**AP PHYSICS 2**

**COURSE SYLLABUS**

**The Classical Academy**

**2022-23**

**Mrs. Smith**

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Welcome to AP Physics 2, a course designed to represent the second semester of College Level Physics course, including topics such as Electrostatics, Thermodynamics and Modern Physics. We will be discussing the concepts in seminar format, weaving laboratory investigations throughout. We are going to have a great year!

**CO-REQUISITE**: You must be currently enrolled in FST, Pre-Calculus or AP Calculus to take AP Physics 2.

**TEXTBOOK:**

Knight, Randall D., Brian Jones, and Stuart Field**. College Physics: A Strategic Approach.** 3rd ed., AP® ed. Boston: Pearson, 2015. **[CR1]**

**Other Resources:**

* Students must bring a graphing calculator or computer with graphing program to class every day.

*Websites:*

* http://www.pearsonmylabandmastering.com/northamerica/masteringphysics/ - *your homework, eText, and video portal*
* https://apstudent.collegeboard.org/apcourse/ap-physics-2 - *resources galore!*
* http://learnapphysics.com/ - *Sign up for daily practice problems*
* https://phet.colorado.edu/ - *Great simulations!*

**POLICIES**:

**Homework/Quizzes:**

Problems from the textbook will be assigned regularly, typically online using MasteringPhysics. Other assignments will be on paper using released AP questions. These assignments will be given after the material has been discussed in class. Homework will graded for correctness most of the time. At times, a short quiz may be given that covers the homework or reading. A 20% late penalty will be assessed for late homework up until the unit exam; this is consistent with the TCA late policy.

**Exams:**

After each unit, an examination will be given. The format for these examinations may mimic that of the questions and problems given on the AP examination. Unit tests will be given during a single class period. Tests containing AP questions may not leave the classroom. However, you will have access to them in the classroom to help you study for the first semester final and for the AP exam in May.

A comprehensive final examination will be given at the end of the first semester. The format will mimic that of the AP examination. All students will take the AP Physics 2 Exam in May 2023. A student who does not complete the AP exam will have the AP course weight removed from their GPA. There is a fee for the exam; exam fees are non-refundable.

**Other Grading Policies:**

Students may come in to correct one test per semester in order to receive half points back. Students must follow the “Test and Corrections Guidelines” in order to receive this credit.

Late assignments other than homework, such as lab reports, will incur late penalties consistent with the TCA homework late policy for papers. No extra credit will be given in this course. Each student's overall score will be determined strictly from the graded events listed in the following table.

**Breakdown of Graded Events:** Graded material is given the following weights.

|  |  |
| --- | --- |
| **Category** | **Weight** |
| Exams (including 1st semester final exam & 2nd semester final project) | 45% |
| Labs | 35% |
| Homework and Quizzes | 20% |
| Total | 100% |

**Final Comments:**

* Keep up with the reading. The textbook for this course is a great resource - read it! I will designate the appropriate sections to read for each lesson.
* Participate in class. Be attentive and take notes. Ask questions and participate in class discussions.
* Learn the concepts. Don't just memorize equations! Learn the concepts first, and then see how the concepts are represented in the math.
* Do the homework. Homework problems will be assigned after the associated concepts have been covered in class. Attempt the homework after each lesson.

*If I have seen further than others, it is by standing on the shoulders of giants.*

Sir Isaac Newton

*Once we accept our limits, we go beyond them.*

Albert Einstein

**INSTRUCTIONAL STRATEGIES**

The AP Physics 2 course is conducted using **inquiry-based instructional strategies** that focus on experimentation to develop students’ conceptual understanding of physics principles. The students begin studying a topic by making observations and discovering patterns of natural phenomena. The next steps involve developing, testing and applying models. Throughout the course, the students construct and use multiple representations of physical processes, solve multi-step problems, design investigations, and reflect on knowledge construction through self-assessment rubrics. In the classroom, they use graphing calculators and digital devices for interactive simulations, collaborative activities and formative assessments.

*Dates below are subject to change. [Textbook section in brackets.]*

**UNIT 1. FLUIDS [CR2b] Aug 19 – Sep 9 (15 days)**

* Density [13.1]
* Pressure: atmospheric and fluid pressure [13.2]
* Pascal’s principle [13.2]
* Buoyant force: Archimedes’ principle [13.4]
* Flow rate [13.5]
* Continuity equation [13.5]
* Bernoulli’s principle [13.6]

**Big Ideas:** 1- Systems, 3- Force Interactions, 5- Conservation

**UNIT 2. THERMODYNAMICS [CR2a] Sep 12 – Oct 5 (17 days)**

* First law of thermodynamics [11.4]
* Heat engines [11.5]
* Efficiency [11.5]
* Carnot cycle
* Second law of thermodynamics: entropy [11.7,8]
* Kinetic theory [12.1,2]
* Ideal gases [12.3]
* Thermodynamic processes and PV diagrams [12.3]
* Heat Transfer [12.8]

**Big Ideas:** 1- Systems, 4- Change, 5- Conservation, 7- Probability

**UNIT 3. ELECTROSTATICS [CR2c] Oct 17 - Nov 16 (21 days)**

* Point charges and other charge distributions [20.1+]
* Electric Force: Coulomb’s Law [20.3]
* Electric Field [20.4-6]
* Gravitational force and field [6.5]
* Electric Potential [21.1-5]
* Capacitance [21.7,8]

**Big Ideas:** 1- Systems, 2- Fields, 3- Force Interactions, 4- Change, 5- Conservation

**UNIT 4. ELECTRIC CIRCUITS [CR2d] Nov 17 – Dec 6, Jan 6 - 18 (17 days)**

* Electric resistance [22.4]
* Ohm’s Law [22.5]
* Power [22.6]
* Series, parallel and combination DC circuits with resistors only [23.1, 3-5]
* Kirchhoff’s Laws [23.2]
* DC circuits with resistors and capacitors [23.6, 7]
* Steady state

**Big Ideas:** 1- Systems, 4- Change, 5- Conservation

**FINAL REVIEW: Dec. 7-9**

**FINAL EXAMS: Dec. 12-16** *(Go over Final Exam on Jan. 5)*

**UNIT 5. MAGNETISM AND ELECTROMAGNETIC INDUCTION [CR2e]**

**Jan 19 - Feb 7 (14 days)**

* Magnetic field [24.1,2]
* Fields of long current-carrying wires [24.3,4]
* Magnetic force on a charged particle [24.5]
* Magnetic force on a current-carrying wire [24.6]
* Motional *emf* [25.2]
* Magnetic flux: Lenz’s law [25.3]
* Electromagnetic induction: Faraday’s Law [25.4]

**Big Ideas:** 1- Systems, 2- Fields, 3- Force Interactions, 4- Change

**UNIT 6. GEOMETRIC AND PHYSICAL OPTICS [CR2f] Feb 8 - Mar 10 (21 days)**

* Transverse and Longitudinal Waves [15.1-3]
* Superposition [16.1-2,6]
* Electromagnetic Waves [25.5]
* Polarization [25.5]
* Interference [17.4]
* Diffraction [17.5]
* Double slit, single slit and diffraction grating interference [17.5-6]
* Thin film interference [17.4]
* Reflection [18.2]
* Image formation by flat and curved mirrors [18.6]
* Refraction and Snell’s Law [18.3]
* Image formation by thin lenses [18.4]

**Big Ideas:** 6- Waves

**UNIT 7. QUANTUM PHYSICS, ATOMIC AND NUCLEAR PHYSICS [CR2g] Mar 13- April 11 (17 days)**

* Atoms, atomic mass, mass number and isotopes [12.1, 29.2]
* Atomic energy levels [28.5,6]
* Absorption and emission spectra [28.6]
* Models of light: wave and particle [25.6, 28.3]
* X-rays [28.1]
* Photoelectric effect, Compton scattering [28.2]
* Conservation of Momentum in 2-D [9.6]
* deBroglie wavelength [28.4]
* Wave function graphs [28.4]
* Mass-energy equivalence [27.10]
* Radioactive decay: alpha, beta and gamma decay [30.4,5]
* Half-life [30.5]
* Nuclear reactions: Conservation of nucleon number and charge [30.4]
* Special Relativity [27.1-8]

**Big Ideas:** 1- Systems, 3- Force Interactions, 4- Change, 5- Conservation, 6- Waves, 7- Probability

**Review:** April 12- May 9 (21 days)

**AP PHYSICS 2 EXAM:** Friday, May 12 @ 12 pm

**FINAL PROJECT DATES:** May 15-19

**LABORATORY INVESTIGATIONS AND THE SCIENCE PRACTICES**

The AP Physics 2 course devotes over **25% of the time** to laboratory investigations. **[CR5]** The laboratory component of the course allows the students to demonstrate the seven **science practices** through a variety of investigations in all of the foundational principles.

The students use **guided inquiry (GI)** or **open inquiry (OI)** in the design of their laboratory investigations. Some labs focus on investigating a physical phenomenon without having expectations of its outcomes. In other experiments, the student has an expectation of its outcome based on concepts constructed from prior experiences. In application experiments, the students use acquired physics principles to address practical problems.

All investigations are reported in a **laboratory journal** (provided by the teacher). Students are expected to record their observations, data, and data analyses. Data analyses include identification of the sources and effects of experimental uncertainty, calculations, results and conclusions, and suggestions for further refinement of the experiment as appropriate. **[CR7]**

|  |  |  |
| --- | --- | --- |
| **UNIT** | **LAB INVESTIGATION OBJECTIVE(S) CR6a**  (Investigation identifier: Guided Inquiry: **GI**  Open Inquiry: **OI**) **[CR6b]** | **SCIENCE PRACTICES [CR6b]** |
| **UNIT 1. THERMO-DYNAMICS** | **1. Gas Laws and Absolute Zero (OI and GI)**  To verify the relationships between pressure, temperature and volume of a gas (air) and to experimentally determine the value for absolute zero. | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **2. Thermal Conductivity and Types of Heat Transfer (GI)**  To determine the thermal conductivity of a material by comparing the difference in temperature across one material to the difference in temperature across a second material of known thermal conductivity. | 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2 |
|  | **3. Heat Engine (GI)**  To determine how the work done by an engine that raises mass during each of its cycles is related to the area enclosed by its *P-V* graph. *OR*  **3.** **Efficiency of a Hair Dryer (GI)**  To determine the efficiency of a hair dryer as it dries a wet towel. | 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  1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2 |
| **UNIT 2. FLUIDS** | **4. Density (OI)**  To determine the densities of a liquid and two unknown objects any way students can think of. | 2.1, 2.2, 2.3, 4.1, 4.2, 4.3, 4.4, 5.1 |
|  | **5. Straw Competition (OI)**  To investigate how tall a straw can be and still provide enough suction in order to drink from a cup at the bottom of it. | 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.4 |
|  | **6. Archimedes’ Principle (GI)**  To determine the densities of a liquid and an unknown object by using the method that is attributed to Archimedes. | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **7. Water Fountain Lab (GI)**  The students design an investigation to determine:   * Exit speed of the water * Radius of the fountain’s exit hole * Flow volume rate * Pressure in pipe at pump | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **8. Torricelli’s Theorem (GI)**  To determine the exit velocity of a liquid and predict the range attained with holes at varying heights using a clear 2-L plastic bottle. | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
| **UNIT 3. ELECTRO-STATICS** | **9. Electrostatics Investigations (GI)**  To investigate the behavior of electric charges, charging processes and the distribution of charge on a conducting object. | 1.1, 3.1, 4.1, 4.2, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **10. The Electroscope (GI)**  To make qualitative observations of the behavior of an electroscope when it is charged by conduction and by induction. | 1.1, 3.1, 4.1, 4.2, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **11. Coulomb’s Law (OI)**  To estimate the net charge on identical spherical pith balls by measuring the deflection (angle and separation) between two equally charged pith balls. | 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 |
|  | **12. Electric Field and Equipotentials (GI)**  To map equipotential isolines around charged conducting electrodes painted with conductive ink and construct electric field lines. | 1.1, 1.2, 1.4, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2 |
| **UNIT 4. ELECTRIC CIRCUITS** | **13. Resistance and Resistivity (OI)**  To explore the microscopic and macroscopic factors that influence the electrical resistance of conducting materials. Students will investigate how geometry affects the resistance of conductive paper | 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 |
|  | **14. Ohm’s Law Lab** (OI)  To represent Ohm’s Law graphically using a battery and two resistors. Additionally, the effect of internal resistance will be investigated in this lab. |  |
|  | **15. DC Circuits: Brightness (GI)**  To make predictions about the brightness of light bulbs in a variety of DC circuit configurations (series, parallel and series-parallel) when some of the bulbs are removed. | 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 |
|  | **16. DC Circuits: Resistors (OI)**  To investigate the behavior of resistors in series, parallel and series-parallel DC circuits. The lab includes measurements of currents and potential differences. | 1.2, 1.4, 32.1, 2.2, .1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **17. RC Circuits: Resistors and Capacitors (GI)**  This investigation consists of two parts:   * An observational experiment where the students make qualitative descriptions of the charging and discharging of a capacitor. * To investigate the behavior of resistors in a series-parallel combination with a capacitor in series. Their investigation includes measurement of currents and potential differences. | 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 |
| **UNIT 5. MAGNETISM, ELECTRO-MAGNETIC INDUCTION** | **18. Magnetic Field of the Earth (GI)**  To measure the horizontal component of the Earth’s magnetic field using a solenoid and a compass. | 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **19. Magnetic Force on a Current-Carrying Wire (GI)**  To determine the magnitude and direction of the magnetic force exerted on a current-carrying wire. | 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **20. Electromagnetic Induction (GI)**  The students move a bar magnet in and out of a solenoid and observe the deflection of the galvanometer. They examine the effects of a changing magnetic field by observing currents induced in a solenoid and determine whether the observations agree with the theory of electromagnetic induction and Lenz' law. | 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 |
| **UNIT 6. GEOMETRIC AND PHYSICAL OPTICS** | **Concave Mirrors (OI)**  This investigation has two parts:   * To determine the focal length of a concave mirror   To determine two locations where a magnified image can be formed using a concave mirror. | 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 |
|  | **22. Index of Refraction (OI)**  To determine the index of refraction of an acrylic block and use the index of refraction to predict the critical angle. | 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 |
|  | **23. Lenses (OI)**  This investigation is divided into two parts:   * To directly determine the focal length of a converging lens directly * To determine the focal length of a diverging lens by combining it with a converging lens. | 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 |
|  | **24. Double-Slit Interference (GI)**  To determine the width of a human hair using double slit interference pattern produced by a red laser. |  |
|  | **25. Diffraction Grating (OI)**  This lab activity consists of two parts where the students design each investigation:   * The students determine the spacing in a diffraction grating using either the green or the red laser. * The students apply the results of the previous experiment to predict the location of bright and dark fringes when a different laser of known wavelength is used. | 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 |
| **UNIT 7. QUANTUM PHYSICS, ATOMIC AND NUCLEAR PHYSICS** | **26. Spectroscopy (GI)**  Students use a quantitative analysis spectroscope to analyze flame tests and spectrum tubes. | 1.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **27. Photoelectric Effect (OI)**  To determine Planck’s constant from data collected from a circuit with an LED color strip. | 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 |
|  | **28. Radioactive Decay and Half-Life (GI)**  In this investigation students simulate radioactive decay and determine half-life. | 1.1, 1.2, 1.3, 1.4, 2.3, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |

**INSTRUCTIONAL ACTIVITIES**

Throughout the course the students engage in a variety of activities designed to build the students’ reasoning skills and deepen their conceptual understanding of physics principles. Students conduct activities and projects that enable them to connect the concepts learned in class to real world applications. Examples of activities are described below.

**1. SIMULATION ACTIVITY**

Students engage in activities outside of the laboratory experience that support the connection to more than one Learning Objective.

**ACTIVITY: Quantum Wave Interference [CR3]**

**DESCRIPTION:**

The PhET Quantum Wave Interference simulation (http://phet.colorado.edu/en/simulation/wave-interference) helps students to visualize the behavior of photons, electrons, and atoms as particles and as waves through a double-slit.

The students work in small groups through a series of ‘experiments’ that confront students with the basic conflict between the wave model and particle model.

The groups have to gather **evidence** that will allow them to justify how the double slit interference pattern is consistent with both the classical wave view and the photon view. After the class discussion, the students should be able to articulate how the wave view is related to the photon view.

**Learning Objective 1.D.1.1**

*The student is able to explain why classical mechanics cannot describe all properties of objects by articulating the reasons that classical mechanics must be refined and an alternative explanation developed when classical particles display wave properties.*

**Learning Objective 6.G.1.1**

*The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate.*

**2.** **REAL WORLD APPLICATIONS [CR4]**

**ACTIVITY 1. Fluid Applications**

**DESCRIPTION:**

Students write a series of questions that they wonder about related to buoyancy and density in real world contexts. In teams of two, the students select one research question. They have two class periods to post their results of the research on a Google Document so that it can be easily shared with the class. Each team presents their information and any sources of data found to the class. Sample questions are:

• How do metal ships float?

• Will a ship full of oil float differently than an empty ship?

• If an oil tanker develops a leak, why does it sink?

• How will a ship float in fresh water as opposed to salt water?

• How and why do hot air balloons work?

• Would hydrogen balloons float better than balloons filled with hot air?

**Learning Objective 1.E.1.1**

*The student is able to predict the densities, differences in densities, or changes in densities under different conditions for natural phenomena and design an investigation to verify the prediction.*

**Learning Objective 1.E.1.2**

*The student is able to select from experimental data the information necessary to determine the density of an object and/ or compare densities of several objects.*

**Learning Objective 3.C.4.2**

*The student is able to explain contact forces (tension, friction, normal,* ***buoyant****, spring) as arising from interatomic electric forces and that they therefore have certain directions.*

**ACTIVITY 2. Laser Applications**

**DESCRIPTION:**

Students first investigate how a laser works using the PhET Laser simulation (http://phet.colorado.edu/en/simulation/lasers)

The simulation helps the students understand how absorption and spontaneous and stimulated emission work.

Students will be able to explain how these factors:  intensity and wavelength of the lamp, the mirror reflectivity, and the lifetimes of the excited states of the atom influence the laser.

After writing their observations they conduct online research to submit a paper that will demonstrate their ability to read and synthesize scientific literature about the applications of lasers in modern medicine. Common research topics of applications include vision correction (LASIK surgery), tattoo removal, and varicose vein treatments.

**Learning Objective 5.B.8.1**

*The student is able to describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed.*

**ACTIVITY 3. The Human Eye**

**DESCRIPTION:**

Students research how the human eye works and which types of lenses are appropriate to correct visual eye defects such as myopia and hyperopia.

**Learning Objective 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.*

**3. SCIENTIFIC ARGUMENTATION**

In the course, students become familiar with the three components of **scientific argumentation**. The first element is the claim, which is the response to a prediction. A claim provides an explanation for why or how something happens in a laboratory investigation. The second component is the evidence, which supports the claim and consists of the analysis of the data collected during the investigation. The third component consists of questioning, in which students examine and defend one another’s claims. Students receive explicit instruction in posing meaningful questions that include questions of clarification, questions that probe assumptions, and questions that probe implications and consequences. As a result of the scientific argumentation process, students are able to revise their claims and make revisions as appropriate. **[CR8]**

**ACTIVITY: Mirrors**

**DESCRIPTION:**

Students are provided with three statements they must either support or refute using physics principles (Concepts include ray diagrams, flat mirror, etc):

1. A student that is 175 cm tall will need a mirror that at least equals his or her total height in order to see a full reflection.
2. It does not matter how far the student stands from the mirror with regard to seeing his or her reflection.
3. It does not matter where the mirror is hung vertically on the wall with regard to seeing his or her reflection.

Students will present the models used to support or refute claims. The teacher will guide a whole-class discussion and peer critique on the models used to support their claims.