Physics 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 a 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.

<u>1st Semester</u>

1. **1-D Kinematics: Constant velocity**
    a. Buggy Lab **[SP1]**
        i. Presented with a constant velocity toy car students will generate a position vs time graph.
    b. Motion Detector Activity: Prescribed motions
        i. Students will predict the shape of x-t graphs given a set of motions. They will test these predictons using motions detectors.
    c. Dominoes Lab: Topple Speed **[GuidedInquiry]**
        i. Shown a line of dominoes toppling S will be asked to test what factors affect topple speed.
    d. Fast/Slow Buggy Collision Activity **[SP4]**
        i. Students will be given a slow and fast toy car. They will be given the task of determining the speeds of both cars and predicting where they will collide if the cars are allowed to roll towards each other starting 4 meters apart.
2. **1-D Kinematics: Constant acceleration**
    a. Inclined Plane Lab: Accel vs Angle
        i. Shown a cart rolling down an incline, students are asked to investigate the affect of angle of incline on acceleration.

b. Graph Matching Activity
    i. Using Vernier motion detectors, students will perform the graph matching activity.
c. Picket Fence Lab/ Ball Toss Lab
    i. Both Vernier labs. Follow the prescribed lab instructions. Determine acceleration due to gravity.
d. Rocket Launch Lab: Vertical
    i. Using compressed air rockets from Arbor Sci determine the height the rockets fly vertically using the time in the air.
e. 40 yd Dash Lab
    i. Students are broken up into groups of 10 and asked to design an experiment when one of their group members will stop speeding up and move at a constant speed during a 40yd dash. Done on the football field.
f. Ball Bounce Lab
    i. Vernier Lab.
g. Meterstick Reaction Time Drop Activity
    i. Students are to determine their reaction time from having to react to and catch a dropped meter stick.

3. Dynamics: a=0

a. Force Table Lab **[SP2]**
    i. Given a force table, students are tasked with constructing a mathematical model for the location of the third mass and pulley when the other two pulleys and masses are located at zero and ninety degrees on the table.
b. Spring Scale Lab (F_g)
    i. Given a spring scale and masses, the students graph weight vs mass and generate Earth's Gravitational Field Strength from the slope.
c. Friction Lab: Kinetic/Analog Spring Scales **[GuidedInquiry]**
    i. Shown a wooden block being pulled at a constant speed along a table with an analog spring scale, students are asked what factors affect the Force of Friction which is the same as the pulling force. Common IV's include normal force, surface types, surface area and pulling speed. Coefficient of friction is determined from the normal force experiment.
d. Friction Lab: Static/ Digital Spring Scales
    i. Using force probes to determine the force of static friction, coefficients of static friction are compared to those of kinetic friction.
    ii. Optional: Inclined Plane Friction Lab (determine mu from angle) 2011Bb1
e. Newton's 3rd Law Lab
    i. Vernier Lab

f. Traffic Light Lab
    i. Two spring scales support a chain with a heavy object of unknown weight hanging off it. Using the spring scale readings and the angles of the chains the students determine the weight of the object.

4. Dynamics: $a \neq 0$

a. Modified Atwood Machine Lab **[GuidedInquiry]**
    i. Given the apparatus, students are tasked with utilizing the GI 5 step process. Newton's 2nd Law is generated through post lab discussion.
b. Elevator Lab
    i. Students stand on a vernier force plate and ride the school's elevator up and down. Using the F-vs-t graph the students determine their acceleration going up and down.
c. Atwoods Machine with Smart Pulley Lab
    i. Vernier Lab.
d. Coffee Filter Drag Force Lab
    i. Vernier Lab
e. Balloon Rockets Activity
    i. Given straws, paper clips, tape and a balloon, students must devise a rocket that will slide along a wire strung from wall to wall of the lab room. Students must take into account the force of friction as well as make sure the thrust is adequate and correctly pointed.

5. 2-D Kinematics

a. Basketball Shot Vernier Lab
    i. Follow the instructions on the lab.
b. Projectile Launcher or Projectile Physlet Lab **[GuidedInquiry] [SP3]**
    i. Utilize the GI 5 step process.
c. Rocket Launch Lab: Angle/Umbrella Contest
    i. Verify the results of the Projectile Physlet lab in real life using the compressed air rockets. Also see how air resistance affects results.
d. Ramp Lab/Contest
    i. Determine the speed of a ball rolling off a ramp horizontally. Using the speed and a new height, predict where to locate a tin can so that the marble rolls into the cup..

6. F_c

a. Spinning Stopper Lab: Horizontal **[GuidedInquiry]**
    i. String threaded through a tube with a rubber stopper on one end spinning in a horizontal circle and a mass on the other keeping a constant tension. Use the 5 Steps of GI.

b. Vertical Centripetal Force Lab (2001 B1)
    i. Same apparatus as the previous lab but the runner stopper spins in a vertical circle and instead of the mass use a force probe. The resulting F-t graph can be utilized to verify several things including the mass of rubber stopper and period.
c. Flying Pigs Lab
    i. Students verify the centripetal force equation from the speed of flight and angle of the string to the ceiling using a toy flying pig.

<u>2nd Semester</u>

7. Energy

a. Rubber Band shot up (H vs x) and shot horizontally (Range/Vel vs x)
    i. Students investigate the relationship between how far they pull back a rubber band and how high it goes and how far it goes. Relating U_s to U_g and K.
b. Ball Toss U/K Lab
    i. Vernier Lab
c. Spring Lab
    i. Simple lab where students hang different weights from a spring and graph deforming force vs deformation and determine that the slope is the spring constant. Three different springs are tested.
d. Kinetic Energy, Cart Spring Lab
    i. Further exploration of the relationship between U_s and K. Students are given a cart with an internal spring which they must determine the spring constant for using conservation of energy and a simple force vs deformation lab.
e. Bungee Rubber Band Contest
    i. Students are given the task of attaching a 200g object to the end of a long strand of rubber bands and dropping it off the balcony onto the floor below. The mass should act like a person on the end of a bungee cord. They must determine how long of a strand of rubber bands to use such that the object does not hit the ground and comes as close to the ground as possible. The group closest to the ground wins the contest.
f. Wrap Around Lab
    i. Pendulum dropped from 90 degrees swings down and the string wraps around a metal rod attached to same ring stand. Students must determine minimum
g. Pulley Lab
    i. Cookbook lab where students investigate single, double and triple pulley systems. Mechanical advantage and efficiency are determined.
h. Inclined Plane Lab
    i. Students are tasked with determining how the angle of an inclined plane affects the efficiency of the machine.

i. Staircase Power Activity
    i. Short activity where students run up a flight of stairs and use their weight, height of stair case and time to determine how 'powerful' they are.

8. Momentum

a. Egg Catch Lab
    i. Introductory contest where students are tasked with creating an egg catch no more than $1ft^3$ that must catch a dropped egg without breaking the egg. Students drop the egg off successfully higher steps into the catch. The student that drops their egg off the highest step wins.
b. Impulse Vernier Lab
    i. Vernier Lab
c. Paper Stops Cart Lab **[GuidedInquiry]**
    i. Students are tasked with designing an 'airbag' for a cart rolling down an incline. The students place a motion detector at the top of the incline and allow the cart to roll down the incline towards their airbag. The airbag is a single piece of paper and some tape. They can cut, fold and tape the paper how they choose. Their task is to create an airbag that stops their car over the longest amount of time possible. They use the mass, change in velocity and stopping time to determine the Force.
d. Collision Physlet Lab
    i. Simple lab where students investigate the result of dozens of collisions between two carts. The law of conservation of momentum is investigated.
e. Ballistic Pendulum Lab
    i. Ballistic Pendulum apparatus. The students determine the launch speed of the marble using the collision. Lots of math. They also check the launch speed by allowing the marble to shoot horizontally, using range and launch height.
f. Hot Wheels Friction Lab
    i. A hot wheels car rolls down a hot wheels track into a paper catch that skids to a stop. If you make several assumptions the initial U_g equals the work down by friction. $mgh = \mu mgd$. Further investigations taking into account the fact that the collision is inelastic can take place. You can also make the catch out of cardstock to further complicate matters.
g. Cart Explosion Lab
    i. Students are given two spring loaded carts, one more massive than the other. They press the carts together and tasked with determining the ratio of the carts masses with the use of a meterstick and stopwatch. After the ratio is determined, they determine the actual masses of the carts and see how much energy was lost and what the actual ratio of the speeds should be.

9. **Gravity/SHM**
    a. Force of Gravity Applet to get G Lab **[GuidedInquiry] [SP6]**
        i. Phet applet
    b. Pendulum Lab **[GuidedInquiry]**
        i. graphing data to possibly get g…$4pi^2L$ vs T^2
    c. Spring Constant from Period of Oscillation Lab
        i. Simple investigation of SHM with a mass oscillating on a spring.

10. **Rotational Dynamics**
    a. Stroboscope Lab
        i. A piece of string is tapped to the shaft of a motor that is hooked up to a power supply unit. A stroboscope is pointed towards the string and the angular speed of the string is determined from FPM/RPM.
    b. Torque Lab **[GuidedInquiry]**
        i. Students investigate an apparatus that consists of a meterstick balanced at the 50cm point with different masses hanging from different distances. Students attempt to generate the torque equation.
    c. Ice Skater Lab
        i. Students investigate the law of conservation of momentum by spinning on a spinny chair with their arms outstretched and bringing their arms in close.
    d. Hoop/Puck/Ball Inclined Plane Lab with Rotational KE **[SP7]**
        i. The law of conservation of energy is investigated with regards to a hoop and a puck rolling down an incline.
        ii. Have them fly off end and land on padded mats from track
        iii. 2006 APCM test question
    e. Thickness of Racquet Ball Lab
        i. The moment of inertia of a racquet ball is investigated by the speed of a ball rolling down an incline. This lab does not have very good success. Only recommended for very strong students.
    f. Angular Momentum Collision Apparatus APCM 2005
        i. The law of conservation of angular momentum is investigated by having a ball roll down an incline into the catch of a rotating arm. Moments of inertia and angular velocities are calculated.
    g. Massed Pulley Lab
        i. http://www.geogebratube.org/student/m650399

11. **Waves/Sound**
    a. Wave Speed Slinky Lab **[GuidedInquiry]**

i. Students are presented with a single wave pulse traveling down a slinky and then they are asked to apply the 5 stop guided inquiry procedure to determine the factors that affect wave speed.

b. Slinky Video Activity: Reflection/Interference
   i. Lab investigation where students video reflection and interference of wave pulses in a slinky.
c. Harmonics w/ slinky lab
   i. Students determine the linear mass density of a slinky by the fundamental frequencies of the slinky.
d. Beats Lab
   i. Vernier Lab
e. Resonance Tuning Fork Golf Tube Lab
   i. Conceptual Physics (Hewitt) Lab
f. Wave Tank Lab
   i. Lab packet of questions for a wave tank apparatus.
g. Students build wind and string instruments out of recycled materials. Instruments must play a 5-note scale. Students compare and contrast the physics involved in the waves produced by their instruments. (LOs: 6.A.1.1, 6.D.1.1, 6.D.3.2)

12. Electrostatics/Circuits

a. McDermott Electrostatics Lab
   i. Lab packet form Lillian McDermotts lab manual for introductory physics. Includes investigations with charged pieces of tape.
b. Electric Force Applet **[GuidedInquiry]**
   i. determine k Lab
c. Ohm's Law Lab
   i. Vernier Lab (Can be done using Phet Circuit Applet)
d. Series and Parallel Circuit Lab
   i. Vernier Lab (Can be done using Phet Circuit Applet)
e. Three Bulb Lab
   i. 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)
f. Conducting Paper Resistance Lab **[SP5]**
   i. Determination of the resistance equation using conducting paper cut to various lengths and widths. $R = \rho L/A$
g. Motor Electric to Mechanical Power Lab 2003Bb2
   i. 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.

Outside the Classroom Lab Experience [CR3]

Students build wind and string instruments out of recycled materials. Instruments must play a 5-note scale. Students compare and contrast the physics involved in the waves produced by their instruments. (LOs: 6.A.1.1, 6.D.1.1, 6.D.3.2)

Real World Physics Activities [CR4]

- Balloon Rockets Activity
    - Given straws, paper clips, tape and a balloon, students must devise a rocket that will slide along a wire strung from wall to wall of the lab room. Students must take into account the force of friction as well as make sure the thrust is adequate and correctly pointed.
- Bungee Rubber Band Contest
    - Students are given the task of attaching a 200g object to the end of a long strand of rubber bands and dropping it off the balcony onto the floor below. The mass should act like a person on the end of a bungee cord. They must determine how long of a strand of rubber bands to use such that the object does not hit the ground and comes as close to the ground as possible. The group closest to the ground wins the contest.
- Paper Stops Cart Lab

- Students are tasked with designing an ‘airbag’ for a cart rolling down an incline. The students place a motion detector at the top of the incline and allow the cart to roll down the incline towards their airbag. The airbag is a single piece of paper and some tape. They can cut, fold and tape the paper how they choose. Their task is to create an airbag that stops their car over the longest amount of time possible. They use the mass, change in velocity and stopping time to determine the Force.