AP Physics C (Mechanics)

Goal: To prepare the student for the AP Physics C (Mechanics) exam in May. The student can earn college credit if his/her performance merits it.

Schedule: The class meets 15 periods every two weeks. Each period is 42 minutes in duration. This allows for a double period of instruction and or lab work every other day.

Approach: This course presents an inquiry-based, problem-solving oriented approach to mechanics topics in physics. The instructor uses various teaching techniques which are designed to impart both process skills and content knowledge to the student. The pedagogy includes lecture, individual problem solving, group problem solving, group lab work, and concept demonstration (both with actual equipment and with computer simulation). The lecture portion of the presentation utilizes calculus (which is then expected to be used in student problem solving as well). A wide variety of teaching strategies are employed to ensure student understanding of the learning objectives. These include such approaches as computer-based learning, inquiry-based and open-ended lab work, and of particular importance, team based "challenge" problems in which groups of students work together to solve difficult problems and earn points based on both speed and accuracy.

Prerequisites and Math Competencies: Students who take this course meet the following prerequisites:
1) 9th grade-Honors Biology
2) 10th grade-Honors Chemistry
3) 11th grade-Honors Physics or AP Physics B
4) Honors Calculus or AP Calculus (AB or BC) previous or concurrent to AP Physics C

Text: Fundamentals of Physics 4th Ed., (Wiley Pub.)Halliday, Resnick, Walker, ©1993
This text presents a calculus-based, problem-solving oriented approach to the study of physics. It is meant for college students studying a pure science or engineering.
Additionally, among others, the following texts are used a primary supplementals:
Physics for Scientists and Engineers, 6th Edition, (Thompson Pub.) Serway and Jewett, ©2004
Physics, 3rd Edition, AP Edition, (Prentice Hall Pub.), Walker, ©2007

HW Policy: Each week, an overview of learning objectives, homework problems, and reading assignments is distributed to the students. Since pop quizzes are administered on

a routine basis, the student will not do well on the quizzes w/o doing the homework on a nightly basis.

Lab Work: Students will have a wide-variety of hands-on lab experiences occurring at least once per week. Approximately 20% of the class time is devoted to lab work. Many of the labs involve the use of PASCO GLX data collection devices. A lab report is always required and will be kept in a cumulative lab notebook. The lab report always includes detailed analysis of the lab work including, but not limited to, graphical analysis of data, presentation of equation manipulation, scientifically valid conclusions based on data, and analysis of error. The lab notebook will be periodically evaluated for neatness, completeness and correctness.

Tests: Each unit has an 80 to 100 point test. The test questions are comparable to AP exam questions. The tests are timed and are generally thought to be difficult.

Grading Scale: Total points are used to determine percentage grades in each quarter. The quarterly grades are averaged to determine the semester and final grades.

A=90 to 100% B=80 to 89% C=70 to 79% D=60 to 69% E=59% and below

Unit	Topic	Approximate Date of Completion
1	Kinematics	Mid September
2	Newton's Laws	Early October
3	Work, Energy, Power	Late October
4	System's of Particles and Momentum	Mid November
5	Rotation	Early December
6	Oscillations	End December
7	Gravitation	Mid January
	AP Test Review	Early May

DETAILS FOR EACH UNIT ARE SHOWN ON THE FOLLOWING PAGES.

AP Physics C (Mechanics) Unit 1 Topics: Kinematics

- Introduction to differential and integral calculus
- Introduction to vector math (unit vectors, dot product, cross product)
- Using calculus to study motion (displacement, velocity, acceleration)
- Analysis of motion graphs
- Horizontal straight-line kinematics
- Free-fall kinematics
- General analysis of motion in two and three dimensions
- Analysis of projectiles
- Analysis of uniform circular motion

Lab Activities:

- Data collection and analysis using devices such as an inertia balance
- Free-fall kinematics
- Analysis of projectile motion using launchers and photgates

Time Frame: 3 weeks

Structure of the exam:

- multiple choice conceptual questions
- free response questions, each containing multiple parts worth various amounts of points. Each topic listed above is found in the free response section. Not all problems will be of the same difficulty level.

AP Physics C (Mechanics) Unit 2 Topics: Newton's Laws

- Newton's Laws (w/unit vector analysis)
- Applications of Newton's Laws
  - Hanging objects
  - Elevator
  - Inclined planes and pulley systems
  - Surface interactions (normal forces for multiple object systems)
  - Heavy algebraic/trigonometric substitution
- Friction forces and Newton's Laws (static case and kinetic case)
- Resistive forces
  - Air drag
  - Terminal velocity

- Using differential equations to find v(t)
- Circular motion (uniform and non-uniform speed)
- Relative velocity problems
  - Galilean transformation
  - Vector analysis

Lab Activities:

- Force table activity
- Applications of Newton's Laws (Carts, pulleys, electronic data collection devices)
- Terminal velocity
- Circular motion (glass tubes, masses, string, stopwatch)

Time Frame: 3 weeks

Structure of the exam:

- multiple choice conceptual questions
- free response questions, each containing multiple parts. Not all problems will be of the same difficulty level.

AP Physics C (Mechanics) Unit 3 Topics: Work, Energy, Power

- The concept of work
  - One-dimensional force ($W=\mathbf{F}*\mathbf{d}$ ....the dot product)
  - Constant and variable forces (Use of calculus)
- The work-energy theorem (defines K)
- Instantaneous power
- The concept of potential energy
- Tests for conservative and non-conservative forces
- The law of conservation of energy (with both conservative and non-conservative forces)
- Analysis of potential energy curves ($dU/dx = -F$)

Lab Activites:

- Elastic potential energy (springs)
- The law of conservation of energy using carts, inclines, and pulleys
- Determination of work done by friction

Time Frame: 3 weeks

Structure of the exam:

- multiple choice conceptual questions
- free response questions, each containing multiple parts

AP Physics C (Mechanics) Unit 4 Topics: Systems of Particles and Momentum

- Center of mass
  - System of particles
  - Extended objects (using calculus)
    - Thin rod (non-uniform density)
    - Planar object (uniform density)
    - 3-D objects (uniform density)
- Momentum and its conservation
  - Explosions
  - Rocket propulsion (using calculus)
    - Thrust equation
    - Speed related to mass
- Collisions
  - Completely inelastic
  - Inelastic
  - Perfectly elastic
- Impulse-momentum theorem
- Newton's Laws and center of mass

Lab Activities:

- Momentum and its conservation (2D with spheres and ramps)
- Rocket propulsion (model rocketry)
- Collisions and explosions (carts and tracks with photogates)

Time Frame: 3 weeks

Structure of the exam:

- multiple choice conceptual questions
- free response questions, each containing multiple parts

AP Physics C (Mechanics) Unit 5 Topics: Rotation

- Basic Angular quantities and Angular kinematics
- Rotational kinetic energy and moment of inertia

- Using integration to determine the moment of inertia for an extended object
- The parallel axis theorem
- The concept of torque (and the cross product)
- Using the second law with angular quantities
- Analysis of systems with massive pulleys (Tension is not the same throughout)
- Rotational work, power, and the conservation of energy
- The physics of rolling (with and without slipping)
- Angular momentum defined and used.
- External torque as the cause of change in angular momentum
- The conservation of angular momentum
- Collisions involving rotation and translation
- Quantized angular momentum
- Static equilibrium of rigid objects
- The concept of center of gravity

Lab Activities:

- Basic angular quantities and angular kinematics using a turntable and photogate
- Using the second law with angular quantities (Pasco GLX data collection devices)
- The conservation of angular momentum
- Static equilibrium of rigid objects (struts, strings, masses, spring balances)

Time Frame: 3 weeks

Structure of the exam:

- multiple choice conceptual questions
- free response questions, each containing multiple parts

AP Physics C (Mechanics) Unit 6 Topics: Oscillations

- The basics of Simple Harmonic Motion
  - Restoring force proportional to displacement
  - Amplitude, period, frequency, phase, initial phase angle
  - Graphical relationships
  - Equations of position, velocity, and acceleration (calculus)
  - Angular frequency related to k and m
  - Be able to determine amplitude given initial position and initial velocity
  - Be able to determine initial phase angle given initial velocity, initial position, and angular frequency

- Be able to determine the angular frequency given the acceleration at a specific position
- Be able to analyze both horizontal and vertical spring/block systems with single or multiple spring configurations
- Energy relationships for SHM oscillators
- Pendula
  - The physical pendulum
  - The simple pendulum
  - The tortional pendulum
- The basics of damped oscillation (b>0)
  - Exponential decay of maximum displacement (calculus, with graphical analysis)
  - Distinguish between underdamped, critically damped, and overdamped oscillators
  - Angular frequency for a damped oscillator
- Forced oscillations and resonance
  - Amplitude determinations

Lab Activities:

- The basics of Simple Harmonic Motion (various oscillators, carts, springs, masses)
- The basics of damped oscillation (Pasco GLX data collection devices)
- The simple pendulum, physical pendulum, and tortional pendulum (various student built pendula and data collection devices)

Time Frame: 3 weeks

Structure of the exam:

- multiple choice
- free response
  - Basic SHM
  - Energy and SHM
  - Physical Pendulum
  - Damped SHM

AP Physics C (Mechanics) Unit 7 Topics: Gravitation

- The inverse square law of gravitation ($F_g = Gm_1m_2/r^2$)
- The superposition of gravitational force
- The determination of g (for source mass M of radius R at distance r....for r>R)

- The fundamental ideas regarding potential and kinetic energies in a system with only conservative forces
- Potential energy function for a two-body system ($U = -GmM/r$.....using $U=0$ when $r =$ infinity)
- The total potential energy in a system of n bodies as the "sum over all the pairs"
- Interpretation of force vs. distance graphs and potential energy vs. distance graphs
- Total energy of an orbiting body ($E_T = K + U$)
    - Circular orbit $E_T = [GMm/2r]-[Gmm/r] = [-Gmm/2r]$
    - General orbit $E_T = [\frac{1}{2} mv_r^2] + [L^2/2mr^2] - [GMm/r]$
- Dynamical analysis of circular orbit
    - velocity as a function of orbital distance
    - Period as a function of orbital distance
- Derivation and use of the escape speed equation
- Gravitational force and extended objects (rods, shells, solid spheres) (calculus)
- Graphical analysis of gravitational force for a particle *within* a sphere (both hollow and solid)
- The concept of gravitational field
- Kepler's laws of planetary motion with in depth analysis of energy relationships
    - **The law of orbits** (and details of the geometry of the ellipse)
    - **The law of equal areas** (be able to derive the relationship dA/dt....also be able to explain how the conservation of angular momentum concept shows us that the speed of a planet must change as it proceeds in its orbit... additionally, be able to use the conservation of energy idea to prove the same thing...you can assume that the net external torque AND the net external force on a planet/sun system are both ZERO)
    - **The law of periods** (be able to dynamically prove the law for circular orbits)

Lab Activities:

- Kepler's laws of planetary motion (graphical--using astronomical data)

Time Frame: 2 weeks

Structure of the exam:

- multiple choice questions