**AP Physics 2 Labs**

**Guided Inquiry**

Selected labs that involve guided inquiry are so labeled. Students will be trained in a 5 step format for guided inquiry labs. They are presented with an apparatus/motion and taught to follow the following 5 steps. **[CR6b]**

1. Identify something about the apparatus that can be manipulated in a quantifiable way. (IV)
2. Identify what about the event/motion would be changed in a quantifiable way. (DV)
3. Predict the functional way in which the IV affects the DV.
4. Design an experiment to test your hypothesis.
5. Graph your data and generate a mathematical model of your graph.

**Science Practices**

All 7 Science Practices will be addressed throughout the course of the robust laboratory portion of the course. There will be several labs each unit. The Science Practices are listed for some select labs to illustrate this. **[CR6a]**

**Vernier Labs**

Some labs’ description simply says Vernier Lab. The instructions for this lab utilize the cookbook handouts that come with logger pro.

1st Semester

1. **Fluid Mechanics** 
   1. Al Boat Construction Activity
      1. Students are tasked with construction of an Al foil boat. They are given 1ft2 of Al and told to construct a boat that will hold the most number of metal washers.
   2. Archimedes’ Principle Lab (applet/spring scale) **[Guided Inquiry]**
      1. <http://www.walter-fendt.de/ph14e/buoyforce.htm>
      2. Students are tasked with identifying what factors affect the buoyant force acting on a submerged object and how those factors affect the buoyant force.
   3. Density of Various Fluids (oil, water, diet vs regular coke, etc)
      1. Students are given various fluids, a very dense object and a force probe. By dipping the object into the fluids and using the volume of the object, weight of the object and buoyant force they can determine the density of the fluids.
      2. Mass vs volume….slope is density
      3. Pour more liquid into a graduated cylinder
   4. Fluid Pressure Applet Lab **[Guided Inquiry]**
      1. Students use the GI questions to determine what factors affect the pressure exerted by a fluid. Phet applet.
   5. Pressure Probe Lab
      1. Dip a pressure probe into water deeper and deeper
      2. Graph pressure vs depth
      3. Rho gh + Po
   6. Density of He Lab (given He balloon and empty balloon) **[SP 2]**
      1. Students are tasked with designing an experiment to determine the density of He given a He balloon.
   7. 2L Water Bottle Lab
      1. Height of poked holes vs range of water squirt
      2. Contest: Predict where the water ends up: <https://vine.co/v/OFnUqIiurKD>
   8. Continuity Equation Applet
      1. PhET Applet av=av
   9. Water Fountain Lab
      1. Exit angle and exit speed of the water
      2. Maximum height of the water
      3. Radius of the fountain’s exit hole
      4. Volume flow rate
   10. Cardboard Boat Activity
       1. Students will design a cardboard boat that will safely allow two passengers to cross a pool and come back. Students must include boat design features and calculations to show how their boat design should float. [LO 1.E.11, 1.E.1.2, 3.A.4.1, 3.A.4.2, 3.A.4.3, 3.B.1.4]
   11. Push Water Gun Lab
       1. Speed you are pushing the tube times the area equals the area of the end tip times the speed from the range shot
2. **Thermodynamics** 
   1. Thermal Speed Lab
      1. The Physics Aviary applet
   2. Maxwell Distribution Lab
      1. The Physics Aviary applet
   3. Gas Properties PhET Lab **[Guided Inquiry]**
      1. Students investigate the relationships between P, V and T using the applet and the 5 steps for GI.
   4. Behavior of a Gas
      1. Vernier Lab
   5. Heat Engine
      1. Vernier Lab
   6. Heat Transfer Apparatus Lab
   7. Thermal Conductivity Lab
      1. Given various lengths of various metals all of the same gauge students make heat bridges between Styrofoam cups of hot and cold water. Using Vernier temp probes they graph the temperature of the cold water versus time to determine the thermal conductivity of the materials.
      2. 12 inch pieces….Copper….Steel….Brass
   8. Entropy Lab
      1. Given a deck of cards create a method of determining the entropy that results from shuffling a deck of cards. Graphing *something* vs number of shuffles. Allowing students to determine the *something*. Could use a smaller subset.
   9. MicroStates Entropy Lab
      1. Put a penny in each day of a pill container. Have them shake the container.
      2. Graph x-axis as number of heads. 1-7
      3. Graph y-axis as number of occurrences
   10. Dipping Bird Heat Engine
       1. <http://www.exploratorium.edu/snacks/dippingbird/>
       2. Mentzer, Robert, "The Drinking Bird - The Little Heat Engine That Could," *The Physics Teacher*, February 1993.
3. **Optics** 
   1. Snell’s Law Lab
      1. Students are given a laser and a plastic block and tasked with investigating the relationship between the angle of incidence and the angle of refraction. The index of refraction for the plastic block is determined.
   2. Converging Lens Lab
      1. Students investigate the lens equation to determine the focal length of a converging lens.
   3. Diverging Lens Applet Lab
      1. Students investigate the lens equation to determine the focal length of a diverging lens.
   4. Converging Mirror Lab
      1. Students investigate the mirror equation to determine the focal length of a converging mirror.
   5. Total Internal Reflection Lab
      1. Students use a laser and a container of water to determine water’s Critical Angle.
   6. Wave Interference Lab
      1. Interference Applet experiment.
   7. Diffraction Lab **[Guided Inquiry]**
      1. Given a diffraction grating and two lasers of different wavelength the student design an experiment where they vary the length away from the wall and the separation of dots to determine the wavelength of the laser.
   8. Thickness of a Hair
      1. Laser shined on a hair and measure the values. Diffraction equation to measure the hair thickness. Use a micrometer to measure the thickness of a hair.
      2. Shine laser through a CD and measure the distance between the lines.
   9. Two Speakers Interference Pattern
      1. Using two computer speakers through which is played a tone of constant frequency and a vernier microphone the students use Young’s Equation to determine the frequency.
   10. Polarization Lab
       1. Using a Vernier Light Meter and pieces of polarizing sheets they see how angle affects light transmission.
       2. Malus’ Law: I = I0 cos2θ
4. **Modern**
   1. Photoelectric Effect Applet Lab **[SP 1]**
      1. Using the PhET applet the students determine the work function for various metals.
   2. Cloud Chamber Lab
      1. Student design an experiment to determine the charge of a particle in a magnetic field.
   3. Penny Half Life Lab and Dice Half Life Lab
      1. Using 100 pennys the students generate a ½ graph by tossing the pennys and ‘decaying’ the ½ that turn up as heads. After successive throws they generate a hyperbola graph representing ½ life decay.
   4. Spectroscopy Lab
      1. Using spectroscope the students determine the wavelengths of emission spectra.
   5. Planck’s Constant Lab
      1. Plot eV vs c/lambda and slope is h
      2. Plug power supply to LED’s turn up till LED lights. Multiply e-charge by the voltage on the y-axis and c/wavelength from the LED package

2nd Semester

1. **Electrostatics**
   1. McDermott Charges Lab
      1. Lab packet form Lillian McDermotts lab manual for introductory physics. Includes investigations with charged pieces of tape.
   2. Construction of a Van de Graaff generator
      1. Students are tasked with creating a small motor run van de graaff generator whose design instructions are easily found online. Videos of such construction are also available.
   3. Electric Force Applet **[GuidedInquiry]** 
      1. Determine the factors that affect Fe.
   4. Electric Field Applet **[GuidedInquiry] [SP 3]**
      1. Determine the factors that affect E.
   5. Electric Potential Applet **[GuidedInquiry] [SP 5]**
      1. Determine the factors that affect V.
   6. 3-D Electric Potential Lab
      1. Students will make a 3-D graph of the electric potential around two point charges.
   7. Electrostatics Vernier Lab
   8. Construction of a Leyden Jar
      1. Students are tasked with constructing a Leyden Jar out of household material using plans found online.
   9. Capacitor Lab
      1. Vernier Lab
2. **Circuits**
   1. Ohm’s Law Lab **[SP 6]**
      1. Vernier Lab (Can be done using Phet Circuit Applet)
   2. Series and Parallel Circuit Lab
      1. Vernier Lab (Can be done using Phet Circuit Applet)
   3. Three Bulb Lab
      1. Students are tasked with connecting three identical light bulbs to a voltage source in various arrangements to give various combinations of bulb brightness. (Can be done using Phet Circuit Applet)
         1. All equally bright
         2. All equally dim
         3. 1 bright and 2 dim
         4. 1 dim and 2 bright (not possible)
   4. Internal Resistance Lab
      1. Graph V vs I and the -slope = internal resistance, y-int = ε
   5. Playdoh Resistivity Lab **[SP5]**
      1. Determination of the resistivity of Playdoh shaping it to various lengths and widths. R = ρL/A
      2. Or use a tub of Playdoh and 15V or so.
   6. Electric to Mechanical Power Motor Lab 2003Bb2 **[SP 7]**
      1. Use an electric motor with a string hanging off the shaft with a mass hanging off of it. Attach an ammeter and voltmeter to the motor to determine the electric power and time how long it takes the mass to rise a certain distance to determine the mechanical power output. Determine the efficiency of the motor.
   7. Capacitance of Styrofoam Lab
      1. Different sizes of Styrofoam with AL sheets on each side
3. **E&M**
   1. Magnetic Field of a Permanent Magnet
      1. First done with compasses and then the Vernier Lab using the magnetic field sensor.
   2. Magnetic Field around a Current Carrying Wire Lab
      1. Using a wire, battery and a compass students investigate the magnetic field around a current carrying wire.
      2. Use a B-field sensor and determine the I through the wire by graphing B vs 1/r.
   3. Magnetic Field in a Slinky Lab
      1. Vernier Lab
   4. qvB Applet Lab **[Guided Inquiry] [SP 4]**
      1. Students investigate the relationships between q, v, B, and r using the applet and the 5 steps for GI.
   5. Faraday’s Law Lab
      1. Given a bar magnet, a Vernier ammeter and a solenoid the students prove Faraday’s Law and Lenz’s Law.
   6. Faraday’s Law Applet Lab
      1. Using the PhET applet the students investigate Faraday’s Law.
   7. Generator Applet Lab
      1. Using the PhET applet the students investigate generators.
   8. Homemade Speaker
      1. Using online instructions in wired article
   9. Homemade Motor
   10. Magnets taped to cardboard sitting on electric balance separated with a current carrying wire running between. Adjust the current and measure and change in force.

**Outside the Classroom Lab Experience [CR3]**

Students will design a cardboard boat that will safely allow two passengers to cross a pool and come back. Students must include boat design features and calculations to show how their boat design should float. [LO 1.E.11, 1.E.1.2, 3.A.4.1, 3.A.4.2, 3.A.4.3, 3.B.1.4]

**Real World Physics Activities** **[CR4]**

* Van de Graaff Generator Construction Activity
  + Students are tasked with creating a small motor run van de graaff generator whose design instructions are easily found online. Videos of such construction are also available.
* Leyden Jar Construction Activity
  + Students are tasked with constructing a Leyden Jar out of household material using plans found online.
* Efficiency of an Electric Motor
  + Use an electric motor with a string hanging off the shaft with a mass hanging off of it. Attach an ammeter and voltmeter to the motor to determine the electric power and time how long it takes the mass to rise a certain distance to determine the mechanical power output. Determine the efficiency of the motor.