Uniformly accelerated motion

1 Introduction

In this lab you will perform measurements on motion in two dimensions. The spark table will allow you to determine the trajectory of a sliding puck. From this you can calculate the velocity and acceleration.

2 Equipment

- spark table with carbon paper
- air pump,
- spark generator,
- pucks of various masses,
- connecting hoses and wires
- paper,
- rubber band puck launcher,
- rulers, protractors and pens

3 Procedures

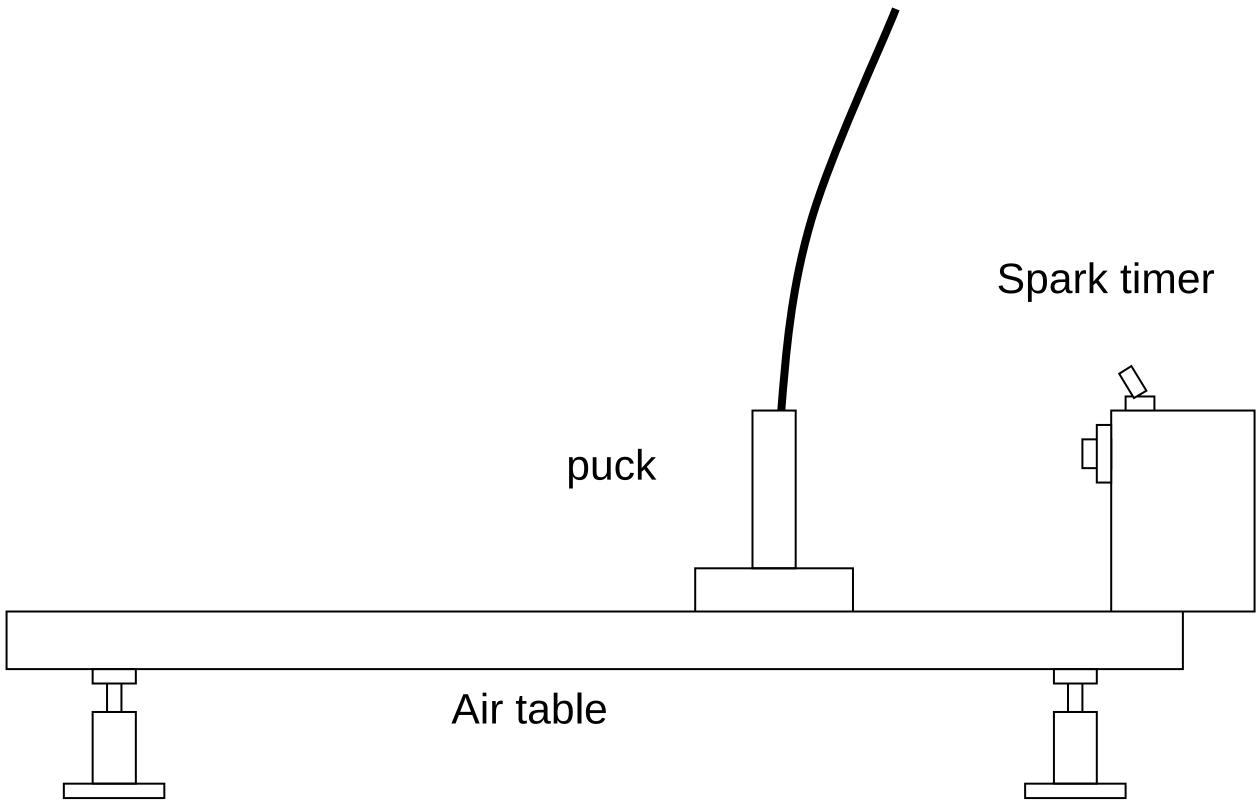
Read through the procedures and familiarize yourself with the equipment. **Do not turn on the spark generator until you know what you are doing!** Make sure you understand the purpose of each measurement and devise a strategy for taking data. How can you best minimize the uncertainty of your measurements?

3.1 Getting Acquainted with Mr. Spark Table:

1. Place a large sheet of paper (newsprint) on the carbon papered surface of the spark table. Put the pucks on top of the table. The pucks should be connected to the pump through the hoses. Turn on the pump and watch the pucks drift about. You should level the spark table in much the same way you leveled the air track: put the pucks at rest and watch for any drift to one side or the other.

2. Turn the spark generator to a setting of 10Hz. which means that it fires ten sparks in one second. Tap the pucks with a plastic or wooden ruler. Do **not** use your hands. When the pucks are gliding, have someone depress the pedal switch for a few seconds. You should hear a clicking noise. You can use the ruler to guide the pucks about. Disappointingly, nothing will show up on your paper.

3. Turn off the pump and spark generator. Remove the paper and look at its underside. Aha! *There* are the marks left by the spark generator. You should see a set of dots that mark the trails of your pucks. When the puck is moving rapidly the dots will be further apart.



In each of the following experiments you will be expected to place a clean sheet of paper on the spark table when you take data. Although you will only follow the motion of one puck, the other must be on the table in order to complete the electrical circuit. Practice each trajectory before you press the switch and actually take data. Make sure that everyone in the group has their hands away from the table before pressing the pedal switch. Use an insulating object (plastic or wood) to move the pucks when the generator is on.

3.2 Special Cases in Projectile Motion:

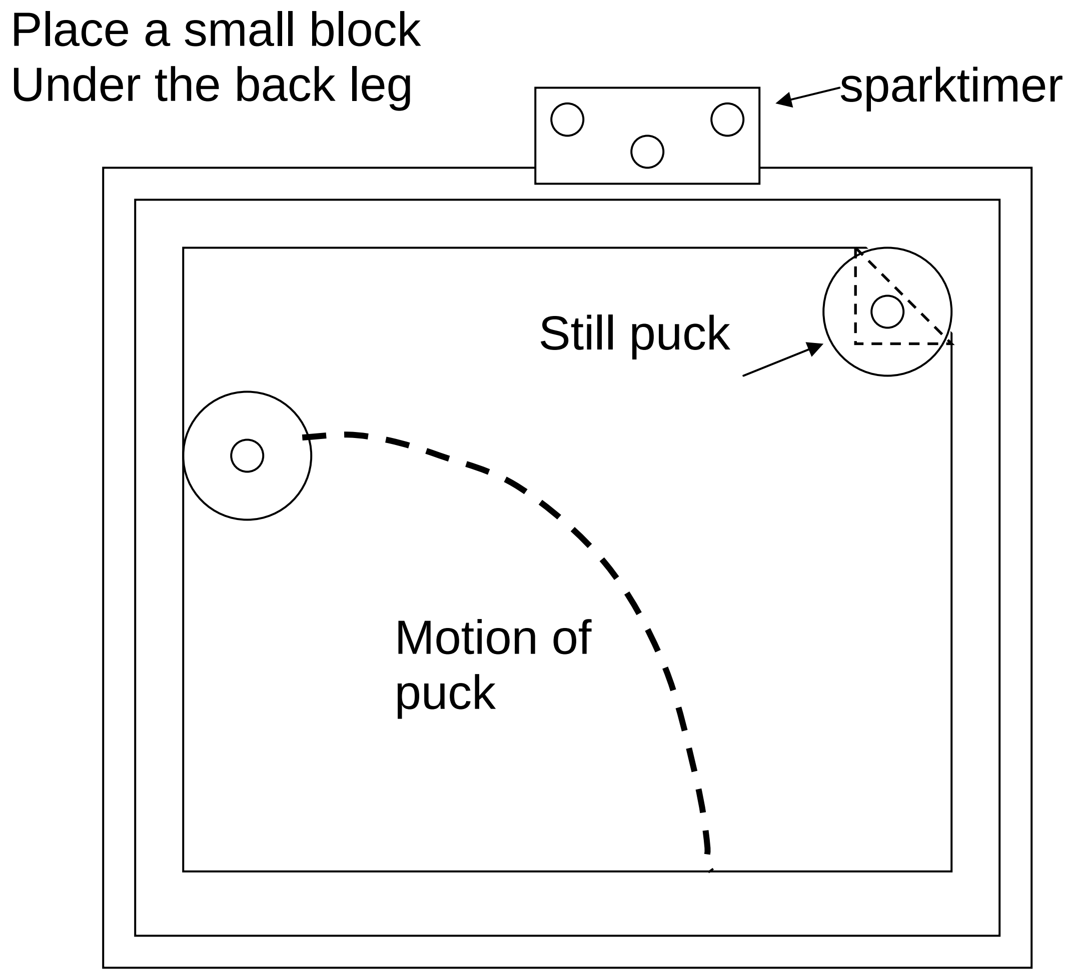
1. Level the spark table. Do this by switching on the compressed air, and placing a puck at rest in the center of the table. Adjust the heights of the table legs until the puck has little or no acceleration off center.

2. Tilt the table either by putting a small block under one leg, or by adjusted the length of one leg. Measure the slope of the angle by measuring the change in height of the table over some distance.

3. Practice using the puck-launchers to give the puck an initial velocity that is exactly perpendicular to the tilt. You can determine the tilt direction by letting a puck accelerate from rest. This determines the direction of the acceleration due to gravity. You want to use the launcher to set the puck off at right angles to this line, tracing out an arc across the spark table.

4. Take data on a clean sheet of paper for such a parabolic trajectory.

5. On the same sheet of paper, simply release the puck from the same initial height, without launching it, and record its motion with the spark table. This trajectory will be a straight line.



6. Remove the paper. Draw a set of *x* and *y* axes on it, centering at initial position if possible. Use the straight-line data to define the direction of the *y*-axis. You may wish to darken the spots slightly and number them for reference. Measure the *x* and *y* locations of the dots with respect to this origin. (If the spark timer is too fast, you may wish to record every other point or so.) Record these positions on the sheet provided, for both the linear and parabolic trajectory.

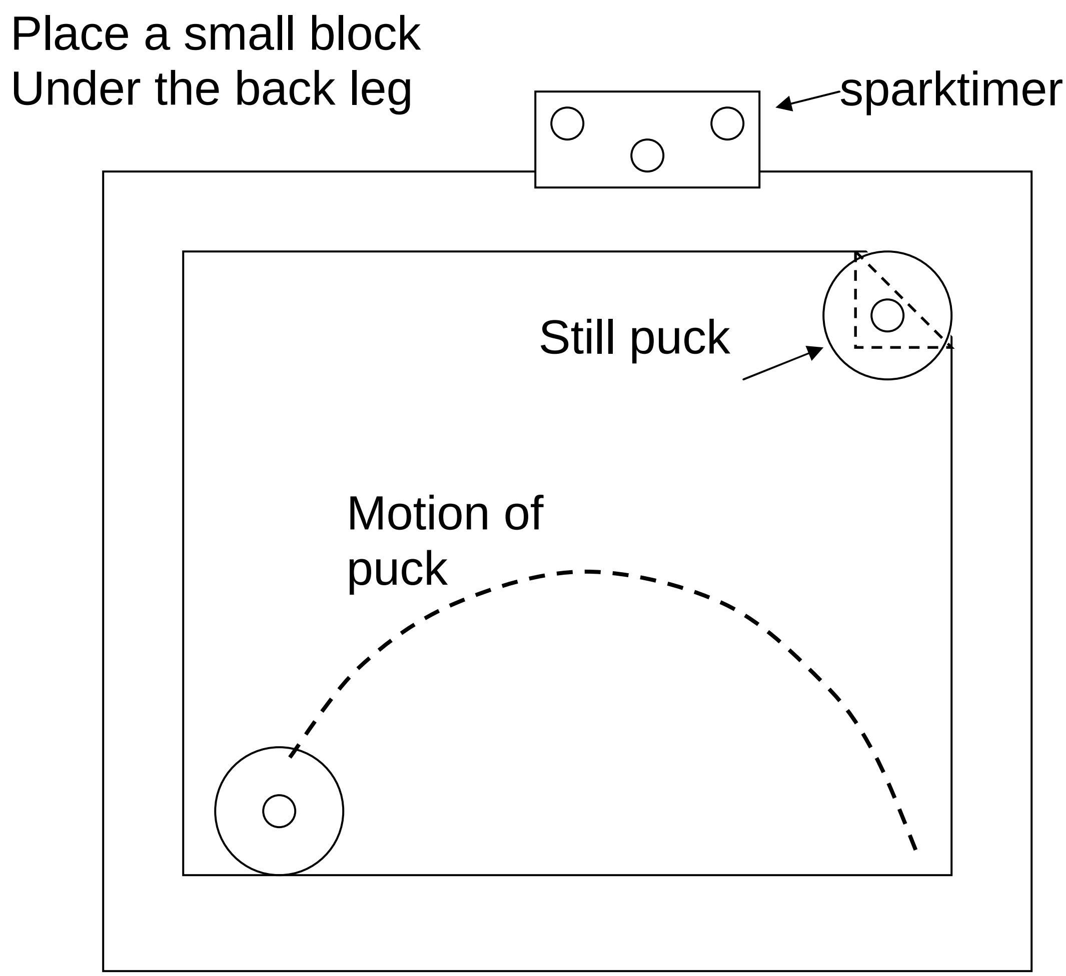
7. Calculate the velocity in the *x*-direction by subtracting two consecutive *x* positions and dividing by the time between measurements. (If your sparker is set for 10 Hz this will be 1/10 sec.) Record your answer in the velocity column. Do this for every position you record. Make sure you record the proper uncertainties using propagation of error.

8. Calculate the acceleration the same way, subtracting by two consecutive velocity measurements, and dividing be the time between sparks. (Can you see why this is the right time interval?)

9. Repeat the above process for the trial in which you merely released the puck without propelling it with the launcher.

3.3 Slightly More General Case:

Place a new sheet of paper on the spark table. Practice shooting the puck in an arc that starts on the bottom of the page, curves upward, and then returns to the bottom. When you have perfected your technique, record the trajectory with the sparker. Repeat the above analysis



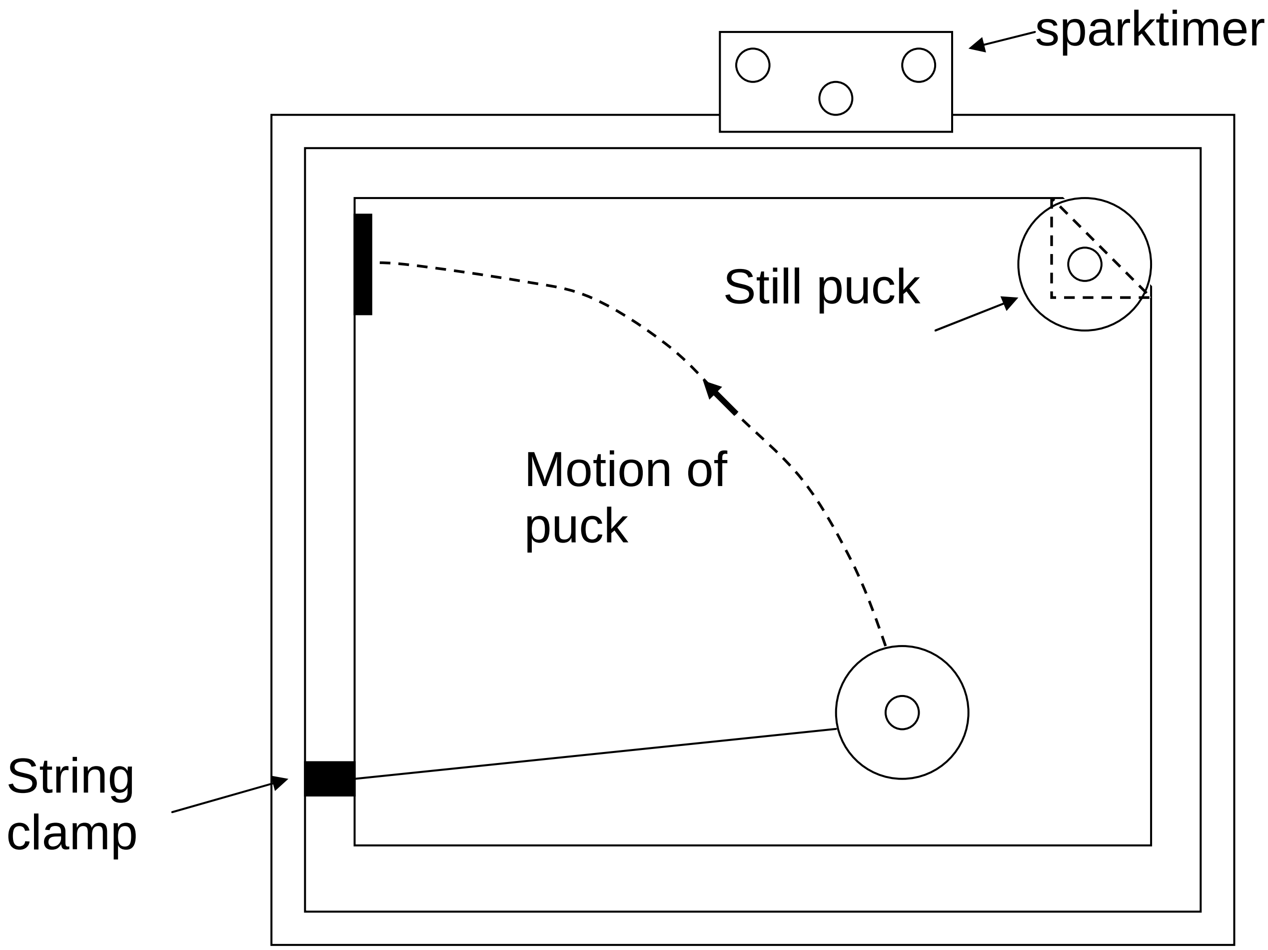
3.4 Circular Motion:

1. Level your spark table again. Do not shock your lab partners while they do this.

2. Tie a string to the center of the puck and anchor it so that it can move on a circular arc. Measure the radius of the circle of the arc, from the center of the puck to the center of the post.

3. Stretch the string taut. Practice giving the puck a velocity perpendicular to the string.

4. Take measurements using the spark table sparker. Record and analyze your data as above.



4 Questions:

In addition, please answer the following questions.

1. Calculate the magnitude of the acceleration, $a = \sqrt{a_x^2 + a_y^2}$ for each time interval. Find its average, its standard deviation, and the standard deviation of the mean, for all the projectile motion cases. Discuss how your results compare with the expected ones you get from calculating the forces involved. Be as quantitative as possible.

2. Assume that the spark generator did not fire at 10Hz but at twice that rate. How would this affect your results? Would you still see uniform acceleration in the projectile motion case?

3. List any possible sources of significant systematic and random errors. State whether or not these errors would affect your ability to observe constant acceleration.

Simple Projectile Case

Point #	x_i	v_x	a_x	y_i	v_y	a_y
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Height change: ________________________________

Range: ______________________________________

Calculated tilt angle: ___________________________

1D Case:

Point #	x_i	v_x	a_x	y_i	v_y	a_y
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Height change: ______________________________

Range: ____________________________________

Calculated tilt angle: __________________________

General projectile case

Point #	x_i	v_x	a_x	y_i	v_y	a_y
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Height change: ______________________________

Range: ____________________________________

Calculated tilt angle: __________________________

Centripetal Acceleration

Point #	x_i	v_x	a_x	y_i	v_y	a_y
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Radius of Circle:______________________________