that were asked were answered correctly and thoroughly.* **[CR7], [CR8]**
- *Mathematical relationships are addressed. The meanings of graphs, slopes, and equations are all discussed when applicable.* **[CR7]**
- *Sources of error are discussed. The error's impact on results, possible solutions for the future, and ways error was avoided are explained.* **[CR8]**
- *Connections to the real world are explained.* **[CR4]**

Students can expect to spend a minimum of 25% of their class time in lab, but in some units up to 50% of the time learning will be in a lab setting. Labs are listed within their respective units and many will be guided inquiry labs (GI) and utilize technology (T). **[CR5], [CR6b]**

Activities. Throughout the course demonstrations, short activities, and computer simulations will be utilized to enhance student learning. These occur outside of the traditional lab setting and students will be expected to keep a record of these learning opportunities in their lab notebooks. Activities are listed within their respective units.

Scientific Argumentation. Students will use written (whiteboards and labs) and oral (discussion) to develop their scientific argumentation process by using claims, evidence, and questions. This process will teach students to revise their claims and make revisions as appropriate.

Students will complete a project which includes them reading the beginning of the book Timeline by Michael Crichton and then researching the most current research on Quantum Teleportation. Students will write a research paper comparing and contrasting the physics in the novel and actual physics research.

Teams of students will watch parts of the movie Gravity and defend or refute the science in the movie using scientific explanations. **[CR8]**

Scope and Sequence

Unit	Instructional Topics	Big Ideas (BI)	Learning Objectives & Enduring Understandings [CR3]	Textbook Chapter and Sections
Scientific Thinking and Tools	1. Introduction to Physics 2. Reliability of Measurements and Estimation 3. Vector and Scalar Quantities			I1-6
Kinematics **[CR2a]**	1. Constant Motion in 1D 2. Accelerated Motion in 1D 3. Projectile Motion-2D	BI 3	3.A.1.1-3.A.1.3	1.1-1.9, 3.5
Dynamics **[CR2b],[CR2c]**	1. Review of Newton's 1st and 3rd Laws 2. Weight, Mass, and Free Body Diagrams 3. Universal Law of Gravitation 4. Newton's 2nd Law 5. Friction 6. 2D Forces	BI 1,2,3,4	1.C.1.1-3, 2.B.1.1, 3.A.2.1, 3.A.3.1-3.A.3.3, 3.A.4.1-3.A.4.3, 3.B.1.1-3.B.1.3, 3.B.2.1, 3.C.4.1, 3.C.4.2, 4.A.1.1, 4.A.1.1, 4.A.2.1-4.A.2.3, 4.A.2.3, 4.A.3.1, 4.A.3.2	2.1-2.10, 3.1-3.4, 3.6, 4.1
Consevation Laws **[CR2e], [CR2f]**	1. Impulse, Momentum, and 1D Collisions 2. Impulse, Momentum, and 2D Collisions 3. Energy and Conservation of Energy 4. Work-Energy Theorem 5. Energy Conversion 6. Power	BI 3,4,5	3.D.1.1, 3.D.2.1, -3.D.2.4, 3.E.1.1-3.E.1.4, 4.B.1.1, 4.B.1.2, 4.B.2.1, 4.B.2.2, 4.C.1.1, 4.C.1.2, 4.C.2.1, 4.C.2.2, 5.A.2.1, 5.B.1.1, 5.B.1.2, 5.B.2.1, 5.B.3.1-5.B.3.3, 5.B.4.1, 5.B.4.2, 5.B.5.1-5.B.5.5, 5.D.1.1-5.D.1.5, 5.D.2.1, 5.D.2.5, 5.D.3.1	5.1-5.7, 6.1-6.9
Circular and Rotational Motion **[CR2c], [CR2g]**	1. Circular Motion 2. Universal Law of Gravitation 3. Torque 4. Translational and Rotational Equilibrium 5. Center of Mass 6. Application of Equilibrium 7. Rotational Kinematics 8. Rotational Dynamics 9. Conservation of Rotational Momentum and Energy	BI 1,2,3,4,5	1.C.1.1-3, 3.A.2.1, 3.A.3.1-3.A.4.1-3.A.4.3, 3.B.1.1-3.B.1.3, 3.B.2.1, 3.C.4.1, 3.C.4.2, 3.F.1.1-3.F.1.5, 3.F.2.1, 3.F.2.2, 3.F.3.1-3.F.3.3, 4.A.1.1, 4.A.2.1-4.A.2.3, 4.A.3.1, 4.A.3.2, 4.D.1.1, 4.D.1.2, 4.D.2.1, 4.D.2.2, 4.D.3.1, 4.D.3.2, 5.E.1.1, 5.E.1.2, 5.E.2.1	4.1-4.7, 7.1-7.7, 8.1-8.7
Waves **[CR2d], [CR2j]**	1. Oscillatory Motion 2. Kinematics and Dynamics of Waves 3. Energy and Pendulums 4. Analyzing Vibrational Motion 5. Mathematics of Sound Waves 6. Wave Interference 7. Sound 8. Standing Waves	BI 3, 5,6	3.B.3.1-3.B.3.4, 5.B.2.1, 5.B.3.1-5.B.3.3, 5.B.4.1, 5.B.4.2, 6.A.1.1-6.A.1.3, 6.A.2.1, 6.A.3.1, 6.A.4.1, 6.B.1.1, 6.B.2.1, 6.B.4.1, 6.B.5.1, 6.D.1.1-6.D.1.3, 6.D.2.1, 6.D.3.1-6.D.3.4, 6.D.4.A, 6.D.4.2, 6.D.5.1	19.1-19.10,20.1-20.11
Electric Charge and Circuits **[CR2h], [CR2i]**	1. Electric Charge Analysis 2. Conductors, Dielectrics, and Electric Fields 3. Coulomb's Law 4. Electric Potential 5. Electric Fields 6. Conductors, Dielectrics, and Capacitors in Electric Fields 7. Electric Current, Circuits, and Ohm's Law 8. Kirchoff's Rules and Resistors	BI 1,3, 5	1.B.1.1, 1.B.1.2, 1.B.2.1, 1.B.3.1, 1.E.2.1, 3.C.2.1, 3.C.2.2, 5.A.2.1, 5.B.9.1-5.B.9.3, 5.C.3.2, 5.C.3.3	14.1-14.7, 15.1-15.8, 16.1-16.11

**Timelines of topics within units are approximate.*

Unit 1: Scientific Thinking and Tools – Summer and 1 day

Unit Description. The information in this unit will help you learn to think like a scientist by teaching you how to organize data and identify data sources, how to use significant figures, how to use the metric system, and how to do basic conversions. These are important skills for any advanced science course.

Labs and Activities

POGIL Organizing Data
Modeling Workshop Significant Figures
TIPERs Practice RT4 Stacked Blocks-Number, Total Mass, and Average Mass

Topic 1.1: Introduction to Physics-1st day
Topics covered: Syllabus, data organization and variables, scientific notation, metric system, dimensional analysis, and a pre-test.

Topic 1.2: Reliability of Measurements and Estimation-1st day
Topics covered: Significant figures, error and uncertainty, and estimation.

Topic 1.3: Vector and Scalar Quantities-1st day
Topics covered: Vector and scalar quantities.

Unit 2: Kinematics (Big Idea 3)-10 days

Unit Description: This unit covers kinematics in one and two dimensions. Constant motion and constant acceleration will be the models studied in this unit. **[CR2a]**

Labs and Activities [CR6a], [CR6b]
Meeting Point (GI, T)
Students were tasked with calculating where two different massed vehicles would meet in a collision. **SP: 1, 2, 3, 4, 5, 6, 7**

Accelerated Motion Graph Matching (GI, T)
Students were provided graphs that they needed to create scenarios for in order to match the graph. **SP: 1, 2, 3, 4, 5, 6, 7**

Target Practice Activity
Students are asked to calculate how far away from the table a cup would need to be placed so that a ball moving with a constant speed would go in the cup. **SP: 1, 2, 3, 4, 5, 6, 7**

Water Balloon Lab (projectile motion)
Students are provided the necessary materials to calculate the velocity of their water balloons. After providing me with their velocity they are assigned an angle. They need to use this information to calculate how far away I should stand from the balloon in order to hit me.
SP: 1, 2, 3, 4, 5, 6, 7

Topic 2.1: Constant Motion in 1D
Topics covered: Interpreting and drawing motion maps, position vs. time graphs, velocity vs. time graphs. (TB 1.1-1.5)

Topic 2.2: Accelerated Motion in 1D
Topics covered: Interpreting and drawing motion maps, position vs. time graphs, velocity vs. time graphs. (TB 1.6-1.9)

Topic 2.3: Projectile Motion-2D
Topics covered: Interpreting and drawing motion maps, independent motion, graphical analysis of projectile motion. (3.5)

Unit 3: Dynamics (Big Ideas 1-4)-10 days

Unit Description: This unit will teach students to draw free body diagrams, which will aide them in developing a qualitative and quantitative relationship between forces and motion. Newton's Laws will be studied in depth and students will be able to apply what they have learned to various situations. **[CR2b], [CR2c]**

Labs and Activities [CR6a], [CR6b], [CR2c], [CR8]
Force Diagram Activity
Students will review how to draw force diagrams. From the diagrams they will be able to determine the qualitative net force on an object. **SP: 1, 6, 7**

Atwood's Machine (GI, T)
The students will determine the relationship between the factors that can control the acceleration of an Atwood's Machine. They will use a photogate to measure the acceleration of the machine. **SP: 2, 3, 4, 5, 6, 7**

Friction Lab (GI, T, WB)
Students will brainstorm and test the variables that affect friction. Each group will collect data on a different variable and the data will be discussed. Through scientific discourse they will determine the relationship between weight and friction. **SP: 1, 2, 3, 4, 5, 6, 7**

Topic 3.1: Review
Topics covered: Students will verify Newton's 1st and 3rd Laws through demos and activities, students will also review what a system is. (TB 2.5, 2.9)

Topic 3.2: Weight, Mass, and Free Body Diagrams
Topics covered: Students will review the relationship between weight and mass and will review how to draw free body diagrams. Students will review what the Universal Law of Gravitation states and how to account for it in free-body diagrams of a system. (TB 2.1-2.4, 2.7)

Topic 3.3: Newton's 2nd Law
Topics covered: The relationship between mass and acceleration. (TB 2.6, 2.8, 2.10)

Topic 3.4: Friction
Topics covered: What friction is, its effects on motion, what affects it. (TB 3.4, 3.6)

Topic 3.5: 2D Forces
Topics covered: Forces with an angle involved. (TB 2.5, 3.1-3.3)

Unit 4: Conservation Laws (Big Ideas 3-5)-13 days

Unit Description: This unit will require students to draw upon their prior knowledge. They will learn about impulse, momentum, conservation of momentum, and collisions in one and two dimensions. They will also cover work, energy in its many forms, and the conservation of energy. Students will connect these new topics to kinematics and dynamics through lab work and problem solving. **[CR2e], [CR2f]**

Labs and Activities [CR6a], [CR6b]
Impulse and Momentum Activity (T)
Students will use technology to verify the impulse momentum theorem when a ball is thrown upward and again caught. **SP: 2, 3, 4, 5, 6, 7**

Collisions Video Analysis (T)
Students will use video analysis to identify if linear momentum is conserved in the collision between a dart and a non-moving cart. **SP: 2, 3, 4, 5, 6, 7**

Egg-Cellent Lab **[CR4]**
In this lab students are asked to create a box to keep an egg safe when it is thrown (not dropped) off the top of the bleachers. They are not allowed to use packing materials for their device. Students are expected to discuss the Impulse-Momentum Theorem (FT=MV) and connect it to Newton's 2nd Law (F=MA). Examples students use to connect this to the real world include seatbelts, airbags, and follow through in sports.
SP: 1, 6, 7

Investigating Work and Energy with Springs (GI, T)
Students will determine the spring constant k of a spring and the mass of an object using their graph. Students will investigate how k changes when springs are in parallel and in series. During this lab students will be asked to Students will also investigate the conservation of mechanical energy of the system by studying mass and spring oscillation. **SP: 1, 2, 3, 4, 5, 6, 7**

Conservation Laws Activity (T)
Students will use Vernier, Logger Pro, and video analysis to validate the work-energy theorem.
SP: 1, 2, 3, 4, 5, 6, 7

Roller Coaster Challenge **[CR3]**
Each group of two students will design and build and use a roller coaster to determine if energy is conserved. Students will provide evidence by using energy charts and mathematical expressions. **LO: 5.B.3.1-3, 5.B.4.2, 4.C.1.1-2**

Topic 4.1: Impulse, Momentum, and 1D Collisions
Topics covered: The relationship between impulse and momentum and the conservation of momentum through collisions will be studied. (TB 5.1-5.6, 6.7)

Topic 4.2: Impulse, Momentum, and 2D Collisions
Topics covered: The ideas of impulse, momentum, and collisions will be studied in two dimensions. (TB 5.7, 6.7)

Topic 4.3: Energy and Conservation of Energy
Topics covered: The idea of energy within a closed system being conserved will be discussed. Types of energy will also be reviewed. (TB 6.2)

Topic 4.4: Work-Energy Theorem
Topics covered: How work is done will be covered. The students will increase their problem solving abilities when they discover that the units of work are the same as the units of energy. (TB 6.1, 6.3-6.4)

Topic 4.5: Energy Conversion
Topics covered: The ways energy can change forms will be studied, a focus will be on the change between PE and KE and friction's role in energy conversion. (TB 6.5, 6.6)

Topic 4.6: Power
Topics covered: The relationship between power and work. (TB 6.8)

Unit 5: Circular and Rotational Motion (Big Ideas 1-5)-15 days

Unit Description: Circular vs. Rotational will be discussed at the onset of the unit. This unit will cover the kinematics of motion that is not linear. Students will learn what causes rotational motion, how it is conserved, and what factors change it. Students will connect these new topics to kinematics and dynamics through lab work and problem solving. **[CR2c], [CR2g]**

Labs and Activities [CR6a], [CR6b], [CR8]
Universal Law of Gravitation (T)
Students will use a PHET simulation to draw conclusions about how mass and radius affect the force between any two objects. **SP: 2, 3, 4, 5, 6, 7**

Centripetal Acceleration (T)
Students will use a PHET simulation to explore the variables involved in rotational motion and will draw some conclusions regarding these variables. **SP: 2, 3, 4, 5, 6, 7**

Torque and Human Joints (GI) **[CR4]**
Students will design and build an apparatus that replicates one of the human body's joint and muscle systems. Each system has a different objective. i.e. For the forearm and the biceps muscle the objective is to determine the biceps tension when holding an object in a lifted position. **SP: 2, 3, 4, 5, 6, 7**

Conservation of Angular Momentum (GI, T, WB)
Students will brainstorm variables to measure, each group will collect data on a different variable, and the data will be discussed. Through scientific discourse the students will determine the relationship between the moment of inertia and the angular momentum of a system. **SP: 1, 2, 3, 4, 5, 6, 7**

Topic 5.1: Circular Motion
Topics covered: Centripetal motion and forces will be the focus of this section. (TB 4.1-4.4)

Topic 5.2: Universal Law of Gravitation
Topics covered: Newton's Universal Law of Gravitation and Kepler's Laws will be qualitatively and quantitatively be explored. (TB 4.5-4.6)

Topic 5.3: Torque
Topics covered: The qualitative idea of torque will be developed. (TB 7.1-7.2)

Topic 5.4: Center of Mass and Translational and Rotational Equilibrium
Topics covered: The idea of center of mass will be qualitatively understood and the idea of how it relates to translational and rotational equilibrium will be developed. (TB 7.4, 7.3)

Topic 5.5: Application of Equilibrium
Topics covered: A quantitative analysis of equilibrium will be studied. (TB 7.5-7.7)

Topic 5.6: Rotational Kinematics
Topics covered: Rotational kinematics will be studied. A connection will be made between linear and rotational kinematics. (TB 8.1-8.2)

Topic 5.7: Rotational Dynamics
Topics covered: Forces and how they are affected by rotational motion will be covered (TB 8.3-8.4)

Topic 5.8: Conservation of Rotational Motion
Topics covered: Rotational momentum and rotational energy are conserved. Students will learn the relationship between angular momentum and rotational inertia.
(TB 8.5-8.7)

Unit 6: Waves (Big Ideas 3, 5, 6)-10 days

Unit Description: Qualitative and quantitative analysis of waves will be studies. How they move, what affects them, and how they affect us will be covered in detail. Students will make the connections between waves and their lives using sound and music. **[CR2d], [CR2j]**

Labs and Activities [CR6a], [CR6b], [CR2d], [CR8]
Pendulums
Students will compare and contrast simple and physical pendulums. **SP: 1, 3, 6, 7**

Pendulum Lab (GI, T, WB)
Students will complete an experiment in which they will identify the variables that control the period of a simple pendulum. Students will determine the variables that can be measured and each group will collect data on a different variable and the data will be discussed. Through scientific discourse the students will determine what affects the period of a pendulum.
SP: 2, 3, 4, 5, 6, 7

Mathematics of Music (T)
Students will use their musical instruments to determine the frequencies of the notes on a music scale and look at the ratio between these notes. They will use this information to determine the patterns used in musical scales. **SP: 1, 2, 3, 4, 5, 6, 7**

Caving Field Trip **[CR4]**
Students will take a field trip to a wild cave where they will see hundreds of bats. They will be able to visualize how bats must use echolocation to survive. Students will follow up the field trip with problems involving bats, echolocation, and waves. **SP: 2, 3, 6, 7**

Gravitational Strength (GI, T)
Building off of what students know about pendulums, energy, and forces students will design a lab to determine the strength of gravity here on Earth. **SP: 1, 2, 3, 4, 5, 6, 7**

Topic 6.1: Oscillatory Motion
Topics covered: Period and frequency will be discussed qualitatively and quantitatively using pendulums and springs. (TB 19.1-19.2)

Topic 6.2: Kinematics and Dynamics of Waves
Topics covered: Speed and acceleration of waves will be studied. Forces in waves will also be covered. Springs will be useful in covering these topics. (TB 19.3-19.4)

Topic 6.3: Energy and Pendulums
Topics covered: The energy of mass and spring systems and pendulum systems will be studied qualitatively and quantitatively. (TB 19.5-19.6)

Topic 6.4: Analyzing Vibrational Motion
Topics covered: Analyzing vibrational motion that include forces and friction will be covered. (TB 19.7-19.10)

Topic 6.5: Mathematics of Sound Waves
Topics covered: How waves and sound work mathematically will be the focus. (TB 20.1-20.4)

Topic 6.6: Wave Interference
Topics covered: Constructive and destructive interference will be covered. How waves are reflected will be studied qualitatively and quantitatively. (TB 20.5–20.6)

Topic 6.7: Sound
Topics covered: Qualities of sound will be studied. Pitch, frequency, and beats will be the focus. (TB 20.7-20.8)

Topic 6.8: Standing Waves
Topics covered: Building on the qualities of sound, standing waves and harmonics will the focus. (TB 20.9-20.11)

Unit 7: Electric Charge and Circuits (Big Ideas 1, 3, 5)-10 days

Unit Description: How charge is transferred and how the electron moves and is affected will be studied. Various rules and laws involving circuits will be covered in detail. **[CR2h], [CR2i]**

Labs and Activities [CR6a], [CR6b]

Charge Conservation (GI)
Various objects will be charged and students will use the ideas of conservation to predict the resulting charge and its sign on each object. They will then test their predictions to see if they are correct. **SP: 1, 3, 4, 6**

Brightness Investigation (GI, T)
Students will make predictions about the brightness of light bulbs in a variety of series and parallel circuits when some of the bulbs are removed. **SP: 1, 3, 4, 5, 6, 7**

Circuits (T)
Students will determine expressions that relate the time rate of change in the electric potential and current to a system. Students will examine the behavior of an AC circuit containing a capacitor, an AC circuit containing a resistor and an inductor, and an AC circuit containing all three elements. **SP: 1, 5, 6, 7**

Topic 7.1: Electric Charge Analysis
Topics covered: Electrostatics, transfer of charge, electric charge, and conservation of charge will be studied. (TB 14.1-14.2)

Topic 7.2: Conductors, Dielectrics, and Electric Fields
Topics covered: How charge is transferred will be studied. (TB 14.3)

Topic 7.3: Coulomb's Law and Electric Potential
Topics covered: Electric force will be covered qualitatively and quantitatively. (TB 14.4-14.7)

Topic 7.4: Electric Fields
Topics covered: Electric fields will be quantitatively studied and connected to Coulomb's Law and Electrostatics. (TB 15.1-15.4)

Topic 7.5: Conductors, Dielectrics, and Capacitors in Electric Fields
Topics covered: Coulomb's Law will be used to understand the role that conductors and dielectrics play a role in electric fields. (TB 15.5-15.8)

Topic 7.6: Electric Current, Circuits, and Ohm's Law
Topics covered: Qualities of electricity will be studied. Various types of circuits will be used to help students understand electricity. (TB 16.1-16.6)

Topic 7.7: Kirchoff's Rules and Resistors
Topics covered: Resistors in series and parallel will be the focus of this topic. (TB 16.7-16.10).