AP Physics C – Mechanics Course Syllabus

Course Overview: AP Physics C – Mechanics is the culminating science class offered through the Romeo Engineering and Technology Mathematics and Science Center. This course follows the mandated curriculum prescribed by AP Central. Taken concurrently with AP Calculus BC, and Applied Physics – Calculus Lab, it affords students the opportunity to partake in a rigorous course that integrates physics, calculus, and technology. The prerequisite to the course is the successful completion of M.S. (Math Science) Advanced Physics, offered in the sophomore year. M.S. Advanced Physics is a theoretical course offering students the opportunity to delve deep into conceptualized knowledge of mechanics, as well as waves and optics, relativity, and electricity and magnetism. Once students have taken the AP Physics C – Mechanics Exam, the duration of the year will be spent on the completion of the special project depicted below, as well as roller coaster physics, followed by an elaboration of electricity and magnetism, time permitting. The final exam is an integrated authentic assessment given at Cedar Point.

Text: Physics for Scientists and Engineers – 5th Edition
Authors: Paul Tipler and Gene Mosca

Special Project: Our current project involves the construction of a free-fall apparatus which will fire a tennis ball out of a pipe. The ball will then hit an object suspended by electromagnets approximately 20 feet away. Working in concordance with not only members of their own class, but potentially with staff and students from machining, electronics, and drafting, students will be called upon to integrate their knowledge of both physics and calculus as they endeavor through the process.

**Laboratory Experiments and Procedures: Students spend five days a week in the Applied Physics – Calculus Lab, conducting experiments in physics, calculus, or an integration of the two. Even in those labs that are considered chiefly physics, or chiefly calculus, a concerted effort has been put forth to insert additional germane calculus or physics content, relatively speaking. A minimum of two laboratory hours per week is devoted specifically to conducting physics experiments where students utilize scientific inquiry, as well as hone their critical thinking skills. Most labs are technology intensive, thus, the acquisition of most data is done with Vernier probes. Subsequent data manipulation and analysis is completed with Logger-Pro 3.1. While in lab, students work in pairings or small groups. Though students work in partnerships, each student must submit a unique report where the data analysis, calculations and conclusions are individual constructs. Students are instructed to keep a folder of all labs and formal lab write-ups. Students receive a packet entitled *Guidelines for Writing a Formal Lab* Report, as well as a copy of the rubric used to assess their formal lab reports. Certain labs will be selected for formal presentation to the whole class. Because students have so much time in lab each week, a few of the labs are student-formulated. Two such labs are depicted below. Lab #31 was presented at the AP Physics C Conference in November, 2007. The other labs, also listed below, are prescribed in the following sources: *Physics with Computers, 3rd edition, Appel, Gastineau, Bakken and Vernier* (an AP approved laboratory experiment collection), *Connecting Mathematics with Science, I. Lyublinskaya, CBL*

***Explorations in Calculus*, *S. Nichols, et al.*, and *Single Variable Calculus Concepts and Contexts with Vector Functions*, *J. Stewart*.**

The following laboratory experiments will be performed. Their respective sources are listed below, as well as the chapter correlation to the text. Brief descriptions of lab amendments are given below, when relevant.

1. **Graph Matching (Physics with Computers – Third Edition) 2**
2. **Back and Forth Motion (Physics with Computers – Third Edition) 2**
3. **Motion on an Inclined Plane (CBL Explorations in Calculus) 2**
4. **Walking a Motion Plane (Connecting Mathematics With Science) 2**
5. **Analyzing a Falling Object (CBL Explorations in Calculus) 2**
6. **More on Falling Objects (CBL Explorations in Calculus) 2**
7. **Where Are You? Vector manipulation and analysis using GPS units - Student generated lab. 2**
8. **Where Should a Pilot Start Descent? (Single Variable Calculus Concepts and Contexts with Vector Functions) Manipulation of cubic functions and their derivatives to calculate maximum vertical acceleration. 3**
9. **Projectile Motion (Physics with Computers – Third Edition) Revisited in Calculus BC- evaluating definite integrals. Students will use previous data sets to generate and evaluate definite integrals (velocity to position). 3**
10. **Ball Toss (Physics with Computers – Third Edition) Revisited in Calculus BC – rates of change. Students will use previous data sets to generate and algebraically evaluate equations. 3**
11. **Bungee Jump Accelerations with a Low-g Accelerometer (Physics with Computers – Third Edition) Revisited during Cedar Point Final Exam. 3**
12. **Pendulum Periods (Physics with Computers – Third Edition) Extension Questions revisited in Calculus BC – linear approximations and differentials. 3**
13. **Newton's Second Law (Physics with Computers – Third Edition) 4**
14. **Spring Thing (CBL Explorations in Calculus) 4**
15. **Atwood's Machine (Physics with Computers – Third Edition) 4**
16. **Newton's Third Law (Physics with Computers – Third Edition) 4**
17. **Vector Analysis of Forces (CBL Explorations in Calculus) 4**
18. **Static and Kinetic Friction (Physics with Computers – Third Edition) 5**
19. **Air Resistance (Physics with Computers – Third Edition) 5**
20. **Energy of a Tossed Ball (Physics with Computers – Third Edition) 6-7**
21. **Energy in Simple Harmonic Motion (Physics with Computers – Third Edition) 7 Revisited in Calculus BC - Students will use previous data sets to generate and calculate distance, velocity, force, KE, PE, and TE equations, as well as determine maxima and minima, if they exist.**
22. **Work and Energy (Physics with Computers – Third Edition) 6-7**
23. **Integration by Parts (Connecting Mathematics With Science) 8**
24. **Riemann Sums – Center of Mass (Connecting Mathematics With Science) 8**

25. **Momentum, Energy and Collisions (Physics with Computers – Third Edition) 8**
26. **Impulse and Momentum (Physics with Computers – Third Edition) 8**
27. **General Solutions of a Differential Equation (Connecting Mathematics With Science) Damped Oscillations. 9**
28. **Torque About It – Students will use pulleys, weights, bars to investigate moment of inertia, angular momentum, and conservation of angular momentum 9-10**
29. **Bicycle Wheels and Gyroscopes. Student generated lab. 10**
30. **Analyzing a Pendulum (CBL Explorations in Calculus). Students will use calculus to prove Kepler's Second Law of Planetary Motion is equivalent to the Law of Conservation of Angular Momentum. 10, 11, 14**
31. **The Physical Pendulum – Angular Momentum, Rotational Inertia and Simple Harmonic Motion 9, 10, 14**
32. **Simple Harmonic Motion (Physics with Computers – Third Edition) 14-15**

Whiteboard Problem Solving: In a small group setting, students are asked to solve problems, given a whiteboard and a whiteboard marker. While in these groups, students must communicate effectively as they venture through the task. Consequently, they are called upon to be metacognizant of their reasoning, while simultaneously exercising clarity of thought and language. Once finished, the groups will be called upon to use formal language to present and explain their solutions to the entire class.

Question and Answer Sessions and Dissemination of Information: Class periods are currently 54 minutes long. Though each day is unique, in addition to laboratory experiments and demonstrations, students frequently have a lecture session, utilizing about 20-30 minutes, followed by a question and answer session.

Evaluation: Students take approximately one quiz per unit, as well as one culminating test per unit. Quizzes are usually comprised of a multiple choice section and one or two free-response problems. The tests are intended to replicate the look and the language of the AP exam, with an 8 – 12 question multiple choice section, followed by a multi-part free-response section. It is the intention of the instructor to employ the identical methods of evaluation as those utilized by the graders of the AP exam. As students progress thorough the curriculum, questions from previous units may once again appear on certain tests and / or quizzes. During the weeks just prior to the exam, students will practice evaluating their own work, as well as the work of others, using rubrics similar to those used to evaluate the free-response section of the AP exam. Both the multiple choice and the free-response questions come from a myriad of sources, such as AP released exams, test-generator exams from Tipler and Mosca, as well as questions I have created. As a general rule, quizzes will be worth approximately 30-50 points, test worth 100-145 points, informal labs worth 30-50 points, and formal labs worth 75-100 points. Though students are apprised ahead of time of their homework for the entire unit, they are expected to progress in sync with the topics studied in class. A random selection of homework problems will be collected sporadically. Because they have time in class to ask questions most every day, students are expected to have their work

with them each class period, and should be ready to submit work, or to present it on a whiteboard, when asked. Generally, homework and whiteboard assignments will be worth 10-20 points.

Unit	Topics Covered	Chapters in Text	# of Days	Suggested Labs, Activities, Assignments
1	Systems of Measurement Dimensional Analysis	1	Summer work 4	P 14-16, #'s 1-9, 10-60 (x3) Activity – *The Physics of Santa*: 15 in-depth dimensional analysis problems W.B. Activity – Results from *The Physics of Santa* Activity
2	Motion in One Dimension (d, v, and a)	2	8-10	Demo - Motion in One Dimension; Lab: Intro to Logger-Pro – coordinate with AP Calc Lab. Students learn the features of Logger-Pro and how to construct and present a formal lab using Logger-Pro: "Area Under the Curve" and "Slope" Activities – tie to calculus; *inquiry-based discovery* of concepts of tangency, derivative, anti-derivative (integral) concepts via graphical comparative analysis, as well as germane applications in the physics-calculus lab. W.B. Activity – Graph Match; HW: p 42 – 45, #'s 2, 5, 8, 12, 13, 16, 19, 20, 27, 36, 37, 41, 43, 45, 48, 50, 57, 58, 60, 64, 67, 68, 69, 71, 72, 75, 76, 78, 81, 84, 89, 92, 95, 96, 99, 101, 105, 108, 115, 116, 118, 119, 120, 122, 125, 128, 132
3	Motion in 2 and 3 Dimensions	3	8-10	Activity: Graphical Analysis of Motion in 2 and 3 dimensions; Force Table Lab w/ W.B. presentation; 3 Methods of Vector Addition – Table, parallelogram and t-t-t; Demo - Where are you? (GPS units and vector addition); Demo - "World In Motion" Video Analysis;

				Review – Pendulums on Parade Lab from 10th grade **W.B. Activity - Students construct pendular timing devices to *derive* the relationships between pendular length, mass, and / or period, if they exist.** **Pre-view: "Mean Kitty" Lab – Hitting a Target;** **HW: p 76-84, #'s 1-33 (x3), 42, 44, 47, 51, 58, and 60 – 68 (x4),** **76 - 108 (x4)**
	Circular Motion (d, v, and a)		**8-10**	**Demo - Mini-Lab: Circular Motion and Electric Buggies** **Review: Centripetal Motion Demo's from 10th grade;** **HW: p 76 - 84, #'s 5, 7, 11, 14, 17, 20, 22, 23, 29, 32, 37 38, 41, 45, 46, 48, 54, 55, 57, 59, 61, 63, 66, 71, 72, 74, 77 79, 83, 86, 91, 94, 98, 99, 102, 106, 109, 115, 116, 119**
4	**Newton's Laws**	**4**	**8-10**	**Review of Free-Body Diagrams from 10th grade;** **Forces: Weight, Friction, Normal;** **Demo – Force Tables;** **Demo – Force Plates;** **HW: p 107 – 116, #'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 16, 17, 18, 21, 25, 26, 27, 28 29, 30, 31, 32, 37, 38, 39, 40, 41, 43, 44, 45, 51, 52, 55, 57, 58, 59, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72, 75, 77, 82, 83, 84, 85, 86, 89, 91, 92, 95, 96, 100, 101, 102**
	Applications of Newton's Laws	**5**	**8-10**	**Demo - Nested Bowl drop;** **W.B. Activity – GP's p 149 – 150, #'s 102 – 118 (x3);** **HW: p 140—150, #'s 1, 4, 5, 11, 13, 16, 19, 20, 21, 23, 25, 27, 28, 29, 31, 33, 35, 37, 39, 40, 42, 44, 45, 50, 52, 54, 57, 59, 64, 65, 67, 68, 69, 71, 74, 83, 85, 88, 91, 92, 93, 95, 101, 104, 106, 112, 115, 116**
5	**Work, Energy, and**			

	Power			
	Work, Energy, and Power	**6**	**5-7**	**Dot Product Activity – tie to calculus;** **Review of Horsepower Lab from 10th grade including data analysis, graphical interpretation, and *derivation of* prediction equations based on mass, and age;** **W.B. Activity – Work Energy Theorem – link to 10th grade;** **Utilizing motion detectors and force sensors to determine both position and force for a hanging mass, spring, and dynamics cart, students will *derive* Hooke's Law. Information gathered via sensors will then be used to calculate velocity, kinetic energy and work;** **W.B. Activity – Work Energy in 3-D;** **Demo - Potential Energy;** **HW: p 175 – 182, #'s 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 14, 16, 17, 20, 21, 22, 23, 25, 26, 28, 30, 31, 35 36, 37, 38, 39, 40, 41, 42, 43, 44, 46, 47, 49, 50, 53, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 67, 69, 81, 82, 83, 84, 85, 87, 89, 90**
	Conservation of Energy	**7**	**6-8**	**Review of Bowling Ball Demo from 10th grade;** **Review of Quantization of energy from 9th grade;** **Hooke's Law – tie to calculus. Students will manipulate the** $W = \Sigma F(s) \Delta s$ **to *discover* the calculus connection inherent in** $W = \int F(s)\, ds$**;** **W.B. Activity – Graphical analysis of Roller Coaster (d, v, and a);** **HW p 207 – 216, #'s 1, 2, 3, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 37, 40, 41, 42, 45, 47, 49, 51, 52, 62, 64, 65, 69, 70, 72,**

				73, 74, 76, 79, 81, 82, 85, 86, 90, 91
6	**Systems of Particles and Conservation of Linear Momentum**	**8**	**8-10**	**Review Collisions Lab (air pucks) and Egg Toss Demos from 10th grade;** **Review c.o.m. Lab from 10th grade;** **Demo – Pool balls and Conservation of Linear Momentum;** **Demo – Air Track and Impulse-Momentum;** **Activity - Pool balls and Conservation of Linear Momentum;** **HW: p 254 – 265, #'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 21, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50, 51, 52, 53, 54, 55, 56, 109, 110, 114, 115, 116, 117, 129, 132, 133, 134**
7	**Rotation and Angular Momentum**			
	Rotation	**9**	**8-10**	**Activity – Analyzing and Interpreting Moments of Inertia;** **W.B. Activity – Moment of Inertia;** **Demo – Gyroscope;** **W.B. Activity – Explain How a Gyroscope Works;** **Demo – Physical Pendulum;** **Demo – How a Yo-Yo Works;** **W.B. Activity – The Parallel Axis Theorem;** **HW: p 296 – 308, #'s 1, 3, 5, 7, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 20, 23, 25, 27, 29, 31, 23, 34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 47, 48, 51, 53, 55, 56, 58. 59. 60, 62, 65, 68, 70, 73, 74, 76, 78, 79. 81, 83, 85, 88, 90, 93, 103, 106, 110, 116**
	Conservation of Angular Momentum	**10**	**8-10**	**Demo: 3-D vectors and Cross product;** **W.B. Activity – Definition and Application of the Right-Hand-Rule;** **Demo – Skating on the Pond;** **Demo – Spinning Disks;** **HW: p 329 – 334, #'s 1, 2, 3, 4, 5, 6, 8, 9,**

				11, 14, 19, 21, 25, 26, 27, 28, 29, 32, 32, 33, 34, 35, 36, 37, 39, 40, 41, 42, 44, 45, 46, 49, 51, 53, 54, 58, 59, 66, 67, 68, 70, 72, 80, 82, 89, 90, 93
8	**Gravity**	**11**	**8-10**	**Picket Fence Free Fall;** **Demo – Free-fall Apparatus;** **Review of Kepler's Laws form 10th grade;** **W.B. Activity – Linearization of Data Using Fig 11-5 p 342;** **Lab: "Mean Kitty"** **HW: p 362 – 363 #'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21 22, 23, 24, 25, 26, 29, 30, 31, 32, 35, 36, 37, 39, 40, 43, 44, 45, 46, 47, 51. 53, 55, 56, 58, 60, 61, 65, 67, 69, 71, 74, 75, 77, 81, 82, 89, 92, 93, 100**
9	**Oscillations and Waves**	**14**	**8-10**	**W.B. Activity – What is Resonance?;** **Damped Oscillations;** **Demo – Revisiting the Simple Pendulum and Simple Harmonic Motion** **Demo – How does a music box work?;** **Activity – Analyzing Oscillating Graphs;** **Demo – Revisiting Hooke's Law;** **Activity – Exploring Resonance in Music;** **HW: p 455 – 464, #'s 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 18, 19, 20 21, 23, 24, 25, 26, 27, 28, 29, 32, 33, 35, 37, 39, 40, 41, 43, 45, 47, 49, 51 55, 57, 59, 60, 61, 62, 65, 67, 69, 71, 73, 78, 81, 82, 83, 84, 89, 91, 93, 95, 96, 99, 102, 103, 111, 113, 122**

Note: Prior to the AP exam, any remaining time will be used to practice AP Exam Questions. Once the AP Exam is over, the remaining time will be spent on special projects and labs, as specified in the course overview.