Advanced Placement Physics C

Course Description
A.P. Physics C is a calculus-based course in Physics. A passing score on the A. P. Physics C Examination will enable the student to earn college credit for the course and proceed to a second year Physics course. Advanced Placement Physics is structured to prepare the student for the demands of a rigorous college academic schedule. Both teaching and learning will be approached with a degree of rigor and focus to challenge each student to achieve. The Advanced Placement Physics C curriculum incorporates extensive independent laboratory investigation as well as enriched content. Advanced Placement Physics C will be a laboratory-based course in which student's use guided and independent research to construct understanding of physical principles.

Student-Centered Laboratory Instruction using the Modeling Method

Instruction will be organized in "modeling cycles" which utilize the scientific method to describe, explain, predict and control physical phenomena. Each unit of instruction starts with a basic demonstration to set the stage for student activities and to provide student with the basic conceptual tools including mathematical, graphical and diagrammatic representations. Once a fundamental question to study is determined students will combine in small groups to collaborate in planning and conducting experiments to answer or clarify the question. Students are guided through their inquiry and given direction though discussion and "Socratic questioning and remarks. Each Advanced Placement Physics C student is required to maintain a laboratory and class-work notebook documenting all laboratory and class-work. This **laboratory notebook is a requirement** of the standardized advanced placement science program and is required to earn college credit. Procedures for accurately and thoughtfully recording and analyzing laboratory data will be discussed and practiced. All lab reports will be completed in the notebook and submitted for evaluation

Meeting Times
This course meets for 60 minutes every school day averaging 300 minutes per week. Student will conduct hands-on laboratory work once a week or approximately 20% of instructional time. Students earn grades for both the lecture and lab portion of the course.

Course Requirements
Advanced Placement Physics C is designed exclusively for the highest caliber of science student. Even the very best students are challenged. It requires continual study, good note-taking skills, extensive time and effort, and excellent math ability. The student must be self-motivated and able to handle the time demands of an advanced science course. ***Completion of or concurrent enrollment in a first semester calculus course*** *is required*

Textbook: Giancoli, Douglas C. *Physics for Scientists and Engineers*. Upper Saddle River, NJ: Prentice Hall.

Supplemental Resources
- Laboratory classroom that includes the space, facilities and equipment to conduct hands-on, inquiry-based investigations.
- Data gathering, graphing, analysis and presentation software including databases, spreadsheets and probe ware interfaces. Students utilize the Pasco sensors, interfaces and video to collect and analyze laboratory data.
- Team teaching with calculus teachers
- Graphing calculators including the Casio model and the TI-83+.
- Internet access and online text and animations.

<u>Independent Research</u>
A major component of this honors Physics C course is the development of strong scientific research skills. **All AP Physics C students are required to conduct independent research during the school year.** Research topics will be chosen during the first quarter. Progress will be monitored regularly. The results of this research will then be presented in report form in the spring. Each student will be required to present his/her project in the Battlefield High School science fair. This project will be a major grade and excellence is expected. I will help students design the projects and begin the research but this is designed as an assessment of each individual student's skill as a scientific investigator.

<u>Assessment</u>
Student coursework will be assessed in two categories – content and lab. While they are integrated during instruction, the student will receive two separate grades for the "AP Physics C" and the "Advanced Physics C Lab".

I. Content Grade – AP Physics C

There are four main types of work assessed for this grade. There will be other smaller content-related grades, including daily warm-ups and student presentation of homework problems. However, the most important components of this grade are listed below.

(1) **<u>Unit Tests</u>** *100-150 points*
A unit test will be administered at the culmination of units 2-11 as well as a 100 point test on the summer assignment. Each of the unit tests will be in the format of the AP Physics C examination, including multiple choice, short answer, and free response problems.

(2) **<u>Section Quizzes</u>** *25-50 points*
Quizzes will be administered periodically to check understanding and gauge progress. These will cover subtopics within the unit and will vary in format. Quizzes will vary slightly in structure and amount of material covered. All quizzes will be announced – there will be no "pop" quizzes.

(3) **<u>White-boarding Homework</u>** *1 point per problem plus 5 for accuracy*
They will include assigned problems from the text, reaction sets, and problem sets. They will be assessed as follows:

1-point **Effort and Completion** – All problems attempted and worked through.
1 to5-points **Accuracy (White-board)** – One problem set chosen at random for each pair of students. Students will work to solve and display their solution on a 3 x 2 ft whiteboard. Both peers and teacher evaluate accuracy and clarity of work.

(4) **<u>Class/Home Work Notebook</u>** *100 points*
Students will maintain a Class/Home work notebook for classroom notes and assigned problems. The notebook is graded at the end of each quarter for clarity of work, corrections, and notes.

(5) **<u>Midterm and Final Examinations</u>** *20% of semester grade*
Cumulative midterm and final examinations will be administered at the semester breaks. They will be in the format of the AP Physics C examination and include both an in-class and a take-home portion. There are no retakes on semester exams.

II. Lab Grade - Advanced Physics C Lab

(1) **Pre-Lab Work** *15 points*
Prior to beginning lab study, students must complete a pre-lab assignment in their research notebooks. This includes first reading the lab handout and then preparing the date, title, purpose, summary of procedures, and data tables. Students are not permitted to begin lab work until the instructor has confirmed that pre-lab work has been completed.

(2) **In-Lab Assessment** *15 points*
The instructor will record a performance grade for each lab pair for each lab investigation. There are three main components to this grade: adherence to safety rules, evidence of effective pair/group work, and maintenance of the lab station (including cleaning up and returning all materials).

(3) **Laboratory Report** *50-65 points*
Following all lab study, students will complete and submit a laboratory report. The structure and point value for each component of the report will be presented in a separate handout. The general grading rubric is as follows:

+2 points **Title and Date**
+3 points **Purpose**
+10 points **Summary of Procedure**
+15 points **Data**
+15 points **Calculations and Graphs**
+20 points **Conclusions and Post-Lab Questions**

(4) **Independent Research Project** *35 – 200 points*
All of the credit awarded for the research project will be included in the laboratory grade. This includes all of the smaller preliminary assignments (including the research proposal, literature notes, and preliminary data) as well as the final report due in January.

(5) **Midterm and Final Examinations** *20% of semester grade*
The semester examinations for the lab course will include a written portion and an in-lab practical assessment. Each will be based on the lab investigations that were conducted during the semester and students will be able to use their laboratory notebooks during the exams. The written portion will consist of a set of data that students will analyze and utilize to draw conclusions. The in-lab practical assessment will present the student with an open-ended task in which they will need to design a procedure, collect data, analyze the data, and present their results. All work will be done individually.

Grading
Individual student grades will be determined using a point system. The class grade will be the percentage determined by the ratio of points earned to points possible: Based upon the percentage grade, a letter grade will be assigned as follows:

Letter Grade	Percentage Range
A	100-90
B+	89-87
B	87-80
C+	79-77
C	76-70
D+	69-67
D	66-60
F	59 and below

AP Physics C Course Outline

INTRODUCTION	*PHYSICS MODELING*	*BASICS*
Unit and Time Frame	**Subtopics**	**Laboratory Experiments**
UNIT I: SCIENTIFIC THINKING IN EXPERIMENTAL SETTINGS	• Experimental design, control of variables, measurement, underlying assumptions • Data collection using graphing a tabular • Mathematical modeling (data analysis, interpreting graphs) • Evaluation of the pendulum model • Lab Report: presentation and defense of findings	**Instructor/Student Inquiry Demonstration Lab#1:** *Students will devise and conduct an experiment to analyze the motion of a pendulum* . **STUDENT LAB MATERIALS:** • Laboratory note book • Scientific Calculator **STUDENT LAB/MATH SKILLS** • Graphical methods • Slope differential • Area integral concepts • Significant figures • Analyzing Data • Analyzing Errors • Communicating Results

KINEMATICS:	*DESCRIPTIVE PARTICLE*	*MODELS*
Unit and Time Frame	**Subtopics**	**Laboratory Experiments**
UNIT II: CONSTANT VELOCITY PARTICLE MODEL Objects in Translation With Constant Velocity	• Reference system, position and trajectory • What is a particle model? • Vector vs. scalar concepts • What is a free particle (FP)? What is its domain? • FP s kinematical properties and law of motion • Motion map • Multiple representations (graphical, algebraic, diagrammatic) • Dimensions and units	**Instructor/Student Inquiry *Demonstration* Lab #2-*"Motion in One Dimension"*** • *Instructor will use an constant velocity simulation to help students identify variables and basic concepts with constant motion* **Students Lab #1-"*Battery-Powered Vehicle Lab"*** • Students will use timers, tape measures and a constant velocity cart to investigate constant velocity
UNIT III: PARTICLE UNDERGOING UNIFORM ACCELERATION Objects in Linear Translation with Constant Acceleration	• **Newton's 1st Law** • Average vs. instantaneous rate of change: the case of velocity • **Newton's 2nd law** • Acceleration vs. velocity • What is a Constant Force Particle (CFP)? What is its domain? • CFP s kinematical properties and laws of motion • Motion map • Multiple representations (graphical, algebraic, diagrammatic) • Free fall	**Instructor/Student Inquiry Demonstration Lab # 3 "*Position, Velocity, and Acceleration"*** • *Instructor will use an acceleration simulation to help students identify variables and basic concepts with constant motion* **Student Lab # 2 Data Studio "*Inclined Rail Lab"*** • *Students will utilize an Inclined rail and computer program to investigate and acceleration and or motion of a cart on an incline rail* **Student Lab # 3 Data Studio *"Marble Free Fall"*** • *Student will drop an object though a computer motion sensor to investigate the acceleration of gravity* **Student Lab #4 " *Logger Pro Video Analysis of Acceleration*** • *Students will utilize frame by frame video to measure changes in motion of a carts in Incline Rail lab and Picket Fence Lab*

DYNAMICS:	*EXPLANATORY PARTICLE*	*MODELS*
Unit and Time Frame	**Subtopics**	**Laboratory Experiments**
UNIT IV: FREE PARTICLE MODEL Inertia and interactions	• **Newton's 1st law** (Galileo's thought experiment) • Inertial reference frames • Interaction and force • **Newton's 3rd law** • Identity force pairs • Superposition principle • FP s dynamical property, force diagrams and motion maps • Static's: equilibrium of a particle	**Instructor/Student Inquiry Lab # 4 *"Inertia, Friction Force and Force Identification"*** • *Instructor will use dry ice to demonstrate an object in motion with little to no friction. Students will be asked to identify all possible forces* **Student Lab # 5 Data Studio "*Collision Carts and Tug of war"*** • *Students will use force sensors with carts to investigate Newtons 3rd law*
UNIT V: CONSTANT FORCE PARTICLE MODEL Force as Cause of Acceleration in Linear Translation	• **Newton's 2nd law** • CFP s dynamical properties, force diagrams and motion maps • Friction • Modeling in paradigm problems	**Student Lab # 6 Data Studio *"Atwood's Machine Lab"*** • *Student will use a modified Atwood machine to investigate the relationship between force, mass and acceleration* **Student Lab # 7 Data Studio "*Constant Mass lab"*** • *Students will investigate the effect on acceleration by transferring mass from a cart to a hanging weight.* **Student Lab # 8 Data Studio *"Constant Force Lab "*** • *Students will investigate the effect of increasing the force on a cart by adding mass to a hanging/pulling weight.* **Student Lab # 9 Data Studio *"Friction & calculating mu"*** • *Students investigate and calculate mu by applying a force to a mass moving at a constant velocity*

Unit and Time Frame	Subtopics	Laboratory Experiments
UNIT VI: PARTICLE MODELS IN TWO DIMENSIONS Describing and Explaining Translation in a Plane by Combining FP and One-Dimensional CFP models	• Superposition principle • FP in different inertial reference systems (FP + FP) • CFP in a non-inertial reference system (CFP + CFP) • CFP in different inertial reference systems (CFP + FP) • Application of CFP in two dimensions: the case of a projectile • Kinematical and dynamical properties, force diagrams and motion maps	**Instructor/Student Inquiry Lab # 5 "Motion in 2-D"** • *Instructor will use an projectile motion simulation to help students identify variables and basic concepts with motion in two dimensions* **Student Lab # 10 CPO *"Projectile Motion Part 1*"** • *Students will investigate how changing the initial speed of a projection effects range and height of a projectile. Students will utilize CPO timers and rulers to measure effects.* **Student Lab # 11 CPO *"Projectile Motion Part 2"* –** • *Students will investigate how changing the launch angle of a projection effects range and height of a projectile. Students will utilize CPO marble launcher, timers, and rulers to measure effects of range.*

Unit and Time Frame	Subtopics	Laboratory Experiments
UNIT VII: WORK, ENERGY AND POWER Explaining Particle Translation via Conservation of Energy	• Revisit paradigm labs- view from energy perspective • Energy Storage modes (potential, kinetic, dissipated) and representational tools • Energy Transfer mechanisms (via working heating, radiating) • Conservation of energy • Work, Rate and Power • Conservative vs. non-conservative forces • More on mathematical modeling in paradigm problems • Simple machines	**Instructor/Student Inquiry Lab # 6** ***"Work Energy and Power"*** • *Instructor will use a demonstration of simple machines to help students identify variables and basic concepts with work, energy and power* **Student Lab # 12 Data Studio** ***"Work-Energy Theorem lab"*** • *Students will investigate the relationship between work and energy by comparing the work done on a lab cart to the change in velocity utilizing motion and force sensors* **Student Lab # 13 Data Studio** ***"Hooks law Part 1, Finding the Spring Constant"*** • *Students will investigate the relationship of spring constant to the force needed to change the length of a spring utilizing force meters and metric rulers.* **Student Lab #14 Data Studio** ***"Hooks law Part 2, Conservation of Mechanical Energy*** • *Students will investigate the relationship of mechanical energy by utilizing a spring-loaded cart, force sensor and motion sensor.* **Student Lab # 15** ***CPO Roller "Coaster and Conservation of Energy"*** • *Students will investigate the relationship of gravitational potential energy, kinetic energy, work, by initializing motion sensors and measuring the change of height of a marble CPO roller coaster.* **Student Lab # 16 CPO** ***"Simple Machines"*** • *Students will utilize pulleys, levers and ramps to investigate work, energy and power. Force sensors will provide data to compare input and output work as well as the efficiency of each machine*

Unit and Time Frame	Subtopics	Laboratory Experiments
UNIT VIII: Circular Motion and Rotation Objects in Circular Translation	• Particle in translation with variable acceleration, centripetal and tangential components • Describing and explaining uniform circular translation: centripetal acceleration and force • Describing and explaining uniformly accelerated circular translation • Angular vs. linear expressions of kinematical laws of motion • Explanatory laws compared: Newton's laws vs. conservation of energy principle • Planetary motion: Universal gravitation and Keller's 3rd law • Centrifugal force and acceleration: Pseudo-concepts and their risks • Fundamental particle models in Newtonian theory: An overview	**Instructor/Student Inquiry Lab # 7** ***"Circular Motion and Rotation"*** • *Instructor will use a demonstration of a rotating body to help students identify variables and basic concepts in circular motion* **Student Lab # 19 Data Studio** ***"Rotational inertia"*** • *Students will investigate and compare the rotational inertia of disc to the rotational inertia of a ring unitizing a rotational inertia sensor with ring and disc.* **Student Lab # 20 Data Studio** ***"Simple Harmonic Motion"*** • *Students will investigate how a change in mass on the end of a spring or spring stiffness will affect the bouncing motion of the spring.* **Student Lab # 21 Data Studio** ***"Centripetal Force on a Pendulum"*** • *Student will investigate the centripetal force on a pendulum by hanging a mass from and force sensor and measuring its angular velocity while comparing calculated figures*

Unit and Time Frame	Subtopics	Laboratory Experiments
UNIT IX: IMPULSIVE FORCE PARTICLE MODEL Conservation of Linear and Angular Momentum	• Interaction in two-particle systems, internal forces • Linear momentum and impulse • Angular Momentum • Newton's 1st and 2nd laws revisited • Elastic vs. inelastic collisions: • Conservation of linear momentum vs. • conservation of energy • Systems of particles	**Instructor/Student Inquiry Lab # 8** ***"Linear and Angular Momentum"*** • *Instructor will use a demonstration of linear and angular momentum to help students identify variables and basic concepts in impulse and conservation of linear and angular momentum* **Student Lab # 22 Data Studio** ***"Collision-Impulse and Momentum Elastic collision 1"*** • *Student will investigate the impulse and conservation of momentum by colliding a cart of know mass with a force sensor and measuring and change in velocity* **Student Lab # 23 Data Studio** ***"Collision-Impulse and Momentum Elastic collision 2"*** • *Student will investigate the impulse and conservation of momentum by measuring the velocity to two carts of different masses as they are pushing apart by a spring.* **Student Lab # 24 Data Studio** ***"Collision-Impulse and Momentum inelastic collision"*** • *Student will investigate the impulse and conservation of momentum by measuring the velocity to two carts of equal and different masses as they collide and combine into one mass* **Student Lab # 25 Data Studio** ***"Conservation of Linear and Angular Momentum"*** • *Student will investigate the conservation of both linear and angular momentums utilizing motion sensors, projectile launcher and a rotating platform to compare linear and rotational momentum*