AP PHYSICS: C SYLLABUS

CLASSICAL MECHANICS

ELECTRICITY AND MAGNETISM

AP Physics is a calculus based physics class that covers the topics of Classical Mechanics as well as Electricity and Magnetism. It prepares students to take both the AP Physics C: Mechanics and the AP Physics: C Electricity and magnetism exams. The prerequisite for this class is a full year of Accelerated Physics which is an algebra based physics course that covers many of the same topics. It is also expected that the students take calculus concurrently, although integrals, derivatives and differential equations are taught and used throughout in AP physics.

Schedule: AP Physics meets five times a week. Classes on Monday and Wednesday meet for 88 minutes. Classes on Tuesday, Thursday and Friday meet for 44 minutes. Tuesday and Wednesday are designated as lab days.

Text: The textboox issued to all students is *University Physics*, Young, Freedman; 10th edition. San Francisco, CA, 2000: Addison Wesley Longman. ISBN 0-201-60322-5. There is additionally a class set so students may leave their book at home and utilize the class set in class.

Lab Reference Material: *Physics Laboratory Instructions Volume I and II*, John Wiley & Sons, Inc., Department of Physics, Community College of Philadelphia, 2004. ISBN 0-471-58115-1

Technology: Students should have a graphing scientific calculator and access to the internet.

Teaching Objectives: It is the goal of this class to provide students with a very thorough understanding of college level, calculus based physics using a variety of methods. The various demonstrations and discussions as well as the extensive lab component to this class provide a student-centered approach where guided inquiry is used to cultivate students' critical thinking skills. The homework is designed to present unique problems to the students that are related to the topics being covered, but ask the students to apply their knowledge in a new way. This requires the students to expand upon their current understanding of the topic as well as assimilate knowledge from several topics to answer the questions. The labs have various levels of pre-determined lab procedures. At times throughout the year, students are presented with a task to accomplish and a list of materials and are asked to come up with their own procedure to accomplish this task. After the lab they are asked to evaluate their procedure and recommend improvements to their own procedure. At other times the lab procedures are more defined, but the analysis of their results requires critical thinking. Even when there is a more directed procedure to the lab, students are asked several post lab open ended questions where they have to assess the meaning of their results.

Course Requirements:

Homework: Homework is assigned weekly from the problems at the end of each chapter through Webassign, an online homework program. The homework assigned in this class is designed to reinforce topics that are currently being covered and to help promote student led question sessions based on any difficulties they are having with the homework. Students are asked to begin the homework no later than Wednesday even though it is not due until Sunday so that the gaps in understanding of the solution process can be used to guide the discussion in class on Thursday and Friday. One of the benefits of using this homework program is that it is an interactive program that provides students with additional support in their learning process. Not only does it provide immediate feedback on the students' correctness, it provides additional help leading students to the correct solution process with the use of additional practice solving similar problems to the ones assigned. The homework may be accessed as early as you want and is available until 11:59 pm on the Sunday following the chapter introduction. Additionally students must write up the last two problems, showing all work, formulas and diagrams, to be turned in on the following Monday at the start of class. The homework is designed to present unique problems to the students that are related to the topics being covered, but ask the students to apply their knowledge in a new way. This requires the students to expand upon their current understanding of the topic as well as assimilate knowledge from several topics to answer the questions.

Tests: After the completion of three chapters there will be a test on these three chapters the following Monday. The tests are closely modeled after AP exams with a series of multiple choice problems based on the topics from the three chapters followed by two extended response problems also in line with the material that was covered in the previous three chapters.

Labs: Labs will be performed on Tuesdays and the double period on Wednesdays. The labs have various levels of pre-determined lab procedures. At times throughout the year, students are presented with a task to accomplish and a list of materials and are asked to come up with their own procedure to accomplish this task. After the lab they are asked to evaluate their procedure and recommend improvements to their own procedure. At other times the lab procedures are more defined, but the analysis of their results requires critical thinking. Even when there is a more directed procedure to the lab, students are asked several post lab open ended questions where they have to assess the meaning of their results. Students are responsible for turning in a lab write up that includes: Purpose, procedure, data analysis and a through conclusion. Once lab reports have been graded, students have their reports returned and are responsible for keeping them as a collection of their work throughout the year.

Grading:

Grades will have the following weight.

Homework	20%
Labs	20%
Tests	60%

Course Outline:

Unit 1: Mathematics review, Vector review and introduction to the derivative, the integral, and the differential equations for velocity and acceleration.

Unit 2: **Motion along a straight line:** displacement, time, average vs. instantaneous velocity, average vs. instantaneous acceleration, velocity and position by integration.

Unit 3: **Motion in Two or Three Dimensions:** Position, velocity and acceleration vectors, projectile motion, motion in a circle, relative velocity.

Unit 4: **Newton's Laws of motion:** Newton's three laws, mass and weight, the differential form of Newton's second law.

Unit 5: **Applications of Newton's Laws:** Particles in equilibrium, dynamics of particles, frictional forces, dynamics of circular motion, air resistance with linear and quadratic drag equations.

Unit 6: **Work and Kinetic Energy:** work, kinetic energy, power, the dot product, calculating work with the definite integral.

Unit 7: **Potential Energy and Energy Conservation:** GPE, Elastic Potential Energy, Conservative and non-conservative forces, force and potential energy, gradient used to calculate force and potential energy in three dimensions, introduction of I j k vector components.

Unit 8: **Momentum, Impulse and Collisions:** impulse momentum theorem derived through the differential form of Newton's second law, conservation of momentum, inelastic and elastic collisions, center of mass.

Unit 9: **Rotation of Rigid Bodies:** Angular velocity and acceleration, rotation with constant angular acceleration, relating linear and angular kinematics, energy in rotational motion, moment of inertia, parallel axis theorem.

Unit 10: **Dynamics of Rotational Motion:** Torque, angular acceleration, rigid body motion about an axis, work and power in rotational motion conservation of angular momentum.

Unit 11: **Equilibrium and Elasticity:** Conditions for equilibrium, center of gravity, solving rigid-body equilibrium problems.

Unit 12: **Gravitation:** Newton's laws of gravitation, weight, GPE, motion of satellites and planets, Keppler's 3 laws.

Unit 13: **Periodic Motion:** Simple harmonic oscillation, Energy in SHM, Applications of SHM, simple pendulum, physical pendulum.

Unit 14: **Electric Charge and Electric Field:** Electric charge, induced charges, Coulomb's law, electric field and electric forces, field calculations.

Unit 15: **Gauss's Law:** Electric charge, electric flux, Gauss's law, applications of Gauss's law, charges on conductors.

Unit 16: **Electric Potential:** Electric potential energy, electric potential, calculating electric potential, Equipotenial surfaces, gradient.

Unit 17: **Capacitance and Dielectrics:** capacitors and capacitance, capacitors in series and parallel, energy stored in capacitors and electric field energy, dielectrics, dielectric breakdown.

Unit 18: **Current, Resistance and EMF:** Current, resistivity, conductivity, resistance, electromotive force and circuits, energy and power in circuits, theory of metallic conduction.

Unit 19: **Direct-Current Circuits:** Resistors in series and parallel, Kirchhoff's rules, electrical measuring instruments, R-C circuits.

Unit 20: **Magnetic Field and Magnetic Forces:** Magnetism, magnetic field, Magnetic field lines and magnetic flux, motion of charged particles in a magnetic field, magnetic force on a current carrying conductor, force and torque on a current loop.

Unit 21: **Sources of Magnetic Field:** Magnetic field of a moving charge, magnetic field of a current element, MF of a straight current carrying conductor, force between parallel conductors, MF of a circular current carrying loop, Ampere's law.

Unit 22: **Electromagnetic Induction:** Induction experiments, Faraday's law, Lenz's law, motional emf, induced electric fields, Maxwell's equations.

Unit 23: **Inductance:** Mutual inductance, self-inductance and inductors, magnetic field energy, R-L circuits, L-C Circuits, L-R-C series circuits.

List of Labs:

Lab # 1 The Physics 500:

The purpose of this lab is to determine what measurements are required to determine the average speed of an object and to use this knowledge to compute the average speed of your lab partners to determine the length of an unknown distance.

Lab # 2 Sliding Block:

I have a device that will slide the block at a known speed (the speed will be given in tiles/second. The reason I am not giving it to you now is that I do not want you trying to mimic my device). I will give you this speed 5 minutes before the contest begins. Using this speed in conjunction with the information that you have determined through experimentation, you will be asked to predict where the block will stop when fired from my device.

Lab # 3 Projectile Launcher

You will be given a projectile launcher and ball with which to do experiments, and take data. You will have 30 minutes to perform these operations. You must test with an angle between 5^o and 20^o. I will then give you an angle at which the projectile launcher will be fired from and I will then tell you the height from which it will be launched (this is the height from the bottom of the ball to the floor). After you are given this information, you will have 15 minutes to put a mark on the floor indicating the spot where you think the ball will land. The group who is closest will claim victory.

Lab # 4 Terminal Velocity

In this lab you will use: 5 coffee filters, Stop watch, Tape measure. The dependent variable is terminal velocity. The independent variable is mass. Determine velocity as a function of time, assuming that air resistance proportional to velocity, i.e. $F_{air} = -kv(t)$, where k is a constant determined by the fluid (air), shape of the filter, and the surface area of the filter. We are holding all three of these constant in this experiment by using nearly-identical coffee filters. Solve for v(m,g,t,k). Check this experimentally: How is terminal velocity related to the mass of the objects? Measure your masses in coffee filters (it won't affect the fundamental relationship, just the constants), and assume $v_T(m) = Cm^n$, where C and n are to be determined. Linearize the data and find the relationship. Analysis: Did theory and experiment match up? Discuss. Contest: Determine how many coffee filters should be released from a given height so that they fall to the ground in a given amount of time.

Lab # 5 Constant force accelerating car

The purpose of this lab is to observe several effects related to Newton's Second Law, in the context of 1-dimensional motion with two themes: first one with constant force and varying mass, secondly with constant mass and varying force. The lab also teaches some concepts of measurement and analysis of experimental data. The gravitational force on a small hanging mass is applied to a cart on a level, nearly frictionless track, using a string and pulley arrangement. The resulting horizontal force accelerates the system of the two masses. Using the laboratory computers, we measure the speed of the cart, and from this deduce the acceleration produced by the force. The measured acceleration and its dependence on the magnitude of the hanging mass are compared with those predicted by Newton's Second Law. Some limiting cases and the accuracy of the measurement method are briefly studied.

Lab # 6 Bungee Drop

In this lab you will need to figure out how much mass to add to the rescue hero (use the duct tape to add it on securely) so that he gets into the water, but does not hit the ground. The hero jumps (from rest) from 8 meters above the ground and the water is 0.3 meters deep. Tie a string with length of 0.4-meters to the end of the spring, which I will tie to the launch point. Attach the other end of the spring to the Rescue hero.

Lab # 7 Balancing Act

In this lab you will be given: A meter stick, A known mass (200-g), A stand on which to balance the meter stick. Your first task is to determine the mass of the meter stick. The task should be accomplished in two different ways. You will now be given: Unknown mass, the known mass will be taken away. Your second task is to determine the unknown mass. The task should be done in two different ways.

Lab # 8 All Things Being Equal

For this lab you will be given the following equipment: An unknown weight, two or three spring scales, String, Meter stick. The unknown mass must be hung from the ceiling with strings (with the spring scales attached) at different angles. By reading scales and taking measurements you are to determine the unknown weight.

Lab # 9 **Keppler**

Keppler's Laws /Orbit of Mercury Lab: given the data for the orbit of Mercury, students chart the orbit of Mercury on polar graph paper and demonstrate Keppler's 1st and 2nd law both mathematically and graphically.

Lab # 10 **Cart Clock**

The task will be to build a clock that keeps good time. The oscillator must be a horizontal mass connected by at least two springs.

Lab # 11 **Graphing Electric Potential**

Your task is to construct a contour map of the electric potential in the area around the charged objects. You will need to attach each end of the voltage source to each of the metal objects. Attach the negative side of the voltmeter to the negatively charged object. Use the positive side as a probe.

Lab # 12 **Ohm's Law Lab**

Design an experiment that determines the relationship between the current and the voltage. Here the current is the dependant variable and the voltage is the independent variable. Design an experiment that determines the relationship between the current and the resistance. Here the current is the dependant variable and the resistance is the independent variable. Write a relationship between current voltage and resistance.

Lab # 13 **Capacitors**

The purpose of this experiment is to familiarize the student with the capacitor as a device for storing charge and demonstrate that the amount of charge stored can be correctly predicted using the concept of capacitance. It is also desired to measure the capacity of a capacitor by measuring the time constant of an RC Circuit

Lab # 14 **Wheatstone Bridge** (EM – 6)

The purpose of this lab is to allow students to become acquainted with the theory and operation of the Wheatstone bridge

Lab # 15 **Kirchhoff's Laws** (EM – 8)

The purpose of this experiment is to study Kirchoff's laws and to demonstrate that they can be used to correctly predict the currents in a multiloop d-c circuit.

Lab # 16 **Electric Heating Effect** (EM – 9)

The purpose of this lab is to investigate the heating effect of an electric current. Current flowing through a conductor produces heat in a conductor.

Lab # 17 **Magnetic effect of an electric current** (EM – 10)

The purpose of this lab is to familiarize the student with the effects of the magnetic field between parallel conductors and to introduce the current balance.

Lab # 18 **Lenz's Law lab**

Drop a magnet through a metal tube and watch it slowly descend. Make a magnet pendulum and swing it over a copper plate. Make a solenoid around an aluminum can and crush the can. Students will have to write up their observations and determine the reasons for their observations.

Lab # 19 **Induction experiments**

Students will induce a current in a wire through a series of induction experiments involving magnets and coils of wire. They should be able to build a device that can light a LED.

Lab # 20 **Light Bright Board**

Wire the light sockets in series and in parallel. Once you have your sockets wired have the circuit checked by the instructor before plugging it in. The other lab groups are going to attempt to decipher the wiring of your light board simply by screwing in and unscrewing your light bulbs and observing the effects on the remaining light bulbs.