PSIM Additional Lab Practicum (Elective 2)
Bryn Bishop
Fall 2018

Lab Experience: I modified the *Aeronautics for Introductory Physics: Terminal Velocity Drag Stations Lab (p92-98)* for my AP Physics 1 courses. I set up eight different lab stations (something I had never done before) and had students rotate to all eight stations in our ninety minute period. Students answered the questions in their Lab notebooks.

Modifications: Instead of having the entire focus be on drag, I changed the focus to be on “Falling Things.” In AP Physics 1, students need to know basic concepts of drag and air resistance. They do not need to use or know the equation for drag. Many will not be taking AP Physics 2 and so many will not be learning fluid dynamics. To align this lesson more with AP Physics 1 content, I replaced Station 6 Drag Test: Size and Station 8 Drag Test: Viscosity. Part of the reason for this was also because I didn’t have the materials for these two stations. In the place of these stations, I had students experience horizontal projectiles with the demonstration of a bullet dropped and billet fired apparatus, and in the final station students experienced simulations of projectile motion.

Reflection: This was my first time setting up lab stations and I loved it. Each station had just about the right amount of time and students got to experience in small groups these activities that I normally do as a whole class demonstration during a lecture. It was more fun for me and for the whole class to let students drop the coffee filters, basketballs, masses, and objects with velocities in their small groups. It was also a great way to introduce the photogate and for students to look at various ways of determining acceleration of an object.

Unintentionally, the lab rotation set-up also made the class more autonomous with seeking help from each other. This was super cool. If a group didn’t understand the photogate, they asked the previous group before asking me! This way they were able to help each other in a timely fashion and not rely on me as being the all knowing keeper of lab equipment knowledge.

I was very surprised that students had so much confusion of Drag test: mass. Students watched at Station 1 as they dropped spheres and cubes of different densities and masses and they all fell at the same rate (no drag). Then, when students dropped 1, 3, and 9 coffee filters together, the 9 coffee filters fell faster than the 3 and the 3 fell faster than the single coffee filter. Many students were audibly upset and confused at these seemingly contradictory stations. One of the reasons for this confusion comes from the belief that the coffee filters were not reaching terminal velocity. In order for students to gain more understanding, next year I’m going to have them conduct an experiment to see if they can determine the accelerations of the 1, 3, and 9 coffee filters.

Another surprise was how much students enjoyed the kinetic sand. Most students said it was their favorite lab station. I used kinetic sand instead of modeling clay because I thought it would work very nicely and it did. I think students found it therapeutic to drop things in the sand and play with the sand.

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The two modified stations worked well - especially the bullet dropped and bullet fired demonstration. I only have one of those apparatus and I have always only done that demonstration myself in front of the class. Letting students do it themselves in small groups of four made sure that everyone could see and participate in the demonstration. The simulation also worked well and was engaging for students. Since there was so much happening in the other stations, it seemed less exciting to me as the instructor, but students were engaged and liked it as a station.

I would also really like to include the original lab stations 6 and 8 for next year and have a total of ten stations. I have the room for this and I usually have more than 40 students per class so i could have 10 groups of four rotating through the stations. I need to get my hands on the materials.

Finally, I think this could be a really cool lesson with using argument-driven inquiry. The discussions and comparisons between masses in station 1 and the coffee filters of different masses could have been an excellent socratic seminar where students could make claims and argue from evidence.

Foreground students dropped objects of different masses onto the red towel. Students used cubes of the same size, but different densities, as well as several different small metal spheres. Background students used chromebooks to play with simulations of projectile motion

Foreground students
Station 1: Mass

1. Have the same person hold objects of different masses in one hand. Drop them carefully onto a protected padded surface. What do you notice about their fall times?

2. Does your observation agree with what you have experienced outside of the classroom? Explain.

Background students

Station 8: Simulations

Try the CK12 Archery Simulation assigned through google classroom.

Or play with the PhET simulation:

https://phet.colorado.edu/en/simulation/projectile-motion

1. What is the horizontal acceleration of projectiles?
2. What is the vertical acceleration of projectiles?
3. At what time is the projectile at its highest position?

This station was taken from NASA Drag Station #2 Velocity and Time. Instead of using modeling clay (which I had), I used kinetic sand. I thought the kinetic sand worked better than the clay and was also surprisingly engaging for students. When I asked which station was their favorite, almost unanimously they said this station because of the kinetic sand.

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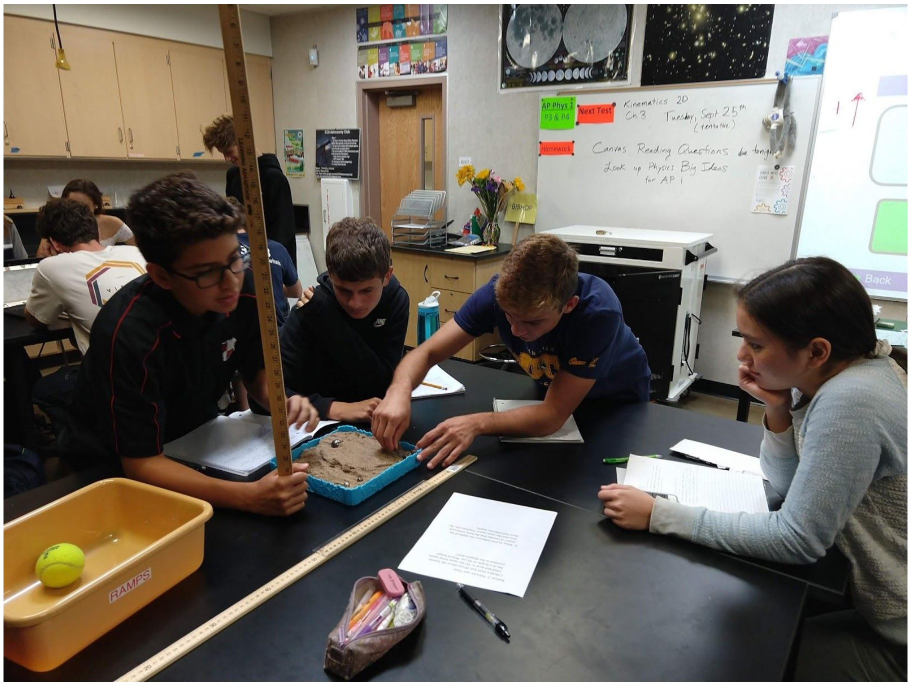


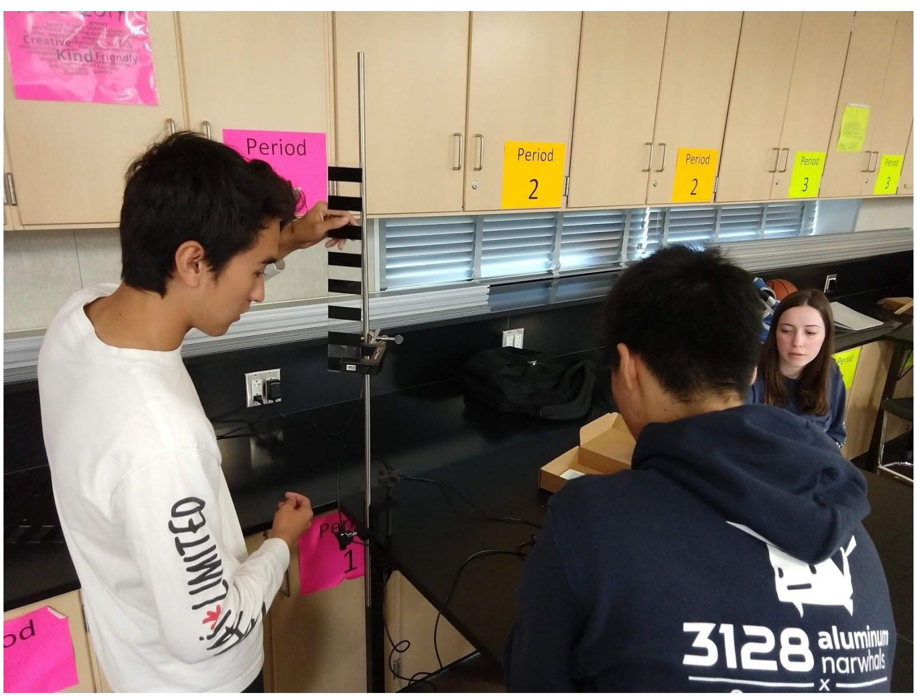
Station 2: Velocity and Time

1. Hold a steel ball 20 cm above the kinetic sand and drop it. Do the same thing again, but at a height of 80 cm. Which height resulted in the deepest dent?
2. What factors influence the depth of the dents? (Consider that the balls used each time had the same mass). Explain why the dents had different depths.

This station nicely compares to the photogates, but students get to learn about the different sensor and setting needed to get good data. In this set up, I had students use the velocity v time graph and take the slope of the line to determine the acceleration due to gravity. They could use Vernier's LabQuests to view the graph and get a slope for the correct segment of data.

Station 3: Motion Detector

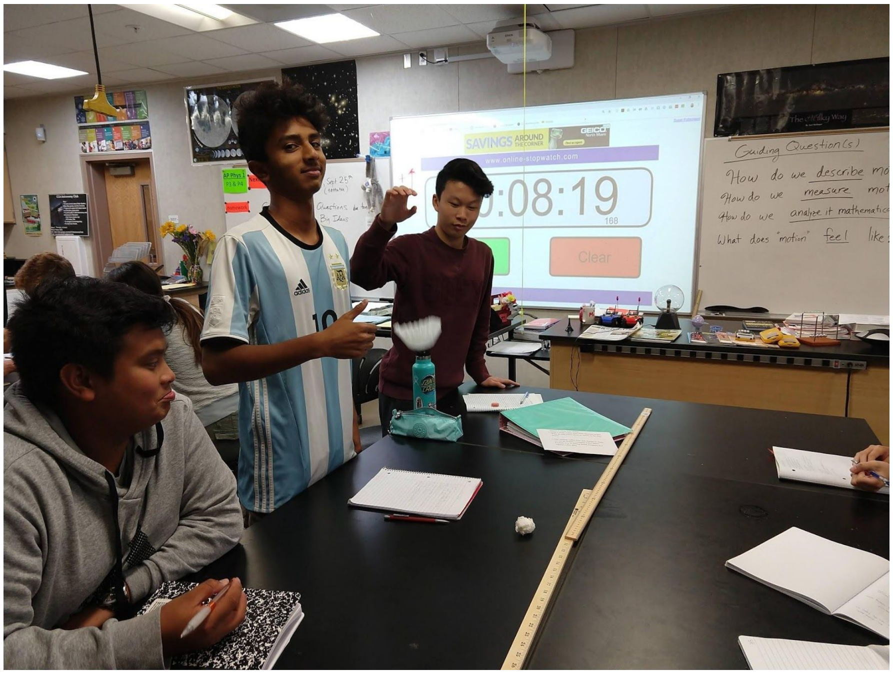
1. Hold the motion detector above the suspended basketball. Determine the acceleration of the basketball as it falls using the velocity graph on the LabQuest. Acceleration:________
2. Explain how you accomplished this.



This was the first time students used photogates so it was a great lesson on using the equipment and getting extremely good data. It was great for students to compare this station with the motion detector station as well so students can view different sensors and see the range in acceptable data. The data was always *really* great for this station ($\boldsymbol{g} \approx 9.79\ m/s^2$)

Station 4: Photogate

1. Determine the acceleration of the picket fence as it falls through the photogate:________
2. Explain how you accomplished this.



The coffee filter stations were super engaging and interesting. This photo is with students changing the shape of the coffee filter by crumpling the coffee filter. In station 6, students used multiple coffee filters together to change mass while keeping the same shape. Station 6 had students asking the most questions (and demanding explanations.)

Station 5: Drag Test: Shape

1. Drop a single coffee filter from shoulder height. What do you notice about its speed on the way down?
2. Take another coffee filter and change its shape (or use an already crumpled coffee filter). Explain how its falling speed compares to a regular coffee filter.

Station 6: Drag Test: Mass

1. Drop the following: 1 coffee filter, 3 coffee filters, and 9 coffee filters. What do you notice about their falling speeds?
2. Explain how this situation compares to dropping balls of different masses (at Station 1).

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Falling Things Stations

station 5.

1) The coffee filter has a constant terminal velocity as it drops. This is because the air resistance is equal to the downward force of motion.
2) When the coffee filter is crumpled, it accelerates, because the force of gravity is much less than the air resistance

station 6

1) When 9 coffee filters are dropped, they fall faster than one, because the higher mass = more downward force acting. (→ more air resistance) The smaller amount of coffee filters the slower they fall.
2) A ball with more mass will drop faster than one with less. This is demonstrated with the coffee filters. BUT they still have constant velocities, just one is a higher velocity

Station 7

1. When the two balls are dropped, they fall at the same speed.
2. My observation with outside experiences because if I drop and throw 2 identical balls from the same height, the one that I throw will hit the ground late.

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Station 8

1. The horizontal acceleration of projectiles is 0.
2. The vertical acceleration of the projectile is -9.8 m/s.
3. The projectile is at its highest position at 1/2 way through the time.

Station 1

1) The objects hit the ground at the same time despite the mass.
2) This does not agree with my experience outside of the classroom, especially my results in the coffee filter experiment.

Station 2

1) The dent is a lot deeper when dropped from 80 cm.
2) When dropped from a higher height, the ball has a longer time to accelerate, and therefore will be going at a higher velocity.

Station 3

1) acceleration = -10 m/s
We looked at the velocity graph on the lab quest.
2) We looked at the graph on the labquest

Station 4

1) acceleration = 9.505

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Falling Things Stations

Station 7: Ball Droped & Ball fired

1. What do you notice ~~abt~~ The fall times?
-They have The same fall time.
2. Yes, the Observations do agree with My real Life observations because if you ~~throw~~ pitch a ball ~~in~~ ~~sports it will~~ in baseball and drop one it will Hit the grand at the same time.

Station 8: Simulations

1. The horizontal acceleration is zero
2. $-9.8 m/s^2$
3. When it has 0m/s horizontal velocity

Station 1: Mass

1. They all have the same falltimes
2. ~~Yes, the Observation does agree~~
~~No, the observ~~
Yes, the observation does agree because if you drop objects of the same size they will Hit the ground at the same time.

Station 2: Velocity & Time

1. From 80 cm the dent was bigger Then from 20 cm
2. Differences in Mass and differences in velocity when the Object Hit The ground. Time it had to accelerate.

Station 3: Motion Detector

1. ~~[illegible]~~
acceleration is 10.068 m/s
we got this by
Finding the slope of the graph at
our best time interval

Station 4: Photogate

1. 9.19 m/s² Trail 2 = 9.765 m/s²
2. we found the slope of an interval
on the Time vs. velocity graph.

Station 5: Dragtest: Shape

1. it has a very slow speed.
2. it has a much faster speed
compared to the Normal coffee filter.

Station 6: Dragtest: Mass

1. They have Different falling
speeds
2. in this demo the 1 coffe filter Reaches
Terminal velocity but the More Mass ones
They new Reach Terminal velocity and
Keep accelerating.

* Air resistance Depends on Shape
& Mass

* when objects fall the velocity
Increases.

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Station 2

#1: The ball dropped from 80 cm resulted in a bigger dent than the one dropped from 20 cm.

#2: The depth of the dents are influenced by the height from which the ball is dropped. When dropping from higher up, the ball has more time to accelerate and thus has a higher magnitude of velocity when hitting the sand, resulting in a deeper dent. Denser sand is also harder to penetrate, resulting in a shallower dent.

Station 3

$a = 9.70\ m/s^2$

We picked a segment of the velocity graph that after the ball was falling and evaluated its slope, which is acceleration.

Station 4

$a = 9.82\ m/s^2$

We dropped the picket fence through the light sensor and the photogate measured the acceleration by calculating the chang in velocity as the light sensor was blocked and unblocked from the light to determine the nature of the motion.

Station 3

1. acceleration = 9.3873 m/s^2
2. to find this, we used the [illegible] to measure the velocity of the falling basketball. we then found the slope of the velocity-time graph for a certain interval

Station 4

1. acceleration = 9.76 m/s^2
2. The photogate measures the time elapsed between the clear portions and since it knows that the clear and black portions are the same length, it is able to calculate the velocity of the thing. It then calculates change in velocity, which is acceleration.

Station 5

1. The uncrumpled coffee filter falls slow because it has a large surface area and there is a lot of air resistance pushing up at it
2. The crumpled coffee filter falls faster because it has a smaller surface area, meaning that there is not as much air resistance slowing it down.

Station 6

1. The piles with more coffee filters drop faster than the stacks with less coffee filters. This is probably because the stacks w/ more mass could resist the air resistance better
2. In this station, the object had different masses and shapes, but on the station 1, the objects had different masses and the same shapes.

Station 7

1. The dropped ball and the fired ball fall at the same rate and hit the ground at the same time
2. This observation does agree with what I have experienced because gravity affects all objects equally, with the same acceleration

Station 8

1. The horizontal acceleration of projectiles is zero
2. The vertical acceleration of projectiles is g (9.8 m/s^2)
3. The projectile is at its highest position when its vertical velocity is zero