| 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. | 4 |
| CR2a The course design provides opportunities for students to develop understanding of the foundational principles of kinematics in the context of the big ideas that organize the curriculum framework. | 8 |
| CR2b The course design provides opportunities for students to develop understanding of the foundational principles of dynamics in the context of the big ideas that organize the curriculum framework. | 9 |
| CR2c The course design provides opportunities for students to develop understanding of the foundational principles of gravitation and circular motion in the context of the big ideas that organize the curriculum framework. | 10 |
| CR2d The course design provides opportunities for students to develop understanding of the foundational principles of simple harmonic motion in the context of the big ideas that organize the curriculum framework. | 11-12 |
| CR2e The course design provides opportunities for students to develop understanding of the foundational principles of linear momentum in the context of the big ideas that organize the curriculum framework. | 11 |
| CR2f The course design provides opportunities for students to develop understanding of the foundational principle of energy in the context of the big ideas that organize the curriculum framework. | 10 |
| CR2g The course design provides opportunities for students to develop understanding of the foundational principles of rotational motion in the context of the big ideas that organize the curriculum framework. | 12-14 |
| CR2h 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. | 14 |
| CR2i 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. | 14-15 |
| CR2j The course design provides opportunities for students to develop understanding of the foundational principles of mechanical waves in the context of the big ideas that organize the curriculum framework. | 13-14 |
| CR3 Students have opportunities to apply AP Physics 1 learning objectives connecting across enduring understandings as described in the curriculum framework. These opportunities must occur in addition to those within laboratory investigations. | 8-15 |
| 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. | 6-7 |
| 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. | 4, 8-15 |
| CR6a The laboratory work used throughout the course includes investigations that support the foundational AP Physics 1 principles. | 8-15 |

| | |
|---|---|
| CR6b The laboratory work used throughout the course includes guided-inquiry laboratory investigations allowing students to apply all seven science | 8-15 |
| 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. | 4-5 |
| CR8 The course provides opportunities for students to develop written and oral scientific argumentation skills. | 4, 7 |

## Course Description

The AP Physics course is designed to meet the objectives of a college level general physics course and to prepare the student to seek credit and/or appropriate placement in college physics. It is designed for the academically talented and mature students who have completed the appropriate math courses. Students enrolled in this course will understand the fundamentals of physics and become competent in solving complex physics problems. Students will develop the ability to think clearly and logically and will be able to express these capabilities in both written and oral form. The problem-solving strategies obtained during this course will prepare students for careers in the sciences, medicine, engineering, and other technical fields. This course is arranged around the seven big ideas and seven science practices articulated in the AP Physics curriculum framework and meets all of the standards designated by the College Board.

## Course Goals

- To provide college-level physics instruction in order to prepare students for the AP exam and/or appropriate placement in a college physics course.
- To provide college-level laboratory experience where students:
    - manipulate equipment and materials to make relevant observations and collect data;
    - use collected data to form conclusions and verify hypotheses;
    - communicate and compare results and procedures both formally and informally
- to prepare students to be independent and critical thinkers who are able to function in a scientific and technological world
- to analyze scientific and societal problems using scientific problem solving skills
- to gain an understanding of the seven big ideas and meet the learning objectives that are outlined in the AP Physics Curriculum Framework.

## Seven 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

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

## Textbook and Resources

Cutnell, John and Kenneth Johnson. *Physics.* 9th edition. Hoboken, NJ: John Wiley and Sons, 2012. **[CR1]**

Hieggelke, Curtis, David Maloney, and Thomas O'Kuma. *Ranking Task Exercises in Physics.* San Francisco, CA: Pearson, 2008.

Morse, Robert. *Teaching About Newton's Second Law: An AAPT/PTRA Teacher Resource Guide.* College Park, MD: American Association of Physics Teachers, 2013.

Nelson, Jane and Jim Nelson. *Energy Supplement: An AAPT/PTRA Teacher Resource Guide.* College Park, MD: American Association of Physics Teachers, 2014.

Nelson, Jane and Jim Nelson. *PTRA Projectile Supplement: An AAPT/PTRA Supplement to be used with Teaching about Kinematics Teacher Resource.* College Park, MD: American Association of Physics Teachers, 2014.

Nelson, Jane and Jim Nelson. *Teaching About Kinematics: An AAPT/PTRA Resource.* College Park, MD: American Association of Physics Teachers, 2009.

Hieggelke, Curtis, David Maloney, Tomas O'Kuma, and Stephen Kanim. *TIPERs: Sensemaking Tasks for Introductory Physics.* Upper Saddle River, NJ: Pearson, 2014.

Alabama Science in Motion Labs and Materials

## Classroom Schedule and Requirements

The AP Physics class meets 5 days per week for 96 minutes allowing for lecture, discussion and a strong laboratory component. In order to allow for more time for laboratory time and other activities, many topics are presented in a flipped classroom format. **[CR6b]**
Topics are covered using PowerPoint presentations in a discussion format. Students are also arranged in study groups to allow for inquiry based learning. The learning groups are used to work through free response questions from past exams. Grades will be determined from tests, quizzes, and laboratory reports/presentations.

## Laboratory

The laboratory component of this course is designed to be the equivalent of a college laboratory experience. Two to three students comprise one lab group. The laboratory activities are investigative in nature and require students to follow or develop procedures, make observations, record, manipulate, process and graph both quantitative and qualitative data obtained during experimentation. At least seven labs per year will be inquiry based allowing students to employ the seven science practices outlined in the AP Physics curriculum framework. A minimum of 25% of student contact time will be spent doing hands-on laboratory activities. **[CR5]**

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. Students also investigate topic-related questions that are formulated through student designed/selected procedures.

Students work in lab groups; each student group must present their results to the class and defend their results. They will also evaluate one other group's approach to the problem and offer a critique of their procedures and results. **[CR8]**
Each student must submit a lab report which is turned in at the conclusion of each activity, then graded and returned. The report must include the following components: **[CR7]**

- Statement of the problem
- Hypothesis
- Discussion or outline of how the procedure will be carried out
- Data collected from the experiment
- Data analysis
- Conclusion including error analysis
- Peer review (if included in this lab)

Students are required to keep the reports in an organized lab notebook. This lab notebook will kept by the students for the entire year and must include the completed lab reports as well as the raw data tables and any notes made during the execution of the labs done in the course. **[CR7]**

## 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. PROJECT DESIGN [CR3]

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

**ACTIVITY: Roller Coaster Investigation**
**DESCRIPTION:**
Working in groups of three, students design a simple roller coaster using provided materials (a track with a vertical loop and toy cars) to test whether the total energy of a car-Earth system is conserved if there are no external forces exerted on it by other objects. Students include multiple representations of energy to provide evidence for their claims. Students use a bar chart, the mathematical expression of conservation of energy represented by the graph, and the corresponding calculations to evaluate whether the outcome of the experiment supports the idea of energy conservation. This activity is designed to allow students to apply the following Learning Objectives:
**Learning Objective 5.B.3.1**
*The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.*
**Learning Objective 5.B.3.2**
*The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.*
**Learning Objective 5.B.3.3**
*The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system.*
**Learning Objective 5.B.4.2**
*The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.*
**Learning Objective 4.C.1.1**
*The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.*
**Learning Objective 4.C.1.2**
*The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.*

### 2. REAL WORLD APPLICATION [CR4]

**ACTIVITY: Torque and the Human Arm**
**DESCRIPTION:**
This activity provides an opportunity for students to make an interdisciplinary connection to biological systems by investigating the structure and function of a major muscle (biceps) in the human body.
Students design and build an apparatus that replicates the forearm and biceps muscle system. The objective is to determine the biceps tension when holding an object in a lifted position. Students may use the Internet to research the structure of the biceps muscle. They can use readily available materials in the classroom, such as a meter stick, a ring stand, weight hangers, an assortment of blocks, and a spring scale. In their lab journal, students are required to document the different stages of their design. Required elements include design sketches, force diagrams, mathematical representations of translational and rotational equilibrium, and numerical calculations.
**Learning Objective 3.F.1.1**
*The student is able to use representations of the relationship between force and torque.*

**Learning Objective 3.F.1.2**
*The student is able to compare the torques on an object caused by various forces.*
**Learning Objective 3.F.1.3**
*The student is able to estimate the torque on an object caused by various forces in comparison to other situations.*
**Learning Objective 3.F.1.4**
*The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system.*
**Learning Objective 3.F.1.5**
*The student is able to calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction).*

## 3. SCIENTIFIC ARGUMENTATION [CR8]

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.

**ACTIVITY 1: Formative Assessment: Changing Representations in Energy**
**DESCRIPTION:**
Students work in pairs to create exercises that involve translation from one representation to another. Some possible translations are:

- from a bar chart to a mathematical representation
- from a physical situation diagram to a bar chart
- from a given equation to a bar chart

Each pair of students exchanges their exercises with another pair. After the students work through the exercises they received, the pairs meet and offer constructive criticism (peer critique) on each other's solutions.
**Learning Objective 5.B.4.1**
*The student is able to describe and make predictions about the internal energy of everyday systems.*
**Learning Objective 5.B.4.2**
*The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.*

**ACTIVITY 2: Laboratory Investigation: Speed of Sound**
**DESCRIPTION:**
Working in small groups, students design two different procedures to determine the speed of sound in air. They brainstorm their approaches and write them on the
whiteboard. Each of the teams presents their ideas to the class. They receive feedback from their peers and then conduct their experiments. They record the revised procedures in their lab journals. During the post-lab discussion, the students discuss their results (evidence) by examining and defending one another's claims. Then as a class we reach consensus about the estimated value for the speed of sound.
**Learning Objective 6.A.2.1**
*The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples.*
**Learning Objective 6.A.4.1**
*The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example.*
**Learning Objective 6.B.4.1**
*The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples.*