Course: AP Physics 2
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AP® Physics 2 Syllabus - 2021 - 2022

AP Physics 2: Curricular Requirements

- Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.
- The course design provides opportunities for students to develop an understanding of the AP Physics 2 foundational physics principles in the context of the big ideas that organize the curriculum framework.
- Students have opportunities to apply Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.
- The course provides students with opportunities to apply their knowledge of physics principles to real-world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.
- Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.
- Students are provided the opportunity to engage in inquiry-based laboratory investigations that support the foundational principles and apply all seven science practices defined in the curriculum framework.
- The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.
- The course provides opportunities for students to develop written and oral scientific argumentation skills.

Course Introduction

AP® Physics 2 is an algebra-based, introductory college-level physics course that explores fluid statics and dynamics; thermodynamics with kinetic theory; PV diagrams and probability; electrostatics; electrical circuits with capacitors; magnetic fields; electromagnetism; physical and geometric optics; and quantum, atomic, and nuclear physics. These topics will be organized around six big ideas that are intended to allow students to see physics as interconnected pieces of a puzzle. Through inquiry-based laboratory investigations, projects, and teacher demonstrations students will see for themselves the big ideas and how they describe the world around them. This will serve to develop scientific critical thinking and reasoning skills that will make them better informed citizens as consumers and voters. When performing laboratory investigations, students will use probeware technology for data acquisition. They will use graphing calculators and/or graphical analysis software to perform data analysis such as curve fits and percent error. Students should have completed AP Physics 1 with a "C" or better. Students should have completed Pre-Calculus with a "C" or better or be concurrently taking Pre-Calculus.

Six Big Ideas

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.
Big Idea 7: The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems.

Seven Science Practices

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.
Science Practice 2: The student can use mathematics appropriately.
Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.
Science Practice 5: The student can perform data analysis and evaluation of evidence.
Science Practice 6: The student can work with scientific explanations and theories.
Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Textbook

Giancoli, Douglas C. Physics: Principles with Applications, 7/e AP, 2014. Englewood Cliffs, NJ: Prentice Hall

Course Outline

Unit	Topic	Ch
0 MasteringPhysics	Introduction to MasteringPhysics	
1 Fluids [CR2b] (Big Ideas 1, 3, & 5)	Density & Specific Gravity	10
	Pressure, Pascal's Principle	10
	Archimedes Principle	10
	Bernoulli's Principle & Continuity	10
2 Thermal Physics [CR2a] (Big Ideas 1, 4, 5, & 7)	Thermal Expansion	13
	Kinetic Theory	13
	Thermal Conductivity	14
	1st Law of Thermodynamics & PV diagrams	15
	2nd Law of Thermodynamics; Heat Engines, Heat Pumps, & Refrigerators (Real and Ideal)	15
3 Electric Force, Fields, and Potential [CR2c] [CR2d] [CR2e] (Big Ideas 1, 2, 3, 4, & 5)	Charge & Force (Coulomb's Law)	16
	E-Field Due to Point Charges	16
	Potential, Work & PE Due to E-Field of Point Charges	17
	E-Field Between Charged Parallel Plates	16

	Potential, Work & PE Due to E-Field of Charged Parallel Plates	17
4 Capacitance [CR2c] [CR2d] [CR2e] (Big Ideas 1, 2, 3, 4, & 5)	Parallel Plate Capacitors	17
	Energy Stored in Capacitors	17
	Capacitors in Series & Parallel	19
5 Resistance & Steady-State RC Circuits [CR2c] [CR2d] [CR2e] (Big Ideas 1, 2, 3, 4, & 5)	Current, Resistance, Ohm's Law, & Power	18
	Introduction to Kirchhoff, EMF, and Internal Resistance	19
	Series & Parallel Circuits	19
	Kirchhoff's Rules and Steady-State RC Circuits	19
6 Magnetism & Induction [CR2c] [CR2d] [CR2e] (Big Ideas 1, 2, 3, 4, & 5)	Magnets, B-Fields, and Force on Wire in B-Field	20
	Force on Charge in B-Field	20
	B-Fields of Straight Wires, Force Between Two Wires	20
	Faraday's Law of Induction and Lenz's Law	21
7 Geometric Optics [CR2f] (Big Idea 6)	Ray Model, Reflection & Images Formed by Plane Mirrors	23
	Images Formed by Spherical Mirrors	23
	Index of Refraction, Snell's Law, Total Internal Reflection	23
	Images Formed by Lenses	23
8 Physical Optics [CR2f] (Big Idea 6)	Double Slit Interference	24
	Single Slit Diffraction	24
	Diffraction Gratings	24
	Thin Films	24
9 Modern Physics [CR2g] (Big Ideas 1, 3, 4, 5, 6, & 7)	The Electron, Blackbodies, Planck's Quantum Hypothesis	27
	Photoelectric Effect	27
	De Broglie Wavelength for Particles	27
	Energy Levels of Hydrogen-Like Atoms and Ions	27
	Nuclear Reactions and Binding Energy	30
10 Special Relativity Supplemental	Classical & Modern Relativity	26
	Time Dilation & Length Contraction	26
	Relativistic Momentum	26
	Mass & Energy	26
	Galilean & Lorentz Transforms; Relativistic Velocities	26

Teaching Strategies: Scope and Sequence

Discussion-Lecture
Each discussion begins with a demonstration of a physical principle. This approach gets students "hooked" and they stay focused as the principle is discussed and the mathematical formalism is presented. Very often, students will be asked to discuss amongst themselves the demonstration and/or the mathematics behind it. Students are then encouraged to give their interpretation of the principle. With all this accomplished, the students are then ready to try solving some example problems given by the instructor or in the textbook. Students will work in groups to solve the problem and will then be called upon at random to present their solution to the class. Homework problems are assigned which give students more opportunity to hone their skills at critical reasoning.

Problem Assignments

Exercises from the main textbook are assigned almost every day. Some of the assigned exercises were selected on the basis of giving students practice using general physics principles such as the conservation of energy to mathematically model a specific problem and then find a solution. Other exercises involve only a single memorized formula to be used in finding a solution; and even then, the students will know the origin or derivation of the formula. Some class time is used for students to pair up and start their textbook assignments, which often consists of five exercises. This allows their progress to be monitored so immediate assistance can be provided, helping to minimize the frustration level that many students face when attempting to do homework on their own. The next day, the assignments are stamped to check for reasonable attempts at solving the problems. Students can then ask for solutions to be put on the board either by the instructor or by another student who will then explain the method of attack. Additionally students can get extra practice at home by doing textbook exercises not assigned or by downloading exercises from the web. Throughout the course, the point will be stressed that memorizing solution recipes is of little value since it is unlikely that a question on the AP Physics 2 exam will be exactly like the ones memorized.

Lab Experiments

Calculation of Laboratory Time
One laboratory investigation will be performed roughly each 2 weeks. Part of a period will involve a pre-lab discussion and an entire period will be devoted to data collection and part of another period will be devoted to post-lab discussion at which time students will present their findings to the class. This will constitute at least 20% of total instruction time.

Curricular Purpose of Laboratory Investigations
The labs are hands-on and provide an opportunity for students to work collaboratively in small groups of three or four. Each student will be expected to keep a lab composition book for all write-ups. Students are given an objective such as: "Determine how voltage is related to current." Students are expected to work together to design their own experiment to meet the objective. To this end, students will state the problem, form a hypothesis such as 'voltage varies directly with current', write a procedure, make observations, take measurements, record data, perform statistical data analysis, and write a conclusion. In writing the procedure, students will make a decision as to which variable to manipulate (independent variable) and which variable changes as a result (dependent variable) and which variables are to remain fixed (control variables). Analysis of the data includes performing calculations, constructing graphs of independent variable vs. dependent variable and writing the appropriate equation of the graph. This can be done by using a graphing calculator, Excel©, the LabQuest™, and/or Logger Pro. Students then look at the equation and the units of the slope to conclude that the slope must be resistance in the example above.

The labs will mostly be "guided-inquiry" which means students investigate a teacher-presented question using student-designed procedures.

Generally, you will:

- Plan in small groups prior to lab day to determine how you will manipulate the equipment to accomplish the goal and how you will process the data. This may involve some initial play with the equipment. Write down your predictions and assumptions.
- Conduct the experiment and then develop and record your analysis. The analysis should include a discussion of your prior predictions and assumptions as well as possible sources of uncertainty.
- Present your findings in a written report and be prepared to present to the class for critique.

Specifically, you will:

- be given a question to be tested and then form a hypothesis that answers the question
- design an investigation which is a plan for collecting the data you need. Here, you will identify the variables including controls, independent, and dependent.
- follow your procedure to collect and present data to be inserted into a data table.
- analyze and interpret results such as the meaning of your graphs, how your design could be improved to limit errors, and conclusion.

Possible Investigations

Fluids (Hydrostatics)

1. Archimedes Principle (OI)

- Use a Spill Cup and a Scale to determine the weight of water displaced by a small ball.
- Compare the weight of the ball to that of the spilled (displaced) water to see Archimedes Principle in action.

(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Fluids (Hydrodynamics)

2. Torricelli's Theorem (GI)

- To measure the range of a liquid exiting from holes of varying heights in a 2 L plastic bottle.
- The ranges are used to calculate the exit velocity of the liquid to determine the validity of Torricelli's theorem.

(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Thermal Physics (Kinetic Theory)

3. Behavior of a Gas (OI)

- Use a Pressure Sensor, Syringe, and Temperature Probe to collect pressure vs. volume, pressure vs. number of moles, and pressure vs. temperature data for a sample of air in an enclosed container.
- Determine relationships between these pairs of variables.
- Determine a single expression relating these variables.
- Determine the constant of proportionality for the relationship between pressure, volume, and temperature.
- Use kinetic molecular theory (KMT) to model the behavior of the gas at various points on each graph.

(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.4, 7.2)

Thermal Physics (Thermodynamics)

4. Heat Engines (GI)

- Design and create a thermodynamic system consisting of a flask, tubing, syringe, and pressure sensor.
- Relate the terms isothermal, isochoric, isobaric and adiabatic to various thermodynamic processes, and how to move your thermodynamic system through these processes.
- Use a Pressure Sensor, Syringe, and Temperature Probe to collect pressure, volume and temperature data for three of these processes.
- Analyze the various P-V processes to keep track of the work (W) done by or on the enclosed gas and

the heat (Q) transferred between the gas and the surroundings.

- Use the first law of thermodynamics to account for the change in internal energy in each of these processes.
- Determine the total work done by enclosed gas in various thermodynamic cyclic processes.

(Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2)

Electromagnetism (Electrostatics)

5. Electrostatics (GI)

- Use a Charge Sensor and Faraday Pail to measure electric charge.
- Observe and quantify the separation of electrical charge by friction.
- Observe and quantify charging by contact.
- Observe and quantify charging by induction.

(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Electromagnetism (Electrostatics)

6. Coulomb's Law (GI)

- To estimate the net charge on identical spherical pith balls by measuring angle and distance between them.

(Science Practices 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2)

Electromagnetism (Geometrical Factors of Resistance)

7. Resistance and Resistivity (OI)

- Collect potential difference and current data for a number of metal rods.
- Determine the electrical resistance for each of the readings.
- Determine how length, cross-sectional area, and type of material affect the resistance of a metal rod of known resistivity.

(Science Practices 1.2, 1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2)

Electromagnetism (Resistors in Circuits)

8. Series and Parallel Circuits with Resistors (GI)

- Measure potential difference and current at various places in series and parallel circuits.
- Determine the relationship between potential difference and resistance in series circuits.
- Determine the relationship between current and resistance in the branches of a parallel circuit.
- Determine expressions for equivalent resistance for both series and parallel circuits.
- Account for differences in bulb lighting in series and parallel circuits.

(Science Practices 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2)

Electromagnetism (Capacitors in Circuits)

9. Series and Parallel Circuits with Capacitors (GI)

- Measure potential difference and current at various places in series and parallel circuits.
- Determine the relationship between potential difference and capacitance in series circuits.
- Determine the relationship between current and capacitance in the branches of a parallel circuit.
- Determine expressions for equivalent capacitance for both series and parallel circuits.

(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Electromagnetism (Resistors and Capacitors in Circuits)

10. RC Cicuits (GI)

- Collect voltage vs. time data for a capacitor charging through a resistor and also discharging.

•Perform curve fit and determine the time constant for the RC circuit.
(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Electromagnetism (Rate of Change in Magnetic Flux vs. Potential)

11. Faraday's Law: Effect of Changing Flux from a Moving Magnet (GI)

•Fashion a simple coil to collect data.

•Use a Voltage Sensor to collect potential vs. time data for a magnet moving through a coil.

•Account for features of the observed graph of potential vs. time.

•Relate the induced emf to changes in the magnetic flux passing through a coil.
(Science Practices 1.1, 1.2, 1.4, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2)

Geometric Optics (Concave Mirrors)

12. Curved Mirrors (GI)

•Use curved mirrors to produce real and virtual images.

•Explore how the position of the object affects the appearance, orientation, and size of real images produced by concave mirrors.

•Determine the relationship between object distance, image distance, focal length, and magnification in real images produced by concave mirrors.
(Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2)

Geometric Optics (Bi Convex Lenses)

13. Thin Lenses (GI)

•Use lenses to produce real images.

•Explore how lens characteristics and the position of the object affect the appearance, orientation, and size of real images.

•Determine the relationship between object distance, image distance, focal length and magnification in real images produced by bi convex lenses.
(Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2)

Physical Optics (Double Slit)

14. Interference (GI)

•Use the principle of superposition to explain how waves from two sources could interfere constructively or destructively.

•Given the wavelength of laser light, predict the spacing between bright fringes in the pattern.
(Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2)

Physical Optics (Single Slit)

15. Diffraction (OI)

•Use the principle of superposition to explain how waves from two sources could interfere constructively or destructively.

•Calculate the wavelength of laser light passing through the slit, given the distance to the first order minima from the central maxima and the distance from the slit to the screen.

(Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2)

Modern Physics (Atomic)

16. Spectrum of Atomic Hydrogen (GI)

•Use a spectrometer to determine the wavelengths of the emission lines in the visible spectrum of excited hydrogen gas.

•Determine the energies of the photons corresponding to each of these wavelengths.

•Use your data and the values for the electron transitions to determine a value for Rydberg's constant for hydrogen.
(Science Practices 1.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2)

Modern Physics (Quantum Mechanics)
17. Photoelectric Effect (GI)

•Apply voltage across several differently colored LED's in turn.

•Record the voltage that barely lights each LED and multiply this by the charge of an electron. This represents the energy of the electrons in the circuit and hence the energy of each photon of light emitted.

•Plot this energy vs. the frequency of the emitted light and the slope of the graph is Planck's constant.
(Science Practices 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2)

Modern Physics (Nuclear)
18. α, β, γ **Decay (GI)**

•Use a radiation counter to measure the absorption of alpha, beta, and gamma radiation by air, paper, and aluminum.

•Analyze count rate data to test for consistency with your model.
(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Modern Physics (Nuclear)
19. Half-Life Measurement (OI)

•Use a radiation counter to measure the decay constant and half-life of barium-137.

•Determine if the observed time-variation of radiation from a sample of barium-137 is consistent with simple radioactive decay.
(Science Practices 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 7.2)

Real World Activity [CR4] [CR8]

To encourage students to become scientifically literate citizens, they will be required to use their acquired knowledge of physics to analyze a real-world problem. In groups of four, students will do research on green technology applied to homebuilding. They are to find existing designs of homes that will stay cool in the summer and warm in the winter using green technology. They will then use the principles of heat transfer and fluid flow to discover the most efficient materials and architectural designs available. These discoveries will be presented as scientific-based evidence to the class for peer review and critique. Any and all critiques must also be presented in a scientific-based manner as opposed to mere opinions about the designs.

Activity to Cross Enduring Understandings [CR3]

In groups of four, students will use the concepts from fluid dynamics to design and construct a paper boat that will allow one passenger to cross a pool. They will be allowed to use wood glue and paint to create a tight seal to prevent leakage into the boat. They will show design features and calculations to prove their boat will float. To this end, they will show a calculation of the location of the waterline when the passenger is in the boat. This will be dependent on the weight of the passenger, the volume of the boat, and the density of the water in the pool.

Evaluation and Grading

Student understanding of the content will be assessed by the following formats:

- Multiple-Choice and/or Free-Response Exams*
- Multiple-Choice and/or Free-Response Quizzes*
- Laboratory write-ups
- Projects and Presentations
- Chapter Practice Problems
- Daily Participation

* The multiple-choice questions usually involve the use of a single equation or concept. The free-response questions involve the use of several equations or concepts to solve multi-part problems or can be based on a lab investigation done in class. Course grades are based on weighted averages between labs and exams.

Grade Distribution:

- A+ 97.0% or higher
- A 93.0% - 96.9%
- A - 90.0% - 92.9%
- B + 87.0% - 89.9%
- B 83.0% - 86.9 %
- B - 80.0% - 82.9%
- C + 77.0% - 79.9%
- C 73.0% - 76.9%
- C - 70.0% - 72.9%
- D + 67.0% - 69.9%
- D 63.0% - 66.9 %
- D - 60.0% - 62.9%
- F 59.9% or lower

Components of the Grade:

Assessments/Projects	70%
Labs/Coursework	30%

If you have a concern about a grade, please visit Google Classroom to submit a form to bring this to my attention. This is the best method in communicating concerns.

Student Responsibilities:

Students are expected to be prepared and ready to participate in class activities on a daily basis. This participation includes, but is not limited to, completion of class-assigned homework to be turned in, possession of pencils/pens, participation in class and group discussions, and behaving in a respectful and professional manner.

Academic Dishonesty

Any student(s) found exhibiting academic dishonesty, which include but not limited to, plagiarism, use of unauthorized material(s), prohibited communication, etc. will be subject to failure of assignment and/or course without the possibility of a retake or remake of assignment, project, assessment, or course credit.

Assignment Submissions:

Students are expected to turn in all course work by the assigned deadline. I ask that students who are having challenges with submitting assignments by the deadline to communicate to me well before the deadline so we can explore a possible resolution. Assignments submitted late may be accepted for credit with a possibly reduced marked score. Regardless of submission, all students will receive some feedback either individually or as a group on the assignment.

Late and Absent Work

Any student who misses a day of school due to a school approved reason (sick, bereavement, etc.) has **three days after returning** to complete the assignment and/or exam, and **five days to complete a lab** before or after school. Any student turning in late work will without an approved reason may receive reduced credit for the assignment.

Technology Used by the Students

The primary use of technology will be in the laboratory. Students will gather data by using various types of electronic equipment such as the Pasco® Smart Timer™ or the Vernier® LabQuest™ Data Collection Interface together with Vernier's Logger Pro© software package. Students can then use Logger Pro©, Excel© or TI® graphing calculators to perform calculations on their data for analysis. Students will also use TI® graphing calculators ranging from the 83 up to the 89 model to compute numerical answers to textbook problems. Occasionally, students will use computers in class to access websites such as AP Central, Google Classroom, G-Suite, and PHET that feature Java Applets©/HTML5 which simulate physical situations, allowing them to vary one variable to see the effect on another variable.

Digital Etiquette:

All students are to conduct themselves in accordance with district and school policies in all forms of digital communication and student learning management systems (i.e. Google Classroom, Zoom, Google Meets, etc.). Students are expected to attend each class virtually when applicable and check Google Classroom daily for the most up-to-date information and assignments in the course.

Technology Used by the Instructor

The instructor will use much of the equipment described in the student technology section to perform demonstrations of principles that are otherwise difficult to grasp. The instructor will use Google Classroom and G-Suite as an aide in lecturing and delivering curriculum to the students.

Office Hours

The instructor will be available 30 minutes before first period and during snack. Students can request for appointments to meet.

AP Exam Review

There will be roughly three weeks to review for the exam. Students are given free-response questions from several of the prior AP exams. These questions are separated by unit such as 'Mechanical Waves and Sound' or 'Work, Energy, and Power'. The multiple choice questions from one AP Physics 1 released exam are also given. Several problems are assigned each day. The first part of each class day is used to answer any questions students may have about the previously assigned problems. With whatever time remains in a period, students are to work independently on free-response questions.

Parents/Guardians:

I encourage every student's parents and/or guardians to be actively engaged with their student's progress. Please feel free to reach out to me via email and I highly recommend joining your student's Google Classroom to receive weekly progress updates.

Please see the Student Handbook for detailed school policies.

Syllabus Disclaimer

The syllabus is a statement of intent and serves as an implicit agreement between the instructor and the student. Every effort will be made to avoid changing the course schedule but the possibility exists that unforeseen events will make syllabus changes necessary. Remember to check your BOHS email and Google Classroom site often.

Curricular Requirements		Page(s)
CR1	Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.	1
CR2a	The course design provides opportunities for students to develop understanding of the foundational principles of thermodynamics in the context of the big ideas that organize the curriculum framework.	1
CR2b	The course design provides opportunities for students to develop understanding of the foundational principles of fluids in the context of the big ideas that organize the curriculum framework.	1
CR2c	The course design provides opportunities for students to develop understanding of the foundational principles of electrostatics in the context of the big ideas that organize the curriculum framework.	1
CR2d	The course design provides opportunities for students to develop understanding of the foundational principles of electric circuits in the context of the big ideas that organize the curriculum framework.	1
CR2e	The course design provides opportunities for students to develop understanding of the foundational principles of magnetism and electromagnetic induction in the context of the big ideas that organize the curriculum framework.	1
CR2f	The course design provides opportunities for students to develop understanding of the foundational principles of optics in the context of the big ideas that organize the curriculum framework.	1
CR2g	The course design provides opportunities for students to develop understanding of the foundational principles of modern physics in the context of the big ideas that organize the curriculum framework.	2
CR3	Students have opportunities to apply AP Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.	5
CR4	The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.	5
CR5	Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.	2
CR6a	The laboratory work used throughout the course includes a variety of investigations that support the foundational AP Physics 2 principles.	2
CR6b	The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.	2, 3, 4
CR7	The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.	5
CR8	The course provides opportunities for students to develop written and oral scientific argumentation skills.	2

Course Introduction

Textbooks: Students will have access to a print copy of Giancoli, D. *Physics: Principles with Applications*. 7th Edition. Upper Saddle River, NJ: Prentice Hall/Pearson Education, 2013. ISBN 0-13-060620-0. They will also have access to an electronic version of Coletta, V. P., *Physics Fundamentals*. 2nd Edition. Lakeview, MN: Physics Curriculum and Instruction, 2010. ISBN 978-0-9713134-2-2. **[CR1]**

CR1— Students and teachers have access to college-level resources including college-level textbooks and reference materials in print or electronic format.

Chart of topics covered and related big ideas (BI):

Topic	Content
Coordinate systems and special relativity	A review of coordinate systems from AP Physics 1 and an overview of special relativity
Thermodynamics *BI 1, 4, 5, and 7* **[CR2a]**	Thermal energy transfer by conduction, convection and radiation, laws of thermodynamics, entropy and ideal gases, and kinetic theory
Fluid statics and dynamics *BI 1, 3, and 5* **[CR2b]**	Buoyant force, Bernoulli's equation, and the continuity equation
Electric forces, fields, and potential *BI 1, 2, 3, 4, and 5* **[CR2c]**	Coulomb's law, electric fields, and electric potential
Electric circuits *BI 1, 4, and 5* **[CR2d]**	DC circuits and steady-state RC circuits; analysis of circuits using Ohm's law and Kirchhoff's laws
Magnetism *BI 2, 3, and 4* **[CR2e]**	Properties of magnets and how electricity is related to magnetism - magnetic forces and fields
Electromagnetic induction *BI 2, 3, and 4*	How magnetism is related to electricity
Geometirc optics *BI 6* **[CR2f]**	Reflection, refraction, and diffraction
Physical optics *BI 6*	Interference, Young's Two-Slit Experiment, Diffraction, Thin Film Interference

CR2a— The course design provides opportunities for students to develop understanding of the foundational principles of thermodynamics in the context of the big ideas that organize the curriculum framework.

CR2b— The course design provides opportunities for students to develop understanding of the foundational principles of fluids in the context of the big ideas that organize the curriculum framework.

CR2c— The course design provides opportunities for students to develop understanding of the foundational principles of electrostatics in the context of the big ideas that organize the curriculum framework.

CR2d— The course design provides opportunities for students to develop understanding of the foundational principles of electric circuits in the context of the big ideas that organize the curriculum framework.

Topic	Content
Atomic physics *BI 1, 3, 4, 5, 6, and 7*	Energy levels of the electrons in atoms
Nuclear physics *BI 1, 3, 4, 5, 6, and 7* **[CR2g]**	Nuclear reactions
Quantum physics *BI 1, 3, 4, 5, 6, and 7*	

Laboratory investigations and their associated science practices (SP): [CR6a] [CR6b]

Laboratory work is an integral part of physics and students are introduced to a variety of different laboratory experiences. Some labs are expected to develop a specific skill while others are open ended—based on a given objective and an equipment list, the students are required to design their own procedure, data gathering, and analysis. Class time is used to introduce the lab; students can design the lab in their own time and then more class time is given to conduct the experiment and record data. The analyses and report generation are completed as homework. Students perform labs either to discover a fundamental concept or to apply a concept previously discussed. Most laboratory experiences are designed to encourage students to develop their own hypothesis, experiments ,and conclusions. Labs also provide the opportunity to gather and analyze data, and to hone critical thinking skills. Part of the lab experience will require students to present their findings to their peers for a peer review and critique. Students must use the evidence they found in the lab to defend their conclusions. **[CR8]**

Students are engaged in hands-on laboratory work, integrated throughout the course, which accounts for 25% of instructional time.**[CR5]**

Note: the following list of labs are labeled as (G) for Guided-Inquiry or (D) for Directed.

Lab	Topic	Description
Index of refraction (D)	Geometric optics	Use refraction dishes or laser refraction tanks to determine the index of refraction of water. SP 1.4, 2.2, 4.2, 4.3, and 5.1
The magnetic field of a slinky (G)/(D)	Magnetism	Determine the relationship between magnetic field and current, and magnetic field and number of turns for a solenoid. Determine an experimental value for the permeability of free space. SP 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, and 6.2

CR2e— The course design provides opportunities for students to develop understanding of the foundational principles of magnetism and electromagnetic induction in the context of the big ideas that organize the curriculum framework.

CR2f— The course design provides opportunities for students to develop understanding of the foundational principles of optics in the context of the big ideas that organize the curriculum framework.

CR2g— The course design provides opportunities for students to develop understanding of the foundational principles of modern physics in the context of the big ideas that organize the curriculum framework.

CR6a— The laboratory work used throughout the course includes a variety of investigations that support the foundational AP Physics 2 principles.

CR6b— The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.

CR8— The course provides opportunities for students to develop written and oral scientific argumentation skills.

Lab	Topic	Description
Interference (D)	Physical optics	Use a diffraction grating to determine the wavelength of a laser pointer. SP 1.2, 1.4, 2.2, 3.1, 4.1, 4.3, and 5.1
Interference (G) **[CR6b]**	Physical optics	Investigate the relationship between slit spacing and the interference pattern. SP 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, and 6.1
The current balance (D)	Magnetism	Use the current balance apparatus to measure the force on a current-carrying wire in a magnetic field. SP 1.4, 2.1, 2.2, 3.1, 4.1, 5.1, and 5.2
Internal resistance (G) **[CR6b]**	Electric circuits	Measure the internal resistance of various batteries. SP 1.4, 2.1, 2,2, 3.1, 4.1, 4.2, and 5.1
Electric fields (D)	Electrostatics	Determine the electric field pattern for certain 2-D shapes. SP 1.4, 2.1, 2.2, 3.1, 4.1, and 5.1
Deflection of an electron beam (G) **[CR6b]**	Magnetism	Use a cathode ray tube apparatus to determine the relationship between deflection and the deflecting and accelerating voltages. SP 1.4, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, and 7.1
Induction (G) **[CR6b]**	Electromagnetic induction	Qualitatively observe the factors that determine the amount of induced current, such as the number of coils of wire and motion of magnet. SP 1.4, 3.1, 3.2, 3.3, 4.2, 5.1, 5.2, and 6.1
Transformers (G) **[CR6b]**	Electromagnetic induction	Qualitatively observe the transfer of energy between two coils. Determine how the ratio of number of coils affects the voltage and current in each coil. SP 1.2, 3.1, 3.2, 3.3, 4.2, 4.3, 5.1, 5.2, and 6.1

CR5— Students are provided with the opportunity to spend a minimum of 25 percent of instructional time engaging in hands-on laboratory work with an emphasis on inquiry-based investigations.

CR6b— The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.

Lab	Topic	Description
Back emf (D)/(G)	Electromagnetic induction	Observe back emf effects (and internal resistance effects) with a small dc motor. SP 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, and 5.1
Measuring Planck's constant (D)	Quantum physics	Use the forward voltage across LEDs and the wavelength of light emitted to calculate Planck's constant. Use the Vernier spectrometer to measure the wavelength of the peak output of each LED. SP 1.2, 1.4, 2.2, 4.3, and 5.1
Photoelectric effect (D)	Quantum physics	Use apparatus to measure the energy of emitted electrons and calculate the work function of the metal. SP 1.1, 2.2, 4.3, 4.4, and 5.1
Mass of the electron (D)	Magnetism	Use a tuning eye tube to calculate the mass of the electron. SP 1.2, 1.4, 2,2, 3.3, 4.3, 4.4, 5.1, and 6.1
Density and the buoyant force (G) **[CR6b]**	Fluid mechanics	Students design an experiment, using a force sensor, to allow them to calculate the density of an unknown rock and an unknown fluid. SP 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, and 5.2
Determine the focal length of a concave mirror or convex lens (G) **[CR6b]**	Geometric optics	Using a selection of standard lab equipment, determine the focal length of a concave mirror or convex lens. SP 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, and 5.1
Investigate heat engines (G)/(D)	Thermodynamics	Using pressure and temperature sensors on a confined sample of gas, students examine some thermodynamic processes to understand how the internal energy of the system (E_{int} or U) is affected by exchanges of energy between the system and the surroundings. SP 1.1, 1.2, 2.2, 3.1, 4.1, 4.2, 5.1, 5.3, and 6.1

CR6b— The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science practices.

Lab	Topic	Description
Energy levels of hydrogen (D)	Atomic physics	Using the Vernier spectrometer, determine the principal lines in the hydrogen spectrum. Calculate the energies of the transitions and relate them to transitions between energy levels. SP 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, and 6.2

Lab portfolio:

Each student is required to keep a lab portfolio. The portfolio may include reports presented in both poster format and video format, as well as components of those alternative formats. Lab reports are expected to include a statement of the problem/ question, a description of the experimental procedure, data and/or observations, analysis (calculations, graphs, and errors), discussion, and conclusions. **[CR7]**

Real-World Applications:

- Students investigate how the human eye works and conduct experiments to determine which types of lenses are appropriate to correct visual eye defects such as myopia and hyperopia. As an extension, the students may investigate how laser eye surgery (LASIK) works. This activity allows students to apply the following learning objectives (LO):

  LO 6.A.1.2: The student is able to describe representations of transverse and longitudinal waves.

  LO 6.E.3.3: The student is able to make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation.

  LO 6.E.5.1: The student is able to use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses.

  LO 6.E.5.2: The student is able to plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses. **[CR3]**

- Students are required to write two short essays on physics topics to help develop their ability to explain physics concepts. Two possibilities include asking the students to describe the structure, function, and applications of the MRI (Magnetic Resonance Imaging), or asking them to explain how electricity is produced and transported to their house. Essays must include the physics explanations and application. **[CR4]**

CR7— The course provides opportunities for students to develop their communication skills by recording evidence of their research of literature or scientific investigations through verbal, written, and graphic presentations.

CR3— Students have opportunities to apply AP Physics 2 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations.

CR4— The course provides students with opportunities to apply their knowledge of physics principles to real world questions or scenarios (including societal issues or technological innovations) to help them become scientifically literate citizens.