**AP Physics 1**

2017-2018

**Richard Hendricks**

**Email: richard.hendricks@rcsdk12.org**

**Website: https://sites.google.com/site/sotaapphysics**

**Room: 409**

**Phone: 585-314-2029**

**TEXTBOOK:**

**Giancoli,** Douglas C. **Physics, Principles with Applications 7thth edition.** Boston, MA Pearson, 2014. *[Cr1]*

**Instructional schedule**

This class meets daily for one 43 min period and every other day for a 43 min lab period for an average of about 8.5 periods a week or about 360 min. Laboratory work is about 1.5 times a week with some sections devoted nearly entirely to lab work and flipped instruction using video instructions for homework issues that would normally be discussed using class time. The class will most often consist of instructional discussion. Socratic Method will be used for the development of the lab activities. Many of the results for the lab will be compiled using the library computer lab we have available.

**INSTRUCTIONAL STRATEGIES**

AP Physics 1 is an AP-level algebra-based physics course, taught as a first-year college physics class for 11th and 12th graders. The AP Physics 1 course is conducted using **inquiry-based instructional strategies** that focus on experimentation to develop students’ conceptual understanding of physics principles. Approximately half the students have had no high school course in physics and the other have. It is not a requirement to enroll. The primary purpose of this class is to establish a fundamental knowledge in physics for students who may require it as a career path. They should find both a challenge and a joy in learning unique to a science in which so many things in theory are so visible and easily manipulated. Students should anticipate learning how to plan their own investigations in a laboratory setting and familiarizing themselves with being able to explain reasoning verbally, in addition to manipulating mathematical symbols.

Many of the devices used to apply are “home- made” such as our ultra-long air track powered by a shop vac, compressed air-apple the “monkey and the hunter” motion apparatus or various bicycle wheels which can be loaded for angular acceleration. Some of these devices are based on classic methods such as the Cavendish balance or diffraction to measure the diameter of a human hair. This is generally due to grant dollars, surplus and household devices used to add “color” and application to the concepts on a shoestring budget. Most of the grant dollars provide raw materials and tooling equipment for custom equipment. We have Vernier motion probes, voltage and temp probes for labs that benefit from a premade technical interface. Students should see the advantages and limitations of these devices and use them when appropriate. In the classroom, they use graphing calculators and digital devices for interactive simulations, Physlet-based exercises, collaborative activities and formative assessments.

It should be noted that prior to this class, most of the students have not had any experience or training in spreadsheets. Most have used word processing but nearly none have used a spreadsheet to compile data or graphical analysis. In my opinion, this is a fundamental skill they must have for the careers most aspire towards so we will use that spreadsheet and document processing applications to analyze data, find trends and determine differential error in the results.

At year end, there will also be heavy emphasis on preparation for the AP test but preparatory sessions will be in the evenings and on weekends. We will not use class time for test prep. Most students only need help with “short-cutting” steps they consider obvious and leaving the grader with no logic to follow. The best way to prepare for the AP exam is to know what you’re talking about to begin with. AP prep will develop strategies to help you tell others in a manner they can follow.

**Grading plan** coursework will be graded approximately:

|  |  |  |
| --- | --- | --- |
| **Tests /Quizzes** | **60%** | You really have to perform under controlled conditions. This is especially true since so many homework solutions are posted – even by me- online. |
| **Labs**. | **20%** | About 1 per week. These labs are more extensive |
| **Homework** | **20%** | Almost daily homework assigned in advance and posted to the website calendar. |

**Tests/Quizzes:**  About 3 tests per marking period. We know that the key to success in physics is to keep current. Cognitive research that quizzing directly after instruction is the best way to gain and retain information for students. Tests are a full period and are comprehensive. If you have been doing homework, you should do great! Generally I will make a few samples ahead of time to let you see what is expected.

**Homework**: At the beginning of each class I will ask you if there were problems with the homework. I know where the problems should have arisen and I can generally tell who has and has not done the homework minutes after I ask that question. Consistent homework is the key to understanding class discussion and anticipating test problems.

It’s typical for me to combine several homework concepts into one question on a test. Understanding these concepts and how they fit is critical. Brain studies tell us that doing small assignments regularly is superior to many assignments all at once. Obviously you can copy or find a solution somewhere on the internet but I assure you, that just copying these solutions will cause you to fail tests.

All homework should be titled with your full name, date and the problems assigned. For example:

*Richard Hendricks 9/4/2012 chapter 4 page 135: 3,6,8,12*

**Parent Involvement**

Parents may call or text me on my cell phone 585-314-2029 at any reasonable hour. E-mail [Richard.hendricks@rcsdk12.org](mailto:Richard.hendricks@rcsdk12.org) . There are several parent conferences preset but parents are welcome to schedule another time with me. I have some free hours in the morning and in the afternoon for a face to face conference.

Students who try and don’t understand are never abandoned. They pay me to teach and I want to earn my pay. If students need help, they may see me before, after or during school or send me an email. Students are always welcome to express frustration after school. Please don’t just complain in class. That does no good. Students who are serious about learning will make the effort and teachers who want to teach will at least match that effort.

**COURSE TOPICS**

**UNIT 1. KINEMATICS [CR2a]**

* Kinematics in one-dimension: constant velocity and uniform accelerated motion
* Vectors: vector components and resultant
* Kinematics in two-dimensions: projectile motion

Big Idea 3

Learning Objectives**:** 3.A.1.1, 3.A.1.2, 3.A.1.3

**UNIT 2. DYNAMICS [CR2b]**

* Forces, types and representation (FBD)
* Newton’s First Law
* Newton’s Third Law
* Newton’s Second Law
* Applications of Newton’s 2nd Law
* Friction
* Interacting objects: ropes and pulleys

Big Ideas 1, 2, 3, 4

Learning Objectives**:** 1.C.1.1, 1.C.3.1, 2.B.1.1, 3.A.2.1, 3.A.3.1, 3.A.3.2, 3.A.3.3, 3.A.4.1, 3.A.4.2, 3.A.4.3, 3.B.1.1, 3.B.1.2, 3.B.1.3, 3.B.2.1, 3.C.4.1, 3.C.4.2, 4.A.1.1, 4.A.2.1, 4.A.2.2, 4.A.2.3, 4.A.3.1, 4.A.3.2

**UNIT 3. CIRCULAR MOTION AND GRAVITATION [CR2c]**

* Uniform circular motion
* Dynamics of uniform circular motion
* Universal Law of Gravitation

Big Ideas 1, 2, 3, 4

Learning Objectives**:** 1.C.3.1, 2.B.1.1, 2.B.2.1, 2.B.2.2, 3.A.3.1, 3.A.3.3, 3.B.1.2, 3.B.1.3, 3.B.2.1, 3.C.1.1, 3.C.1.2, 3.C.2.1, 3.C.2.2, 3.G.1.1, 4.A.2.2

**UNIT 4. ENERGY [CR2f]**

* Work
* Power
* Kinetic energy
* Potential energy: gravitational and elastic
* Conservation of energy

Big Ideas 3, 4, 5

Learning Objectives**:** 3.E.1.1, 3.E.1.2, 3.E.1.3, 3.E.1.4, 4.C.1.1, 4.C.1.2, 4.C.2.1, 4.C.2.2, 5.A.2.1, 5.B.1.1, 5.B.1.2, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2, 5.B.5.1, 5.B.5.2, 5.B.5.3, 5.B.5.4, 5.B.5.5, 5.D.1.1, 5.D.1.2, 5.D.1.3, 5.D.1.4, 5.D.1.5, 5.D.2.1, 5.D.2.3

**UNIT 5. MOMENTUM [CR2e]**

* Impulse
* Momentum
* Conservation of momentum
* Elastic and inelastic collisions

Big Ideas 3, 4, 5

**Learning Objectives:**  3.D.1.1, 3.D.2.1, 3.D.2.2, 3.D.2.3, 3.D.2.4, 4.B.1.1, 4.B.1.2, 4.B.2.1, 4.B.2.2, 5.A.2.1, 5.D.1.1, 5.D.1.2, 5.D.1.3, 5.D.1.4, 5.D.1.5, 5.D.2.1, 5.D.2.2, 5.D.2.3, 5.D.2.4,5.D.2.5, 5.D.3.1

**UNIT 6. ROTATIONAL MOTION**

Torque

* Center of mass
* Rotational kinematics
* Rotational dynamics and rotational inertia
* Rotational energy
* Angular momentum
* Conservation of angular momentum

**Big Ideas 3, 4, 5**

**Learning Objectives:**  3.F.1.1, 3.F.1.2, 3.F.1.3, 3.F.1.4, 3.F.1.5, 3.F.2.1, 3.F.2.2, 3.F.3.1, 3.F.3.2, 3.F.3.3, 4.A.1.1**,** 4.D.1.1, 4.D.1.2, 4.D.2.1, 4.D.2.2, 4.D.3.1, 4.D.3.2, 5.E.1.1, 5.E.1.2, 5.E.2.1

**UNIT 7. SIMPLE HARMONIC MOTION [CR2d]**

* Linear restoring forces and simple harmonic motion
* Simple harmonic motion graphs
* Simple pendulum
* Mass-spring systems

**Big Ideas 3, 5**

**Learning Objectives:** 3.B.3.1, 3.B.3.2, 3.B.3.3, 3.B.3.4, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2

**UNIT 8. MECHANICAL WAVES [CR2j]**

* Traveling waves
* Wave characteristics
* Sound
* Superposition
* Standing waves on a string
* Standing sound waves

**Big Idea 6**

**Learning Objectives:** 6.A.1.1, 6.A.1.2, 6.A.1.3, 6.A.2.1, 6.A.3.1, 6.A.4.1, 6.B.1.1, 6.B.2.1, 6.B.4.1, 6.B.5.1, 6.D.1.1, 6.D.1.2, 6.D.1.3, 6.D.2.1, 6.D.3.1, 6.D.3.2, 6.D.3.3, 6.D.3.4, 6.D.4.1, 6.D.4.2, 6.D.5.1

**UNIT 9. ELECTROSTATICS [CR2h]**

* Electric charge and conservation of charge
* Electric force: Coulomb’s Law

**Big Ideas 1, 3, 5**

**Learning Objectives:** 1.B.1.1, 1.B.1.2, 1.B.2.1, 1.B.3.1, 3.C.2.1, 3.C.2.2, 5.A.2.1

**UNIT 10. DC CIRCUITS [CR2i]**

* Electric resistance
* Ohm’s Law
* DC circuits
* Series and parallel connections
* Kirchhoff’s Laws

**Big Ideas 1, 5**

**Learning Objectives:** 1.B.1.1, 1.B.1.2, 1.E.2.1, 5.B.9.1, 5.B.9.2, 5.B.9.3, 5.C.3.1, 5.C.3.2, 5.C.3.3

Exact topics, homework problems and tentative test dates are posted at : <http://sites.google.com/site/sotaapphysics>

**Labs [CR5,6,7,8]**

An important part of this class involves laboratory work, which involves conducting experiments, collecting data, doing analysis on the data, and submitting all data and analysis in the form of a ***lab report***. Labs will occupy 25-40% of class time, which is 2+ periods per week. **[CR5].** The laboratory component of the course allows the students to demonstrate the seven **science practices** through a variety of investigations in all of the foundational principles.

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.

All investigations are reported in a **laboratory journal**. Students are expected to record their observations, data, and data analyses. Data analyses include identification of the sources and effects of experimental uncertainty, calculations, results and conclusions, and suggestions for further refinement of the experiment as appropriate. **[CR7]**

You are responsible for keeping data individually and collectively. That is, if you work with a group. EACH of you should have access to the data. Don’t tell me later than you can’t turn lab in because someone else has the data.

Some reports are more involved, take more time and are worth more. Others are simple, take one period and you may write them even before the class ends. Some are much more fun. Playing around unsafely is not allowed but iteration is a common method for getting an experiment to go well. Check with your teacher if you want to change method but don’t be afraid to suggest something you think may work better. In general I will allow any suggestions that doesn’t pose a risk. Be prepared to describe why you feel your technique is an improvement.

There are 4 key areas of a written lab report to keep in mind

**1. What you did**

An abstract that describes briefly what you did. This can be brief such as “ We dropped a mass out the window and timed the displacement of the fall with a video camera which took frames each 1/25th of a second” It could be longer.

**2. How you did it.**

Physics is about reality. There is theory that suggests a result should occur. Like Rutherford experiment, sometimes the theory is contradicted, sometimes it is supported. I want to know what you expect and why. What physical principle is being tested? What predictions does the theory make?

Describe how the experiment was done. If someone else wanted to repeat the experiment to confirm your results, how would they do it? What would they need to know?

**3. What were the results?**

Sometimes this is only a few data points, other times a table and graph of results are appropriate. You decide how to best tabulate results.

**4. What do the results mean?**

Analysis and discussion of your results are the most important piece. Did you get the result predicted by the theory? Was it within the range of significant digits based on your measuring device or technique? How might you or how did you modify your result to get improvement in the reliability of the result?

Use your judgement about what applies the way you do in the prior sections. Writing the report should NOT be an agonizing effort. It should be succinct and complete. Sometimes a graph is appropriate and sometimes not. If it is appropriate, make sure it is labeled clearly.

Engineers are often criticized for an “inability to write a report”. This is either because they include nearly no supporting references, assuming them obvious, or provide a vast overkill of supporting evidence while understating the major thrust of a conclusion. See if you can find that balance here.

**LABORATORY INVESTIGATIONS AND THE SCIENCE PRACTICES**

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| --- | --- | --- |
| **UNIT** | **LAB INVESTIGATION OBJECTIVE(S) CR6a**  (Investigation identifier: Guided Inquiry: **GI**  Open Inquiry: **OI**) **[CR6b]** | **SCIENCE PRACTICES [CR6b]** |
| **UNIT 1. KINEMATICS** | **1. Meeting Point (OI)**  To predict where two battery-powered cars will collide if they are released from opposite ends of the lab table at different times. Both “cars” are constant velocity models but one of them has a secondary load on the battery to slow it down. | 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **2. Up the air track and back (GI)**  We used a large air track and Vernier distance sensors to detect motion of a track car moving up the air track. This is used to determine either the value for g based on the angle of the track OR the angle of the track based on g and results. Students use distance vs. time data to find velocity and acceleration. | 1.2, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **3. Free-Fall Investigation (OI)**  To determine the acceleration of an object which is dropped using results from a ticker tape timer and an ultra sound distance sensor. A value of gravity and the precision of that value is determined graphically using differential error for either technique. | 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **4. Vector Addition (GI)**  To determine the value of a resultant of several vectors, and then compare that value to the values obtained through graphical and analytical methods. | 1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **5. The monkey and the hunter (OI)**  Students will use an air power apple canon to shoot at a target suspended from an electromagnet. The electromagnet will release a ball (monkey) when the canon is fired. Students must determine where to aim the apple to strike the monkey. | 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **6. Police chase (OI)**  Student release a car on a level air track just after another car has passed while moving up an inclined neighboring track. One car is accelerated while the other is at constant velocity. Students predict where the cars will intersect. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3,  6.1, 6.2, 6.4, 7.2 |
|  |  |  |
| **UNIT 2. DYNAMICS** | **7. Inertial and Gravitational Mass (GI)**  Students will compare times for balls of various mass and mass density to roll down an inclined plane. An 8 pound bowling ball, a 16 pound bowling ball, a soccer ball and small solid rubber ball or marble will be compared. | 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **9. Static Equilibrium (OI)**  Students will use strings (or fishing line) to determine the mass of objects by deflection of support lines. | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **10. Newton’s Second Law (OI)**  Vernier motions sensors OR ticker tape timers will be used to determine the variation of the acceleration of a dynamics cart in two scenarios: (1) the total mass of the system is kept constant while the net force varies, and (2) the net force is kept constant while the total mass of the system varies. | 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **11. Coefficient of Friction (OI)**  To determine the maximum coefficient of static friction between a wooden block and various grades of sandpaper ranging from 40 to 2000 grit. The experiment will be repeated for low m surfaces such as wax paper and Tyvek house wrap. | 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **12. Atwood’s Machine (GI)**  To determine the acceleration of a hanging mass and the tension in the string. | 1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **13. Centripetal motion (GI)**  To determine the tension in the string and the centripetal acceleration of an object (generally a heavy rubber stopper) in constant circular motion using geometric angles and tangent | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  |  |  |
| **UNIT 3. CIRCULAR MOTION AND GRAVITATION** | **14. Roller Coaster Investigation (OI)**  To design a simple roller coaster using provided materials to test whether the total energy of the system is conserved if there are no external forces exerted on it by other objects. | 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.2, 6.4, 7.2 |
| **UNIT 4. ENERGY** | **15. Work Done in Stretching a Spring (GI)**  To use Vernier force sensors to determine the work done on the spring from force-versus-distance graph of the collected data. Students should determine the work graphically from area. | 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **16. Energy and Non-Conservative Forces (GI)**  The Atwood’s machine experiment is repeated for mass over pulley dragging mass along a frictional surface table. Results are used to determine the energy dissipated by friction. | 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 6.5, 7.2 |
|  | **17. Crumple Zone Crash worthiness Design (OI)**  To design a paper bumper that will soften the impact of the collision between a cart and a fixed block of wood. Their designs are evaluated by the shape of an acceleration-versus-time graph of the collision. Students must make conclusions in terms of factors of g commonly used to determine survivability of the crash. | 1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  |  |  |
| **UNIT 5. MOMENTUM** | **18. Impulse and Change in Momentum (GI)**  To measure the change in momentum of a dynamic cart and compare it to the impulse received. | 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **19. Elastic and Inelastic Collisions (OI)**  To investigate conservation of momentum and conservation of energy using a nail gun and wood block ballistic pendulum to determine the speed of the nail and the amount of heat generated per nail. | 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **20. Expert witness (OI)**  Students must use: Apply principles of conservation of energy, conservation of momentum, the work-energy theorem, and a linear model of friction to determine the range of speeds of a car which has struck another car at a traffic light. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  | **21. Finding the Spring Constant (OI)**  To design two independent experiments to determine the spring constants of various springs of equal length. These could include simple stretch, harmonic oscillation or any reasonable method. | 1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  |  |  |
| **UNIT 6. SIMPLE HARMONIC MOTION** | **22. Graphs of an Oscillating System (GI)**  Vernier motion sensors will be used to general graphs of position, velocity, and acceleration versus time for an oscillating system to determine how velocity and acceleration vary at the equilibrium position and at the endpoints. Students will compare displacement to velocity vs time. More advanced (mathematically) students will be asked for comparison of sin and cos. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **23. Height of the staircase Investigation (OI)**  Students will use a long pendulum in the building staircase to measure the distance from the top floor to the basement using a pendulum and a precision value for gravity. They will then compare results to a value determined by measuring tape. | 1.2, 1.4, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
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| **UNIT 7. ROTATIONAL MOTION** | **24. Torque on the tire (OI)** A tire wheel with a large rotational moment is torqued by a hanging tangential mass. This torque causes a predictable angular acceleration, which is measured with a ticker tape. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.1, 7.2 |
|  | **25. Rotational Inertia (GI)**  An open inquiry ball and ramp experiment with the landing point of a bowling ball. With only PE and KE information, students incorrectly place a landing point for a ball rolling down a ramp, off a counter top and onto the floor. When Rotational KE is added in, the placement becomes correct. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **26. Conservation of Angular Momentum (GI)**  To investigate how the angular momentum of a rotating system responds to changes in the rotational inertia. Along with lab equipment for more precise results, this lab features a visit to a neighboring playground where students ride the “rotor”. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **27. Mechanical Waves (OI)**  To model the two types of mechanical waves with created on a vibrating string or wire with variable bulk modulus. A hanging mass provides a given tension. The lab emphasizes factors for string instruments, which many of our students study. The characteristics affect the speed of a pulse: frequency, wavelength and amplitude. Harmonics of a standing wave on the string are connected to musical octave. | 1.2, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2 |
|  |  |  |
| **UNIT 8. MECHANICAL WAVES** | **28. Speed of Sound (OI)**  Designtwo different procedures are used to determine the speed of sound in air. The first is a resonance effect with a given frequency. The second involves destructive interference of in phase sources. Again the emphasis on factors that make for clear sound and acoustics that effect performing arts. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  | **29. Wave Boundary Behavior (GI)**  This lab examines phase shift, diffraction patterns and reflected waves for perturbations in a water surface. Extensions are made to resonance patterns in solids. | 1.4, 3.1, 4.1, 4.2, 4.3, 5.1, 6.1, 6.4, 7.2 |
|  | **30. Doppler Waves (OI)**  Doppler effect of a car horn: Using data gathered with a cell phone and sound software to determine the speed of a car from its Doppler shift | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **31. Sound thermometer (GI)** decibel meters (and ears) are used to find resonance length for open and closed end resonance tubes. The length is used to calculate temperature of the room. This modification of the classic resonance length experiment, emphasizes the dependency of speed on temperature for sound. | 1.1, 1.2, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, |
|  | 1. **Static Electricity Interactions (GI)**   Drawing equipotential lines: students use a table with a salt water solution to establish the equipotential lines between conductors. Rather than a standard voltage source, students use a low voltage signal generator as the source and establish equipotential lines by listening for a tone with headphones. This similar to conductive paper mapping but uses sound instead to show the effect of a potential difference audibly. | 1.2, 3.1, 4.1, 4.2, 5.1, 6.2, 7.2 |
| **UNIT 9. ELECTROSTATICS** | **32. Coulomb’s Law (OI)**  To estimate the charge on two identical, equally charged spherical pith balls of known mass. Using angles and separation distances. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **33. Brightness Investigation (GI)**  To make predictions about the brightness of light bulbs in a variety of series and parallel circuits when some of the bulbs are removed. | 1.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2 |
|  |  |  |
| **UNIT 10. DC CIRCUITS** | **34. Combining resistors (GI)**  Combine resistors in series and parallel in various configurations. See if the new combination resistances are as predicted by series and parallel combination laws. The resistances are placed into a (premade) RC time constant circuit that produces an audible tone. Student will compare the tone generated by a single fixed resistor to group of resistors that are, ostensibly,the same resistance. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2 |
|  | **35. Resistance and Resistivity (OI)**  This lab compares the VI characteristics of a fixed resistor to the VI characteristics of a small lamp with a variable resistance. Power of each will also be related to the VI curve. | 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1,5.3, 6.1, 6.4, 7.2 |
|  | **36. Series and Parallel Circuits (OI)**  Basic circuit analysis techniques for single, double loop systems using Kirchoffs voltage and current law. Students will solder the circuit in a way that leaves test points for current and voltage. Optional: Mathematically ambitious students will learn matrix solutions for n-level simultaneous equations for n-loop circuit. | 1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4, 7.2 |

**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: The Monkey and the hunter Investigation**

**DESCRIPTION:**

Students will use an air power apple “canon” to shoot at a target suspended from an electromagnet. The electromagnet will release a ball (monkey) when the canon is fired. Students must determine where to aim the apple to strike the monkey.

**Learning Objective 3.A.1.1**

*The student is able to express the motion of an object using a narrative, mathematical and graphical representation.*

**Learning Objective 3.A.1.2**

*The student is able to design an experimental investigation of the motion of an object.*

**Learning Objective 3.A.1.3**

*The student is able to analyze experimental data describing the mothing of an object and is able to express the results of the analysis using a narrative, mathematical and graphical representation.*

**Learning Objective 3.A.3.1**

*The student is able to analyze a scenario and make claims (develop arguments, justify assertion) about the forces exerted on an object for different types of forces or components of forces.* ***[SP6.4,7.2]***

**Learning Objective 3.E.1.3**

*The student is able to use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and whether kinetic energy of that object would increase, decrease or remain unchanged..*

**Learning Objective 3.E.1.4**

*The student is able to apply the mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object.*

**Learning Objective 4.A.2.1 [SP6.4]**

*The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time.*

**DESCRIPTION:**

Working in groups of three, Students will connect PVC tubing to an air track which can be discharged with a pneumatic ASCO switch. 1.5 “ and 2 “ PVC of various lengths are available to cut to desired length. Apples are used as the projectile and a soccer ball is used instead of a monkey.

Students quickly connect the length of the tube to the work done on the apple and resulting Kinetic energy. Practical applications such as the fact that apples fragment at times when the tube size changes.

Shooting apples at anything involves Newtons 3rd law. Students find quickly that the mass of the apple causes a recoil which change the aim. They must react, redesign and consider results in order to eventually hit the soccer ball at outside distances of about 60 feet from the target.

**2.** **REAL WORLD APPLICATION**

**ACTIVITY:Combining resistors [CR4]**

**DESCRIPTION:**

Combine resistors in series and parallel in various configurations. See if the new combination resistances are as predicted by series and parallel combination laws. The resistances are placed into a (premade) RC time constant circuit that produces an audible tone. Student will compare the tone generated by a single fixed resistor to group of resistors that are, ostensibly, the same resistance.

Again the emphasis at this performing arts school is on the relationship between physics principles and the theatre. Students prefer sound based applications and are often audibly talented enough to pick up nuances they can use.

**Learning Objective 5.B.9.1 [SP:1.1,1.4]**

*The student is able to construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series / and/or , at most, one parallel branch as an application of the conservation of energy (KVL, KCL)*

**Learning Objective 5.B.9.2 [SP:4.2, 6.4, 7.2]**

*The student is able to appl the conservation of energy concepts to athe design of an experiment that will demonstrate the validity of Kirchoff’s loop rule ( V = 0) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches.*

**Learning Objective 5.B.9.3 [ SP: 2.2, 6.4, 7.2 ]**

*The student is able to apply conservation of energy (Kirchoff’s loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and , at most, one pair of parallel branches.*

**3. SCIENTIFIC ARGUMENTATION**

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**. [CR8]**

**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.*

**Calendar:**

**More precise topical sequence and homework plan**

**(on website:** [**http://sites.google.com/site/sotaapphysics**](http://sites.google.com/site/sotaapphysics) **)**