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PHYSICS A/P 2
2022-2023

Document: APPhysics2SyllabusDocument.odt

Curricular Requirements (College Board)[1]

No.	Requirement	Applicable portions of Syllabus
CR1	Students and teachers have access to college-level resources including a college-level textbook and reference materials in or electronic format	Course Materials, p 5, demonstrates approved college-level resources including college-level textbook.
CR2	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 1: Fluids.	See Course Content | Course materials/topics flow, p. 11ff for FLUIDS below, including chapters 11 and 12, which cover all required topics, and address Big Ideas SYS, INT, CON and PRO.
CR3	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 2: Thermodynamics	See Course Content | Course materials/topics flow, p. 11ff for THERMODYNAMICS below, including chapters 13, 14, 15 and reference to Chapter 8, covering all required topics and addressing Big Ideas SYS, INT, CHA, CON and PRO.
CR4	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 3: Electric Force, Field, and Potential.	See Course Content | Course materials/topics flow, p. 11ff for ELECTRIC FORCE, FIELD and POTENTIAL below, including Chapters 18 and 19, including all required topics, and addressing Big Ideas SYS, FLD, INT, CHA, CON

1 These requirements are explicitly listed in the College Board AP document, "AP Physics 2: Algebra Based / Syllabus Development Guide" along with examples of supporting evidence required to meet each of the twelve requirements The ------------ AP Physics 2 Syllabus must conform not only to our ------------ requirements, but also to the College Board AP requirements.

CR5	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 4: Electric Circuits.	See Course Content | Course materials/topics flow, p. 11ff for ELECTRIC CIRCUITS, including Chapters 20, 21 and some material from Chapter 19, covering all required topics, and addressing big Ideas SYS, FLD, CHA, CON.
CR6	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 5: Magnetism and Electromagnetic Induction.	See Course Content | Course materials/topics flow, p. 11ff below for MAGNETISM and ELECTROMAGNETIC INDUCTION, including chapter 22, and 23, which include all required content, and address Big Ideas SYS, FLD, INT CHA.
CR7	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 6: Geometric and Physical Optics.	See Course Content | Course materials/topics flow, p. 11ff below for Geometric and Physical Optics, including Chapters 24, 25, and 27, which include all the required content, and address Big Idea 6, WAV.
CR8	The course provides opportunities to develop student understanding of the required content and related big ideas outlined in Unit 7: Quantum, Atomic and Nuclear Physics	See Course Content | Course materials/topics flow, p. 11ff below for Quantum Atomic and Nuclear Physics, including Chapters 28, 29, 30, 31, and 33, which include all the required content, and address Big Ideas SYS FLD INT CHA CON WAV PRO.
CR9	The course provides opportunities for students to develop the skills related to Science Practice 1: Modeling	Scientific Practice 1: Modeling is incorporated in a large number of laboratories, particularly #4 (Bottle Jack Fluid Hydraulics / Open Inquiry) and #5 (Thermodynamic Efficiency / Open Inquiry) (See Laboratories p 23ff)
CR10	The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines	A very large number of homework assignments include portions of Science Practice 2: Mathematical Routines, as well as Laboratories. In particular: #10 (Electromagnet) and #12 (Lens Lab). (See Laboratories p 23ff)

CR11	The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning	Science Practice 3: Scientific Questioning is particularly evident in Lab #8 (Single Resistor Inquiry) where students pose scientific questions to investigate the relationship between current and potential difference. (See Laboratories p 23ff)
CR12	The course provides opportunities for students to develop the skills related to Science Practice 4: Experimental Methods	Multiple Labs provide opportunities to practice Science Practice 4: Experimental Methods, for example #1 (Boyle's Law Gas Lab/Guided Inquiry) and #4 (Bottle Jack Fluid Hydraulics/Open Inquiry) and #5 (Thermodynamic Efficiency / Open Inquiry). (See Laboratories p 23ff)
CR13	The course provides opportunities for students to develop the skills related to Science Practice 5: Data Analysis	Multiple labs provide opportunities for students to develop skills of Science Practice 5: Data Analysis, for example #8 (Single Resistor Inquiry / Guided Inquiry) and #15 Diffraction Lab / Open Inquiry), in which part of the lab uses a diffraction grating to measure the wavelength of light. (See Laboratories p 23ff)
CR14	The course provides opportunities for students to develop the skills related to Science Practice 6: Argumentation	Multiple labs provide opportunities for students to develop skills related to Science Practice 6: Argumentation, in particular #14 (Electroscope Lab) with claims & predictions of the impact of different photon sources, and #15 (Diffraction Lab, Guided/Open Inquiry) in which students will make claims about the patterns of light and the impact of changes of wavelengths. (See Laboratories p 23ff)

CR15	The course provides opportunities for students to develop the skills related to Science Practice 7: Making Connections	Several labs allow the students to develop skills related to Science Practice 7: Making Connections, including #5 (Thermodynamic Efficiency / Open Inquiry) between water vaporization state change energy and electrical power conversion to heat; #6 (Thermodynamics of air conditioner / Guided Inquiry) between calorimetric changes in air heat content and electrical power input; #7 (Electrostatics / Guided Inquiry) between particle or wave energies and ionization; and #16 (Hydrogen Atom Lab/ Guided Inquiry) between wavelength of light, photon energy and energy transitions within the atom. (See Laboratories p 23ff)
CR16	The course provides students with opportunities to apply their knowledge of AP Physics concepts to real-world questions or scenarios to help them become scientifically literate citizens.	Course Content | Real World Problem (p 20) provides the students with a chance to apply their knowledge to planning and analysis of nuclear warfare civilian protection from damaging impacts of radioactive decay.
CR17	Students spend a minimum of 25 percent of instructional time engaged in a wide range of hands-on laboratory investigations with an emphasis on inquiry-based labs to support the learning of required content and development of science practice skills throughout the course.	See Laboratory Experience p. 21, below, where it is explicitly stated that students will spend a minimum of 25% of instructional time in a wide range of hands-on laboratory investigations with an emphasis on inquiry based labs; the labs are listed with titles and brief explanations and marked appropriately with Guided Inquiry, or Open Inquiry as applicable.
CR18	The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format)	Lab Notebook is required, Laboratory Experience | Lab Notebook p. 21, see below, where explicitly required.

COURSE MATERIALS[2] (CR1)

We will be using multiple textbooks. These include:

PRIMARY TEXTBOOK
College Physics for AP(R) Courses, Irina Lyublinskaya, Greg Wolfe, Douglas Ingram, Liza Pujji, Sudhi O Beroi, Nathan Czuba. OpenStax, Rice University 6100 Main Street MS-375 Houston, Texas 77005, current web version (c) 2017 Rice University. Students will be using both print versions purchased through Amazon, and the downloadable PDF.

College Physics for AP(R) Courses Lab Manual. OpenStax, Rice University, Houston Texas, XanEdu. Copyright 202.

Princeton Review AP Physics 2 Premium Prep, 2021 (or 2022, or 2023). Princeton Press. Copyright 2021 or 2022 or 2023. This text provides terse overview of the required principles, and will provide abundant problems at the appropriate level for homework as well as tests. Students should be aware that this is a COLLEGE level course and all test problems will be at the college level. Students should be able to work any applicable problem from these review texts, presented more likely as an open-ended, "show all your work" problem, or possibly as the concise multiple-choice problem. Students should be aware that the Instructor has a much larger pool of questions from which to draw, so a complete grasp of the **principles** is required.

Physics Laboratory Experiments, ----------------, *unpublished*.[3] From my notes and files of teaching this course successfully more than a decade previously.

Additional research sources and instructional materials from suitable internet sources, as appropriate for each section.[4]

2 These texts meet the level of college-level algebra-based Physics, and thus meet the requirements of Curricular Requirement 1 (CR1).
3 Just as our Chemistry laboratories are now published as a formal textbook, material from this course may also be eventually published for wider usage.
4 Because classical education is *integrative*, our students will be observing the process of scientific development of these theories, models and applications, using additional material as appropriate. This will better prepare them for future academic or scientific service.

COURSE OUTLINE

The ------------- AP Physics 2 course is an extremely advanced and accelerated course that provides selected students who have already proven their advanced abilities in either Honors or AP Chemistry, the chance to pursue the entire curriculum of Physics 2 in an accelerated two-quarter (1 semester) course. Recognizing that this course is expected normally to be taught as an advanced, five-days-a-week full year course, we provide greatly enlarged opportunities for instruction for our specially chosen students:

Monday 0800-1100	Advanced problem solving and/or Laboratory
Tuesday	50-minute regular class period
Wednesday	50-minute regular class period
Thursday	50-minute regular class period
Friday	50-minute regular class period

Additional instructional time by appointment as needed. Because of our very small class size, we can be more flexible...

The course includes abundant inquiry-based experience for our students as well as teacher-oriented lecture, including derivations of equations, demonstrations of physical phenomena, vocabulary related to the content, and most importantly, probing of the students' grasp of the material and the problem solution techniques. The content of the course addresses the following 7 "Big Ideas"[5]:

Big Idea 1 -- Systems (SYS) Objects and systems have properties such as mass and charge. Systems may have internal structure.

Big Idea 2 -- Fields (FLD) Fields existing in space can be used to explain interactions.

Big Idea 3 -- Force Interactions (INT) The interactions of an object with other objects can be described by forces

Big Idea 4 -- Change (CHA) Interactions between systems can result in changes in those systems

Big Idea 5 -- Conservation (CON) Changes that occur as a result of interactions are constrained by conservation laws.

Big Idea 6 -- Waves (WAV) 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.

5 These BIG IDEAS are an important component of the College Board AP Course, and Course Audit. They provide our students with an overview lens of looking at the universe from the viewpoint of a physicist.

Big Idea 7 -- Probability (PRO) The mathematics of probability can be used to describe the behavior of complex systems and to interpret the behavior of quantum mechanical systems.

STUDENT PRACTICE

Throughout each unit, students will get a list of important TOPICS and key understanding that must be achieved. There will be presented via the weekly/biweekly "packets" of course scheduling and course problems. *In our course, students will normally have homework questions to answer after every lecture and experience*.[6] Our students are very familiar with this process from their time in Chemistry. These questions will begin or reach at the A/P level, every question based, in one way or another, on published A/P Exams--setting the *rigor* of the course is easy-- all work must be at college level! It is our policy that all collected student work is graded absolutely as soon as possible, and *almost always* returned the very next class period so that the students get **immediate and pointed feedback of their progress**. Our work will generally involve multi-step calculations and logical steps. It is our policy that student work is carefully reviewed LINE BY LINE so that very detailed corrections can be made to A/P students' work. While many of the problems of an AP Test involve immediate application of principle and experience from addressing problems and a multiple-choice answer, in general this is not a multiple choice class. Students are very familiar with the requirement that they must be able to provide a logical flow of all solutions, starting from fundamental principles and proceeding step-by-step with all units and conversions demonstrated.

At the end of each Unit or at key points, students will have some form of a Personal Progress Check which may be a homework assignment, or an examination, to allow them to measure and evaluate their performance. These are graded as soon as possible and generally returned the very next period, during which there is extensive review of all the problems. It has not been a significant issue that this caliber of students enrolled in this A/P class would fall behind, but in that event, individualized tutoring can be provided to bring that student back up to speed.

6 In a large percentage of the homework problems, selection of a valid mathematical routine to solve the problem will be a key portion of the problem. (SP2.1) The mathematical routine must be applied properly (SP2.2) and in many problems there may be a degree of estimation of reasonable quantities (SP2.3). These will provide many opportunities to help meet Course Requirement 10 (CR10), along with Laboratories.

COURSE CONTENT

The College Board emphasizes the following Scientific Practices that are widely referenced (sometimes with minor variations) in the literature of scientific advancement and education:[7] [8] [9]

SCIENTIFIC PRACTICES

No.	Topic	Description
1	Modeling	Use representations and models to communicate scientific phenomena and solve scientific problems.
	1.1	The student can **create** representations and models of natural or man-made phenomena and systems in the domain.
	1.2	The student can **describe** representations and models of natural or man-made phenomena and systems in the domain.
	1.3	The student can **refine** representations and models of natural or man-made phenomena and systems in the domain.
	1.4	The student can **use representations and models** to analyze situations or solve problems qualitatively and quantitatively.
	1.5	The student can **re-express key elements of natural phenomena across multiple representation in the domain.**
2	Mathematical Routines	Use mathematics appropriately
	2.1	The student can *justify* the **selection of a mathematical routine** to solve problems.
	2.2	The student can **apply mathematical routines** to quantities that describe natural phenomena
	2.3	The student can **estimate numerical quantities** that describe natural phenomena.
3	Scientific Questioning	Engage in scientific questioning to extend thinking or to guide investigations within the context of the AP Course
	3.1	The student can **pose** scientific questions

7 From "Science Practices," AP Physics 1: Algebra-Based Course and Exam Description. Accessed 8/5/2022 at: https://apcentral.collegeboard.org/courses/ap-physics-1

8 The Eight Science and Engineering Practices You Need to Know, Elizabeth Chapman, accessed 8/5/2022 at: https://medium.com/@egchapma/the-eight-science-and-engineering-practices-you-need-to-know-cf813c206879

9 NGSS 8 Science Practices - Definitions and Examples. Instructional leadership for science practices (ILSP). Accessed 8/5/2022, at http://www.sciencepracticesleadership.com/uploads/1/6/8/7/1687518/8_practices_v4.pdf

No.	Topic	Description
	3.2	The student can **refine** scientific questions.
	3.3	The student can **evaluate** scientific questions.
4	Experimental Methods	Plan and implement data-collection strategies in relation to a particular scientific question.
	4.1	The student can justify the **selection of the kind of data needed** to answer a particular scientific question.
	4.2	The student can **design a plan for collecting data** to answer a particular scientific question.
	4.3	The student can **collect data** to answer a particular scientific question.
	4.4	The student can **evaluate sources of data** to answer a particular scientific question.
5	Data Analysis	Perform data analysis and evaluation of evidence
	5.1	The student can **analyze data** to identify patterns or relationships.
	5.2	The student can **refine observations and measurements** based on data sources
	5.3	The student can **evaluate the evidence** provided by data sets in relation to a particular scientific question.
6	Argumentation	Work with scientific explanations and theories.
	6.1	The student can **justify claims with evidence**
	6.2	The student can **construct explanations of phenomena based on evidence** produced through scientific practices.
	6.3	The student can **articulate the reasons that scientific explanations and theories are refined or replaced**.
	6.4	The student can **make claims** and predictions about natural phenomena based on scientific theories and models.
	6.5	The student can **evaluate alternative scientific explanations**.
7	Making Connections	Connect and relate knowledge across various scales, concepts, and representations in and across domains.
	7.1	The student can **connect phenomena and models across spatial and temporal scales**.
	7.2	The student can **connect concepts in and across domain(s)** to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

Course materials/topics flow:

Major Topic	Corresponding AP Physics2 Unit Material	Big Ideas
UNIT 1: FLUIDS[10] 10-12% Weighting, Approx 14-17 class periods		
Chapter 11: Fluid Statics		Chapter 11 addresses Big Idea 1 (SYS), particularly EU 1.A, 1.E, Big Idea 3 (INT), particularly EU 3.A, 3.B, 3.C Big Idea 7 (PRO), particularly EU 7.A
What is a fluid?	1.1 Fluid Systems	
Density	1.2 Density	
Pressure	1.3 Fluids: Pressure & Forces	
Variation of pressure with depth in a fluid	1.3 Fluids: Pressure & Forces	
Pascal's principle	1.4 Fluids and free-body diagrams	
Gauge pressure, absolute pressure, and pressure measurement	1.4 Fluids and free-body diagrams	
Archimedes principle	1.5. Buoyancy	
Cohesion and adhesion in liquids: surface tension and capillary action	1.4 Fluids and free-body diagrams	
Optional: pressures in the body		
Chapter 12: Fluid Dynamics and Biological and Medical Applications		
Flow rate and its relation to velocity	1.7 Conservation of mass flow rate in fluids	
Bernoulli's equation	1.6 Conservation of energy in fluid flow	Chapter 12 addresses Big Idea 5 (CON), particularly EU 5.B, EU 5.F
The most general application of Bernoulli's equation		
Overview: Viscosity and laminar flow; Poiseuille's law		
Overview: The onset of turbulence		
Overview: Motion of an object in a viscous fluid		
Optional: Molecular transport phenomena: diffusion, osmosis and related processes		
UNIT 2: Thermodynamics 12-18% Weighting, Approx 15-20 Class periods		

10 Note that OpenStax College Physics for AP(R) Courses includes significant additional information for the Fluids area, particularly with additional material on turbulent flow and biomedical/medical applications. Due to the constrains of time, we will cover these rather lightly, with main emphasis given to the essential components of the AP Physics2 requirements.

Chapter 13 Temperature, Kinetic Theory, and		Chapter 13
the Gas Laws		addresses
Temperature	2.2 P, T, Equil. and Ideal Gas law	Big Idea 3 (INT),
Thermal Expansion of solids and liquids	2.2 P, T, Equil. and Ideal Gas Law	particularly EU
The idea gas law	2.2 P, T, Equil. and Ideal Gas Law	3.A;
Kinetic theory: atomic and molecular	2.2 P, T. Equil. and Ideal Gas Law	Big Idea 7 (PRO)
explanation of pressure and temperature	2.3 Thermodynamics and forces	in particular EU
	2.8 Thermodynamics and elastic	7.A.
[Additional reference:	collisions; conservation of	Boundary
Chapter 8	momentum	Statement:
8.6 Collisions of Point Masses in Two	2.9 Thermodynamics and inelastic	Includes full 2-D
Dimensions]	collisions: conservation of	treatment of cons.
	momentum	of mom. and
		velocity of center
		of mass; involves
		content including
Phase changes		nuclear decay,
Humidity, evaporation and boiling		nuclear reaction,
		interactions of
Chapter 14 Heat and Heat Transfer methods		subatomic particles
Heat	2.1 Thermodynamic systems	with each other
Temperature change and heat capacity		and photons.
Phase change and latent heat		
Heat transfer methods	2.6 Heat and Energy transfer	Chapter 14
Conduction	2.10 Thermal Conductivity	addresses
Convection	2.5 Thermodynamics & contact	Big Idea 1 (SYS),
Radiation	forces	particularly EU
		1E;
		Big Idea 3 (INT),
		particularly 3.B,
Chapter 15 Thermodynamics	2.1 Thermodynamic systems	3.C;
The first law of thermodynamics	2.4 Thermodynamics and free	Big Idea 4 (CHA);
	body diagrams	particularly EU 4C
The first law of thermodynamics and	2.7 Internal energy and energy	Big Idea 5 (CON),
some simple processes	transfer	particularly EU
Introduction to the second law of	2.7. Int. energy and energy transf.	5.B
thermodynamics: heat engines and their		
efficiency		Chapter 15
Carnot's perfect heat engine: The second		addresses
law of thermodynamics restated		Big Idea 4 (CHA),
Applications of Thermodynamics: heat		particularly EU
pumps and refrigerators		4C;
Entropy and the second law of		Big Idea5 (CON),

thermodynamics: disorder and the unavailability of energy Statistical interpretation of entropy and the second law of thermodynamics: the underlying explanation	2.11 Prob., T. Equil, and Entropy	particularly EU 5.B; Big Idea 7 (PRO) particularly EU 7.B
UNIT 3: Electric Force, Field, and Potential 18-22%; approx 23-25 class periods Chapter 18 - Electric Charge and Electric Field Static electricity and charge: conservation of charge Conductors and insulators Conductors and electric fields in static equilibrium Coulomb's Law Electric Field Lines: multiple charges Electric Field: concept of a field revisited (add additional comparison of gravitational and electromagnetic forces to the discussion on Example 18.1 on page 799) Electric Field lines: multiple charges Electric forces in biology Chapter 19 - Electric Potential and Electric Field Electric potential energy: potential difference Electric potential in a uniform electric field Electrical potential due to a point charge Equipotential lines Capacitors and Dielectrics Overview: Capacitors in series and parallel Energy stored in Capacitors	3.1 Electric systems 3.2 Electric charge 3.3 Conservation of electric charge 3.4: Charge distribution: friction, conduction, and induction 3.7 Electric forces and free-body diagrams 3.8 Describing electric force 3.9 Gravitational and Electromagnetic forces 3.10 Vector and scalar fields 3.11 Electric charges and fields 3.12 Isolines and electric fields 3.12 Isolines and electric fields 3.12 Isolines and electric fields 3.12 Isolines and electric fields 3.13 Conservation of Electric energy 3.5 Electric permittivity	Chapter 18 addresses Big Idea 1 (SYS), particularly EU 1A; Big Idea 2 (FLD), particularly EU 2.C; Big Idea 3 (INT), particularly EU 3.A, 3.C Big Idea 4 (CHA) particularly EU 4.E; Big Idea 5 (CON), particularly EU 5.A, 5.C Chapter 19 addresses Big Idea 1 (SYS), particularly EU 1.E; Big Idea 2 (FLD), particularly EU 2.C, 2.E; Big Idea 4 (INT), particularly EU 4.E; Big Idea 5 (CON), particularly EU 5.B

UNIT 4: Electric Circuits		
10-14% ; Approx 14-16 class periods		
Chapter 20 - Electric Current, Resistance and Ohm's Law		Chapter 20 addresses
Current	4.1 Definition and conservation of electric charge	Big Idea 1 (SYS) particularly EU 1.B;
Ohm's Law: resistance and simple circuits		
Resistance and resistivity	4.2 Resistivity and resistance	
[Chapter 19: Capacitors and Dielectrics]	4.3 Resistance and Capacitance	Big Idea 4 (CHA) particularly EU 4.E
Electric power and energy		
Alternating current versus direct current		
Electric Hazards and the human body		Big Idea 5 (CON) particularly EU 5.B
Nerve conduction - electrocardiograms		
Chapter 21 - Circuits, Bioelectricity and DC instruments		Material from Ch 19 addresses Big Idea 2 (FLD);
Resistors in series and parallel	4.4 Kirchhoff's Loop Rule	
Electromotive force; terminal voltage (complex DC circuits)		Chapter 21 addresses
Kirchhoff's Rules	4.4 Kirchhoff's Loop Rule	
	4.5 Kirchhoff's Junction Rule and the Conservation of Electric Charge	Big Idea 4 (CHA) particularly EU 4.E;
		Big Idea 5 (CON) particularity EU 5.B
Overview: DC voltmeters and ammeters		
Overview: Null measurements		
DC circuits containing resistors and capacitors	4.3 Resistance and Capacitance	

UNIT 5: Magnetism and Electromagnetic Induction 10-12% weighting; approx 13-15 periods		
Chapter 22: Magnetism Magnets Ferromagnets and electromagnets Magnetic fields and magnetic field lines Magnetic field strength: force on a moving charge in a magnetic field Overview: The Hall Effect Magnetic force on a current-carrying conductor Torque on a current loop: motors and meters Magnetic fields produced by currents; Ampere's law Magnetic force between two parallel conductors More applications of magnetism	 5.1 Magnetic systems 5.2 Magnetic permeability and magnetic dipole moment 5.3 Vector and scalar fields 5.4 Monopole and dipole fields 5.5 Magnetic fields and forces 5.6 Magnetic forces 5.6 Magnetic forces 5.6 Magnetic forces 5.6 Magnetic forces 5.7 Forces Review 5.6 Magnetic forces 5.7 Forces Review	Chapter 22 addresses Big Idea 1 (SYS), particularly EU 1.3 Big Idea 2 (FLD), particularly EU 2.D Big Idea 3 (INT), particularly EU 3.C Big Idea 4 (CHA) particularly EU 4.E.
Chapter 23: Electromagnetic Induction, AC Circuits and Electrical Technologies Induced EMF and magnetic flux Faraday's law of induction; Lenz's Law Motional EMF Overview Eddy currents and magnetic damping Optional: Electric generators Overview: Back EMF Optional: Transformers Optional: Electrical safety: systems and devices Overview: Inductance Optional: RL circuits Optional: Reactance, inductive and capacitive Optional: RLC Series AC Circuits	 5.8 Magnetic flux 5.8 Magnetic flux 5.8 Magnetic flux	Chapter 23 addresses Big Idea 4 (CHA), particularly EU 4.E

UNIT 6: Geometric and Physical Optics 12-14% Approx 15-18 class periods		
Chapter 24: Electromagnetic Waves Maxwell's Equations: electromagnetic waves predicted and observed Production of electromagnetic waves The electromagnetic spectrum Energy in electromagnetic waves	6.1 Waves 6.2 Electromagnetic waves 6.3 Periodic waves 6.4 Refraction Reflection, and Absorption 6.5 Images from Lenses and Mirrors	Chapter 24 addresses Big Idea 1 (SYS), particularly EU 1.E; Big Idea 6 (WAV), particularly EU 6.A; 6.B; 6.F.
Chapter 25: Geometric Optics The Ray aspect of light The law of reflection The law of refraction Total internal reflection Dispersion: The rainbow and Prisms Image formation by Lenses Image formation by mirrors	6.4 Refraction, Reflection and absorption 6.4 Refraction, reflection and absorption 6.4 Refraction, reflection, and absorption 6.4 Refraction, reflection and absorption 6.5 Images from lenses and mirrors 6.5 Images from lenses and mirrors	Chapter 25 addresses Big Idea 6 (WAV), particularly EU 6.3, EU 6F
Chapter 27: Wave Optics The wave aspect of light: interference Huygen's Principle: Diffraction Young's double slit experiment Multiple slit diffraction Single slit diffraction Limits of Resolution: the Rayleigh criterion Thin film interference Polarization	6.6 Interference and Diffraction 6.6 Interference and Diffraction 6.6 Interference and Diffraction 6.6 Interference and Diffraction 6.6 Interference and Diffraction 6.6 Interference and Diffraction	Chapter 27 addresses Big Idea 6 (WAV), particularly EU 6.a
UNIT 7: Quantum, Atomic and Nuclear Physics 10-12% Approx 13-15 class periods Chapter 28 Special Relativity		Chapter 28 addresses Big Idea1 (SYS),

Einstein's Postulates Simultaneity and time dilation Length contraction Relativistic addition of velocities Relativistic momentum Relativistic energy	 7.3 Energy in modern physics (energy in radioactive decay and $E = mc^2$) 7.4 Mass-Energy equivalence	particularly EU 1.C; Big Idea 3 (INT), particularly EU 3.A; Big Idea 4(CHA), particularly EU 5.B
Chapter 29 Introduction to Quantum Physics Quantization of energy The photoelectric effect Photon energies and the electromagnetic spectrum The particle-wave duality The wave nature of matter Probability: The Heisenberg uncertainty principle The particle-wave duality reviewed	 7.6 Photoelectric effect 7.5 Properties of waves and particles[11] 7.7 Wave functions and probability[12]	 Chapter 29 addresses Big Idea 1(SYS), particularly EU 1.D; Big Idea 5 (CON), particularly EU 5.B and 5.D; Big Idea 6 (WAV), particularly EU 6.F, EU 6.G; Big Idea 7 (PRO),particularly EU 7.C
Chapter 30 Atomic Physics Discovery of the Atom Discovery of the Parts of the atom Bohr's theory of the hydrogen atom X rays: atomic origins and applications Applications of atomic excitations and de-excitations The wave nature of matter causes quantization Quantum numbers and rules The Pauli Exclusion principle	 7.5 Properties of waves and particles	Chapter 30 addresses Big Idea 1 (SYS), particularly EU 1.A, 1.B;
Chapter 31 Radioactivity and Nuclear Physics Nuclear Radioactivity Radiation Detection and Detectors Substructure of the nucleus	 7.2 Radioactive decay[13] [14] 7.2 Radioactive decay 7.1 Systems and fundamental	Big Idea 5 (CON), particularly EU 5.B;

11 Includes wave-particle duality; wave nature of particles (demonstrated in single/double slit); interference patterns that can only involve waves; de Broglie wavelength; diffraction of electrons.

12 Includes wave functions, probabilistic nature of location of electrons; energy states; impact of photon absorption and emissions.

13 Including concepts of linear momentum, elastic, inelastic collisions, kinetic energy and center of mass effects of of sub atomic particles.

14 Applications of conservation of nucleon number and conservation of electric charge.

	forces[15]	Big Idea 7 (PRO), particularly EU 7.C
Nuclear decay and conservation laws	7.2 Radioactive decay	
Half-life and activity	7.2 Radioactive decay	
Binding Energy		
Tunneling		
Chapter 33 Particle Physics		
The yukawa Particle and the Heisenberg Uncertainty Principle Revisited		
The four basic forces	7.1 Systems and fundamental forces[16]	
Accelerators create matter from energy	7.1 Systems and fundamental forces	Chapter 31 addresses Big Idea 1 (SYS), particularly EU 1.A; Big Idea 3 (INT), particularly EU 3.g; Big Idea 5 (CON), particularly EU 5.B, 5.C Big Idea 7 (PRO), particularly EU 7.C
Particles, patterns and conservation laws	7.1 Systems and fundamental force	
Quarks: Is that all there is?		
GUT: The unification of forces		
		Chapter 33 addresses Big Idea 1(SYS), particularly EU 1.A, 1.C, 1.E; Big Idea 2 (FLD), particularly EU 2.A; Big Idea 3 (INT) particularly EU 3.G; Big Idea 4 (CHA), particularly EU 4; Big Idea 5 (CON)

15 "Students will not be expected to know specifics of quark charge or quark composition of nucleons."
16 "Students will not be expected to know specifics of quark charge or quark composition of nucleons."

		particularly EU 5.B, 5.C

REAL-WORLD PROBLEM (CR16)

Students will be asked to study the likely wind drift of radioactive material from the King's Bay nuclear submarine base, if attacked with fission/fusion weapons, and likely arrival data to our city of Gainesville, Florida. Using data on the typical products of a ground-blast or low-altitude attack, and their half-life and activity profiles, students will be asked to design (or evaluate, if suitable exiting structures are located) structures that would result in significant civil defense life saving during the immediate post-attack radiation period. The results will be orally presented by small groups, defending their claims and analyses, and in individual reports from participants. (CR 16)

LABORATORY EXPERIENCE

Laboratories are extremely important to the development of the physics education. Our students already have very significant exposure to physical laboratory practices because of the advanced nature of our Chemistry course, which all have completed very successfully.

As explicitly required by the College Board, labs will occupy at least 25% of our instructional time, and may incorporate more time.[17] (CR17) In a 20 week accelerated program of Physics 2, this means that the laboratory effort will subsume on the order of 35 total hours -- **or 1.75 hours PER WEEK**. [18] Adding scientific inquiry to lecture results in significantly more effective physics education.[19] This is why the College Board so strongly urges double-sessions for laboratories. Inquiry and measurement will be key characteristics of our laboratories. Setting up laboratories requires quite significant effort and time. Our students will need to be joining in at time to help bring about the required laboratory. There is no time to be reading the laboratory during the allotted time for completion -- **students must have adequate time to prepare adequately for the required laboratories so that they can move with agility through the paces of the lab and even assist in the work to bring it about.** This is part of the effort of understanding the scientific process.

The AP approach to learning also includes a continuum from confirmation, structured inquiry, to guided inquiry, and open inquiry The level of investigations in an AP Physics 2 class is expected to focus primarily in the area of guided and open inquiry. However, an individual lab may incorporate varying degrees of student decision-making, appropriate for each segment of the laboratory..[20] See examples of AP Labs published at: https://apcentral.collegeboard.org/media/pdf/ap-physics-2-investigation-1-8.pdf My reading of that document indicates the majority of the Laboratories are at the "directed inquiry" stage.

LAB NOTEBOOK (CR18)

All students are required to maintain a LAB NOTEBOOK including a record of all their laboratory work.[21] They may utilize provided paperwork or their own design, but each laboratory report, when submitted, must include

- Title
- Object/Problem
- Design of the Experiment ("Methods")
- Data ("Results")
- Calculations, Graphs other analysis including any references to mathematical methods with full reference as in in a scientific paper.
- Conclusions, including weaknesses and strengths of the work, and recommendations for improvements.

17 This is in compiance with AP Course Requirement 17 (CR17)
18 The Sample Syllabus for an A/P Course has more than twenty laboratories.
19 See: Hussain A, Azeem M, Shakoor A, Physics Teaching Methods: Scientific Inquiry Vs. Traditional Lecture. http://www.ijhssnet.com/journals/Vol_1_No_19_December_2011/28.pdf
20 See "Guided Inquiry in AP Physics 2", AP Physics 2: Algebra-Based Course and Exam Description
21 This is in compliance with AP Course Requirement 12 (CR18)

Students may provide advanced electronic presentation in addition, but if so, they must be maintained on an available electronic medium, accessible for at least the subsequent 3 years, and providing sufficient privacy for the student. URLs or other identifiers for electronic presentation must be properly provided in their paper laboratory report.

Inquiry

The AP College Board emphasizes the need to develop certain Scientific Practices, skills important to scientific inquiry. As our students gain more grasp of techniques, we can move labs from more Guided Inquiry (where more structure is provided by the Instructor) to more Open Inquiry, where the students take on more and more of the tasks of defining the goals, techniques, and refinements on the way to data gathering, interpretation and conclusions.

Laboratories[22]

No.	Laboratory	Detail	Science Practices	Course Requirements
1	Boyle's Law Gas Lab (Guided Inquiry)	Boyle's' Law apparatus to measure V versus P - Simple set up with lubricated glass syringe and changing masses with measurement of resulting volume. Students will be given an incorrect relationship between ideal gas law quantities and then refine the experiment to determine the correct relationship.	SP 1.3, 1.4 SP 2.2 SP 3.2 SP 4.2, 4.3P SP 5.1,5.3 SP 62,6.3.	CR9 CR10 CR11 CR12 CR13 CR14
2	Gas PV Work Lab (Open Inquiry)	Extension of Boyle's Law Lab to calculate work done on gas with transitions using Riemann sums and explain and justify the conclusions reached.	SP 2.1, 2.2 SP 4.1, SP 5.1, 5.3, SP 6.1, 6.2	CR10 CR12 CR13 CR14
3	Fluid Dynamics (Guided Inquiry)	Application of Torricelli's Theorem to 2L bottle with multiple holes. Students will solve Bernoulli's equation for final velocity of water from holes.	SP 2.2 (Mathematical Routines)	CR10
4	Bottle Jack Fluid Hydraulics (Open Inquiry)	Use automotive bottle jack to quantitate hydraulic effects and explore conservation of energy. This laboratory activity will require that the students design a plan to collect data to explore the hydraulic effects and conservation of energy.	SP 1.1 SP 2.2, 2.3 SP 4.1, 4.2, 4.3 SP 5.1	CR9 CR10 CR12 CR13

22 These labs may not be carried out in exactly this sequence.

5	Thermodynamic Efficiency (Open Inquiry)	Hair Dryer efficiency. Quantitate water vaporized by mass changes and energy utilized by measurement of current/voltage.[23]	SP 1.1, 1.2 SP 2.1, 2.2 SP 3.1 SP 4.1, 4.2,4.3, 4.4 SP 5.1 SP 6.1, 6.2 SP 7.1, 7.2	CR 9 CR10 CR11 CR12 CR13 CR14 CR15
6	Thermodynamics of air conditioner (Guided Inquiry)	Measuring coefficient of performance of window air conditioner using gas volumes from large garden bags and temperature measurements. (Calorimetry applied to a heat engine).	SP 1.2 SP 2.2, 2.3 SP 4.3 SP 5.1 SP 6.1 SP 7.2	CR 9 CR10 CR12 CR13 CR14 CR15
7	Electrostatics (Guided Inquiry)	Charged tape / charged balloons and calculations of electrostatic forces Additional demonstration: depletion of charge with radioactive irradiation; making connections between particle or wave energies and ionization.	SP 2.2 SP 5.1 SP 6.2 SP 7	CR10 CR13 CR14 CR15
8	Single Resistor Inquiry (Guided Inquiry)	Using a single resistor, students will create a plot of current versus potential difference and pose scientific questions to investigate how these quantities are related (Ohm's Law).	SP3.1, 3.3 SP 4.2, 4.3 SP 5.1, 5.2,5.3 SP 6.1, 6.2	CR11 CR12 CR13 CR14
9	Resistor circuits (Guided Inquiry)	Measurements of current and voltages in resistor systems. Students will use wiring diagrams to construct one or more electrical circuits and determine both the theoretical and experimental resistance of the circuit.	SP 1.1,1.4 SP 2.2 SP 4.3 SP 5.1	CR9 CR10 CR12 CR13

23 Our students already have experience using a wrap-around ammeter.

10	Electromagnet (Open Inquiry)	Creation of electromagnet and measurement; creating a representation of the magnetic field created, making connections between electrical currents, and magnetic fields. Students will discuss their representations in their peer groups and in their report.	SP 1.1, 2.2 SP 2.1,2.2 SP 4.2,4.3 SP 5.1 SP 6.2 SP 7.2	CR9 CR10 CR12 CR13 CR14 CR15
11	Back EMF (Guided Inquiry)	Generation of back EMF using spark coil and analysis of data to estimate of parameters using high voltage resistive step-down network and oscilloscope.	SP 1.2 SP 2.2 SP 4.3 SP 5.1, 5.2	CR9 CR10 CR12 CR13
12	Lens Lab (Guided Inquiry)	Creation of simple pinhole and single lens camera and conversion to telescope. Students will use mathematical routines to determine the focal length of a lens as part of this Inquiry.	SP 2.1,2.2 SP 4.3 SP 6.1	CR10 CR12 CR14
13	Total Internal Reflection Lab (Open inquiry)	Observations to confirm the existence of total internal reflection and measurement of angles	SP 1.1 SP 4.1, 4.2 SP 5.1 SP 6.1, 6.2	CR9 CR12 CR13 CR14
14	Electroscope Lab (Guided Inquiry)	Photoelectric effect on electroscope. Measurement of charge decay with various wavelengths of applied light. The student must make claims and/or predictions during this laboratory inquiry, where they must use the photon model of energy.	SP 4.3 SP 5.1 SP 6.1, 6.2	CR12 CR13 CR14
15	Diffraction Lab (Open Inquiry)	Use of diffraction grating to measure wavelength of light from various lasers. Students will make claims about the pattern the light will make after passing through the grating and how the passage will change if the wavelength of light is altered. Analysis of Data is used to validate and refine their claims / predictions.	SP 4.2,4.3 SP5.1, 5.2, 5.3 SP6.1, 6.2	CR12 CR13 CR14
16	Hydrogen Atom lab (Guided Inquiry)	Measurement of wavelength and calculation of photon energy of various hydrogen atom energy transitions and assignment to Bohr orbits. Students will	SP 4.3 SP 5.1 SP 7.2	CR12 CR13 CR15

		make connections between the radii of presumed electron orbitals, their resulting energy, and the wavelength of emitted light and energy.[24]		

24 Students from our Chemistry class will already be familiar with this investigation.

Classical Christian Science Teaching

We are at a classical Christian school. Traditionally the theory of classical Christian education revolves around a trivium of Grammar, Logic, and Rhetoric. These categorizations apply well to many of the subjects of the humanities. It has been questioned at times, and formally discussed how much difficulty there is in applying these to the Sciences and Mathematics. In my experience, in teaching Che misty and Physics, we are teaching all three levels to each class. The Grammar of Chemistry involves understanding the components of the atom, the fundamental forces that exist in our Universe, the names of elements, their characteristics. Logic and Rhetoric come on top of this background and at the top, the student can answer complicated questions of theoretical interactions between particles. Of note, the brilliant minds that discovered a large number of the authors of the astonishing breakthroughs all the way through those of the atom, were themselves from a Classical educational background.[25]

Susan Bauer[26] has provided a framework for evaluating how Science is taught with the principles of classical Christian concepts. Primary in her analysis is that

> **"Classical education is language-focused; learning is accomplished through words, written and spoken, rather than through images (pictures, videos, and television)."**

My classes are very classical in this sense: we will be primarily teaching through lecture, combined with laboratory, rather than entertaining videos/television -- though they may be used where appropriate.

Bauer continues,

> **"...follows a specific three-part pattern: the mind must be first supplied with facts and images, then given the logical tools for organization of facts, and finally equipped to express conclusions."**

Our class will involve a LOT of facts and images, and an understanding of laws and principles that explain how our Universe works, and will move toward solving problems logically and expressing the conclusions.

Bauer concludes that "to the classical mind, all knowledge is interrelated" She provides explanation:

> **"Astronomy (for example) isn't studied in isolation; it's learned along with the history of scientific discovery, which leads into the church's relationship to science and from there to the intricacies of medieval church history. The reading of the Odyssey leads the student into the consideration of Greek history, the nature of heroism, the development of the epic, and man's understanding of the divine."**

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25 Drake, Paul. Classical Christian Education and the Future of Science. Accessed 8/4/2022, https://societyforclassicallearning.org/classical-christian-education-and-the-future-of-science/

26 Bauer, Susan. What is Classical Christian Education? accessed 8/4/2022 at https://www.classicalchristianmb.org/what-is-classical-christian-education

My classes are VERY classical in this sense. I am constantly trying to help the students understand how these great discoveries of God's universe throughout the course of Physics were accomplished, because ***the process of being part of scientific development is important to understand*** Some of our students will end up in advanced science and will be doing scientific research and publishing in their future. Understanding how we move toward great discoveries of God's universe is very important to our students

We will also frequently be relating the material that we are studying to the decisions and outcomes of world peoples, leaders and nations. In view of the current world situation, Physics is extremely relevant.

Assignments

Assignments will be provided in a **packet** that covers a defined period of time. They will also be posted in lesson plans using the school's online FACTS system. Students are responsible for being up to date with all assignments. Our students are very familiar with this system.

GRADING

This is an A/P Course. By definition, it is taught, tested, and graded at the College level. Students will be almost continually working A/P / College questions. The exact relationship between raw scores on true AP-level questions, and applicable Cornerstone Grades is subject to adjustment, but begins roughly at this level:

Raw Score	Scaled Score
75%	90% = A
65%	80% = B
45%	70% = C

These levels approximate the "5" "4" "3" levels of AP tests.
Students that consistently score lower than what is appropriate for an A/P Score of 4, should expect to have special discussions with their parents and the Instructor to decide how to proceed.

Homework	25%
Tests and Laboratories *There is a possibility of unannounced quizzes at any time, which will be given the weighting of 1/2 a test, presuming I can make a way to make that happen.*	50%
Final Exam (at the end of this Physics I Course)	25%

Classroom Behavior

I do not anticipate having any difficulties with classroom behavior. The class will be taught as a college level class, with rigorous lecture, debate, probing questions and laboratories.

Make-up Policy

Excused absence/s due to sickness will merit the Make-up Policy. One day of extension is given for each day of absence.

Students who have a scheduled trip or a planned absence are expected to submit completed work upon return to class. This is also true to quizzes or tests. Participation in a sport activity is proof of ATTENDANCE of that day of school per school rules, and therefore does not excuse a student for their responsibilities toward the PRIMARY goal of Christian Education: which is Education.

Early notice and arrangement should be made for convenience and order.

Late Work

- An assignment or homework is to be turned in at the class period and time designated by the teacher, typically at the beginning of the period. Teachers are to designate the venue for receiving the assignment or homework, electronic, hard copy, or other.
- Work not turned in as the manner delineated above will be late. The table below lists the points to be deducted per day late.

Days Late	One Day	Two Days	Three Days	Four or More
Logic & Rhetoric	- 11 percent	- 21 percent	- 31 percent	Not Accepted
	LATE homework cannot be guaranteed to be graded to the same standard as homework turned in on the appropriate day, and cannot be guaranteed to be graded or returned in the same timely fashion as appropriately completed work.			

- As an example, Rhetoric homework assignment turned in one day late, and receiving a grade of 80% will then be reduced to 69% (reduced by 11 percent) for being turned in late.
- There are two exceptions to this standard:
  - If a student has an unplanned, but excused, absence, the due date will be extended by the number of days the student was absent.
  - If a student has a planned, but excused, absence the due date may be extended by <u>half the number of days</u> the student was absent.
  - I reserve the right to extend additional grace in very unusual situations.

Redo Policy

Life does not always provide make-overs for crucial testing events. *There is a trap in allowing students to feel that they will always have the chance to repeat an effort for which they did not devote sufficient planning, effort and time. As a parent, I've observed this work to the detriment of some of my own children.* Therefore, only on **rare occasions** will retakes or repeat work be allowed. In this class, students should expect that any re-do work will be at an accelerated level even for A/P.

Why do we have tests? There is an important Christian answer to this question. It is because of the Fall. Humans are innately flawed as a result of the Fall, and now we must have objective measures of accountability to guarantee performance on required studying.

RECOMMENDATIONS

Students are encouraged to remember me when they need to file letters of recommendation or have character references. With my background I have dealt with tens of thousands of patients and families and many many other professionals. My friends are often leaders in law or public service, or education. It will do our students good to get to know quality examples of Christian Leaders in our community who have stood the test of time and can accurately evaluate the character and performance of aspiring young people who have an entire life ahead them and important choices to make. Everyone deserves a good recommendation for the effort they have put forward, and everyone has their own set of God-given gifts -- we are not the same! Finding the niche for which God developed each and every one of us is part of the Christian walk, and if I can help a student with that, it's great.

By signing below, you are signifying that you understand and agree to the above terms of education at AP Physics 2.

________________________________ ______________________________

Student Signature Date

________________________________ ______________________________

Parent(s) Signature Date