On-line activities for kinematics labs

Below is the list of experiments (real, video based and data-based) that students can perform as labs for kinematics. For each experiment we provide goals, equipment and rubrics for self-assessment. Rubrics can be found at https://sites.google.com/site/scientificabilities/rubrics

1. Application experiment: studying the snail

Goals: a) apply the concept of motion at constant velocity to analyze real life motion;

b) record and represent data;

c) evaluate experimental uncertainty;

Equipment: none

Rubrics for self-assessment Ability to collect and analyze experimental data Rubrics G1, G2, G4 and G5.

Observe the video of a snail [https://youtu.be/aJKRq2zjZeg]. Use the period and comma keys on the keyboard to advance the video frame by frame.

a. Decide if the snail moves with constant velocity. If it does, determine the magnitude of the velocity (the snail's speed).

b. Record the data below in a table and plot a position-vs-time graph for the snail.

2. Testing experiment: how do you walk?

Goals: a) learn how to test an idea;

b) learn how to make a prediction based on an idea under test.

Equipment: distance measuring device, stopwatch, bean bags or any other materials you might need.

Rubrics for self-assessment: Ability to design and experiment to test an idea C1, C2, C3, C4, C7.

a. Design an experiment to test whether or not you walk across a room in your house (apartment) at constant speed. Think what it means to test an idea. In physics, experimental testing consists of the following steps:

1) you accept the idea (the hypothesis) being tested as true;

2) you design an experiment whose outcome you can predict using this idea;

3) you make the prediction of the outcome (here you also need to think of what you assume to be true in addition to the idea you are testing—these are called *assumptions*);

4) you perform the experiment and compare the outcome to the prediction, and based on the comparison, you make your judgment concerning the idea being tested.

b. Describe the experiment and the materials you will need to conduct it. If you do not have a meterstick or bean bags, use available materials to improvise. Make a prediction of the outcome of the experiment based on the idea under test (not your intuition). Write it here.

c. Collect, record and analyze your data here. Did the outcome match the prediction? What is your judgment about the idea under test?

d. If you determined that you walk at approximately constant speed, what is your speed? What assumption(s) did you use to make this estimate (Hint: think of what happens when you just start your motion.)

3. Testing experiment: do objects fall at the same speed?

Goals: a) learn how to test an idea;

b) learn how to make a prediction based on an idea under test.

Rubrics for self-assessment: Ability to design and experiment to test an idea C1, C2, C3, C4, C7.

Use the video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-2-6-7]

to test if the position of the object that you drop from a certain height can be described mathematically as $y = v_y t$. Consider the location from which the object is dropped to be the origin.

a. Think what it means to test an idea. In physics, experimental testing consists of the following steps:

1) you accept the idea (the hypothesis) being tested as true;

2) you design an experiment whose outcome you can predict using this idea;

3) you make the prediction of the outcome (here you also need to think of what you assume to be true in addition to the idea you are testing—these are called *assumptions*);

4) you perform the experiment and compare the outcome to the prediction, and based on the comparison, you make your judgment concerning the idea being tested.

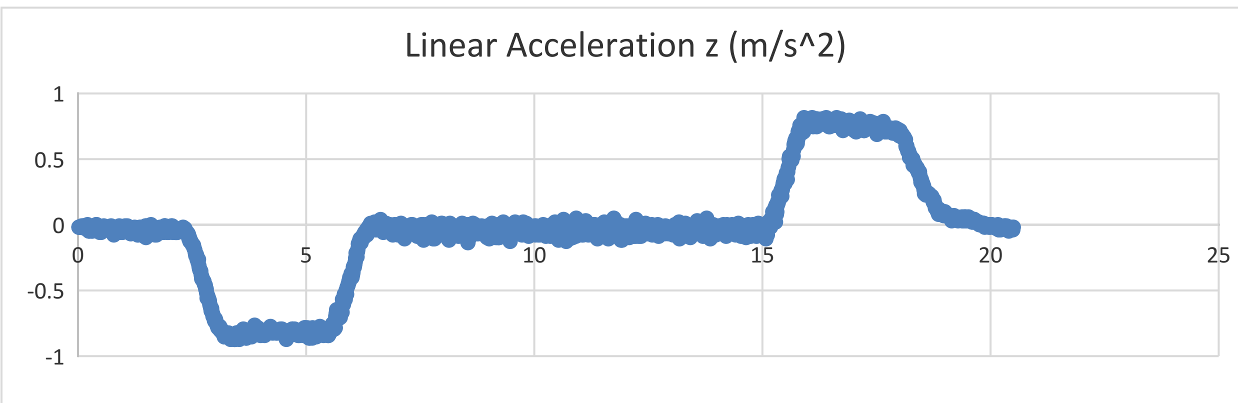
b. In this case, the experiment is performed already but you still need to make a prediction of its outcome based on the idea under test. Write your prediction down.

c. Now use the video to collect the data and compare the outcome to the prediction. Use the arrow keys on the keyboard to advance the video frame by frame. Record the data in a table. Examine the data you collected. Are they sufficient to gain confidence or reject the idea that a falling object moves at constant speed?

4. Application Experiment: Riding an elevator

Goals: a) To learn to analyze and interpret real life data

You visited Westin Boston Waterfront Hotel and rode one of the elevators from the bottom floor to the 11th floor. While in the elevator you used the Phyphox app on your phone to record the acceleration of the elevator. The graph created by the app is displayed below.



a. What can you determine from the graph? Make a list of physical quantities and describe how you will determine each of them.

b. We festimated that the maximum speed of the elevator was 2.6 m/s and the total distance traveled was 33 m. How did we arrive at these numbers?

c. What else can you determine from the graph?

5. Application experiment: Walking and running

Goals: a) learn how to analyze photo and video data

Equipment: a ruler

Rubrics for self-assessment Scientific ability to design an application experiment rubrics D7, D8, D9.

The photo above shows Eugenia's footprints on sand. Analyze the footprints to
a. Tell a story about Eugenia's motion.

b. Draw a motion diagram. What assumptions did you make?

c. Watch the video of Eugenia walking on the sand [https://youtu.be/faEMgURzNfc] and estimate how fast she was walking. Eugenia's shoe size is 7. What assumptions do you need to make? Advance the video frame by frame using period and comma keys on the keyboard.

6. Observational experiment: Toy car up and down the plane

Goals: a) Design an experiment to investigate the motion of a toy car

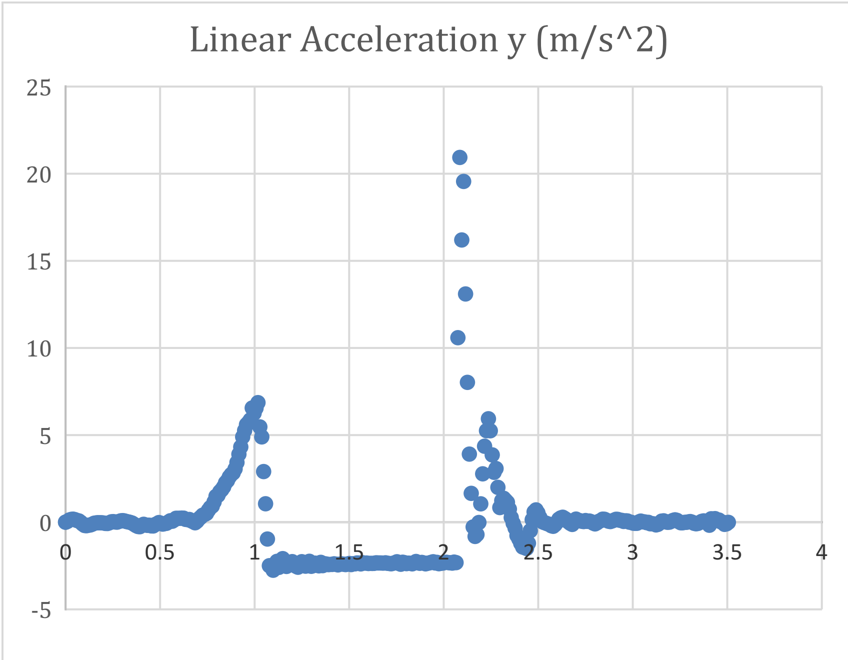
b) Collect and analyze data

Equipment: a mechanical toy car, an incline plane, the Phyphox app on your phone, a distance measuring device and any other equipment you might need.

Rubrics for self-assessment Scientific ability to design and conduct an observational experiment B1, B2, B3, B4, B5.

a. Download the Phyphox app on your phone. Attach the phone to a mechanical toy car and push the car up an inclined plane (you can tilt a table at home) and let it go up and down. Collect acceleration-vs-time data and analyze the graph Phyphox created. What can you determine from the graph?

b. In case you cannot perform the experiment, below is the data collected by the Phyphox in a similar experiment (the cart with the phone on top went up and down the plane). The *y*-axis of the app is along the inclined plane. On the graph the vertical axis is along the direction of motion of the cart and the horizontal axis is time. Examine the graph and determine everything you can about the motion of the cart.



7. Observational experiment: a fall of a cotton ball

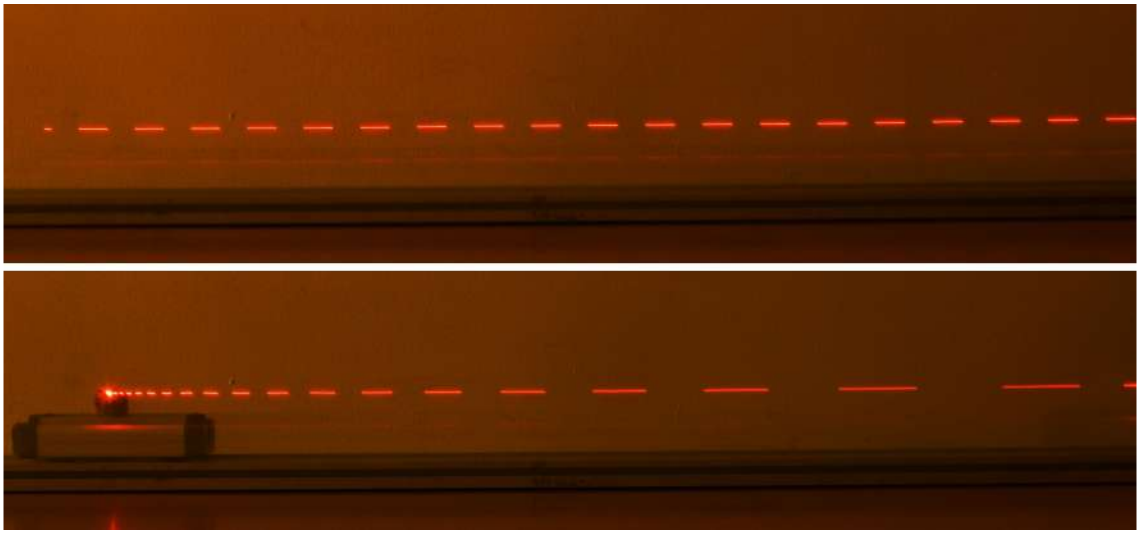
[https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-2-9-14]

Watch the video using link above. Take relevant data from the video, draw motion diagram(s), and plot appropriate graphs to fully analyze the motion of the cotton ball. Write a short report of your results and analysis. In conclusion, what can you say about the motion of the cotton ball from your analysis?

The last two lab activities involve photos.

8. Observational experiment: Blinking LED on a cart

The figure below shows long-exposure photos of two experiments with a blinking LED that was fixed on a moving cart. In both cases, the cart was moving from right to left. The duration of the ON and OFF times for the LED is 154 ms, and the length of the cart is 17 cm.

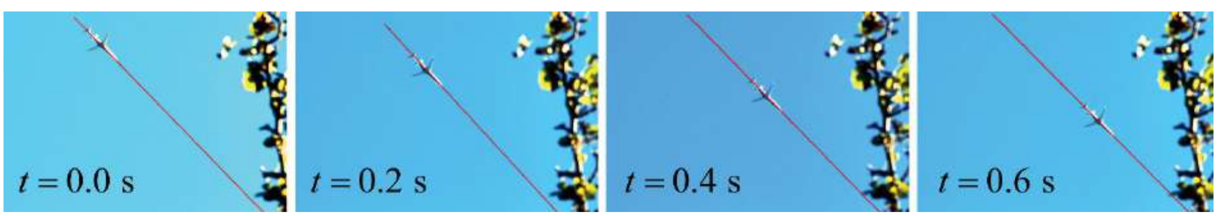


a. Specify a coordinate system and draw a qualitative velocity-versus-time graph for the motion of the cart in both experiments.

b. Estimate the speed of the cart in the first experiment. Both photos were taken from the same spot and with the same settings. Indicate any assumptions that you made.

9. Observational experiment: Airplane in the sky

Daniel fixed a camera on a tripod and took four successive photos of an airplane that was flying above him. The time interval between the photos was 0.2 s (see the first figure below; a straight line was added later to help you compare the position of the airplane in the different photos).



a. Draw a motion diagram for the airplane.

b. Estimate the length of the airplane using the magnified photo (shown in the second figure below) of the airplane and data that you can find on the Internet. Indicate any assumptions that you made.

c. Draw labeled position-versus-time and velocity-versus-time graphs for the airplane's motion. Indicate your assumptions (they will relate to the airplane you choose and the direction of motion) and the choice of a coordinate system. Make sure the axes of your graphs contain units. Note that you will need a ruler to solve this problem.