# LAB 2: VISUAL ODOMETRY

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***Abstract***
*The Visual Odometry lab explores experimental unit conversions and calculating the acceleration of gravity. Using a tracking camera to find the position of a hockey puck with respect to time while sliding down a tilted airtable, kinematics was utilized to find the appropriate functions of position, velocity, and acceleration.*

***Keywords*** *position, velocity, acceleration, pixel units, S.I. units*

**Introduction:**

The goal of this experiment begins with deriving a conversion between pixels and centimeters. The tracking camera, which is again being used for the experimental procedure, tracks the location of an object using pixel coordinates. In experiment #2, we will be tracking the movement of a puck sliding across a sloped DAQ table. Based on the positioning and the timestamps, our team will determine the functions of the puck's position, velocity, and acceleration. As aforementioned, the tracking camera measures coordinates only in pixels. Given that the camera reports pixel values, it is impractical for finding kinematic equations of the puck. As a result, we will find a standard conversion between pixels and the SI unit centimeters. This will be calculated using the tracking camera to collect data points from a meter stick that has two neon stickers. The stickers are a set distance between each other, so the distance between the points can be measured in pixels, then converted to centimeters using the known distance between the stickers.

Once this conversion has been established, the experiment can proceed. The next concept to be used is based on the kinematic equations. That is, knowing that velocity is the first derivative of position and acceleration is the second derivative of position, our team will solve for the functions of the position, velocity, and acceleration.

**Experimental Procedure:**

The first step in this experiment was converting pixels to S.I. units. Two neon dots were placed approximately 50 cm or 0.50 m apart on a meter stick. The stick was placed under the tracking camera and the coordinates of the neon dots were recorded. The distance between the dots was calculated by plugging in the x and y coordinates into the distance formula. This yielded a length in pixels. A conversion ratio was then calculated by dividing the length in pixels by the approximate length in centimeters. This ratio could then be used when deriving the functions of the position, velocity, and acceleration of the puck. This concluded the first part of the experiment: that is finding a proportion between pixels and centimeters.

For the second part of the experimental procedure, our team was required to calculate the position, velocity, and acceleration of the puck sliding down an incline. Similar to the first experiment, a green neon dot was stuck to the center of the puck. This creates a point that the camera could track. To create a slope for the puck to slide down, the air table was tipped to an angle of 3.6 degrees. Next, the air table was turned on to simulate a frictionless surface for the puck to slide across. Simultaneously, the tracking camera was connected to our computer and prepared for recording data from the moving puck. Once all our equipment was set and prepared for the acquisition of data, we were ready to move onto the procedure.

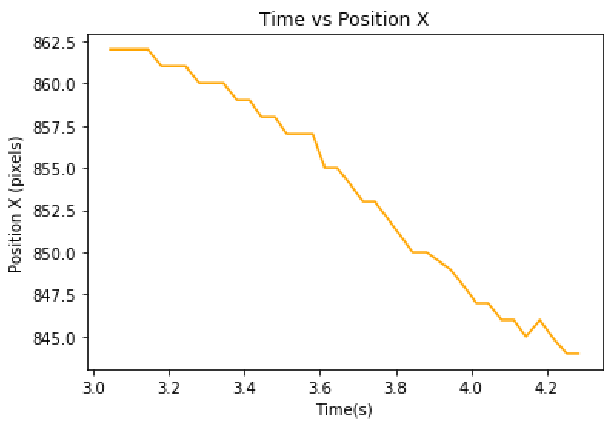
For our first trial, the puck was set at the top of the air table. The puck was then released from a resting position and the tracking camera recorded the position of the puck in pixels as the puck slid within the view of the camera. Several trials were run to acquire consistent data. These compilations of data were then saved to a .csv file, which was to be manipulated later.

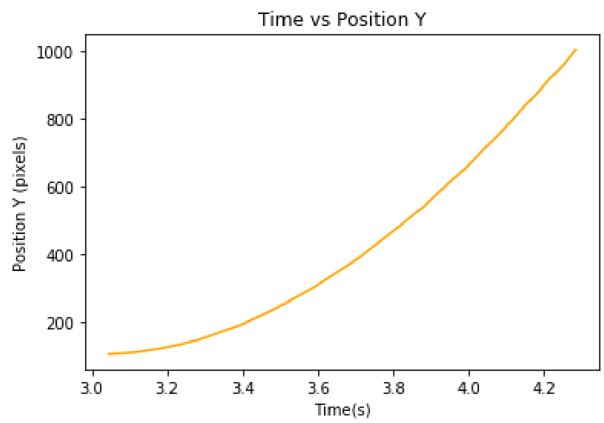
**Results:**

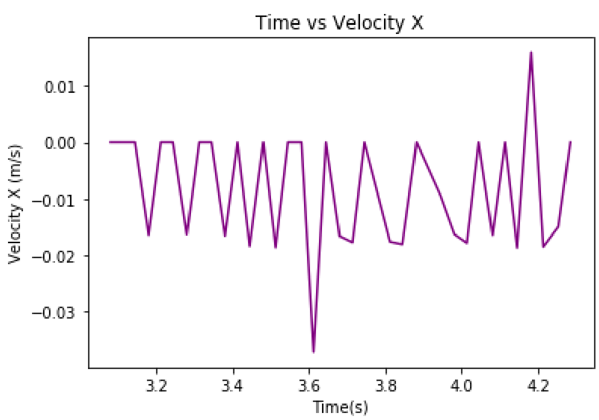
The graphs below include time vs position, time vs velocity, and time vs acceleration, for both the x and y components. These graphs utilize the raw data of the trials in order to calculate the gravitational acceleration. For both x and y components of the position, it is measured in pixels. The x and y component of velocity is measured in meters per second. Acceleration's x and y components are measured in meters per second squared.

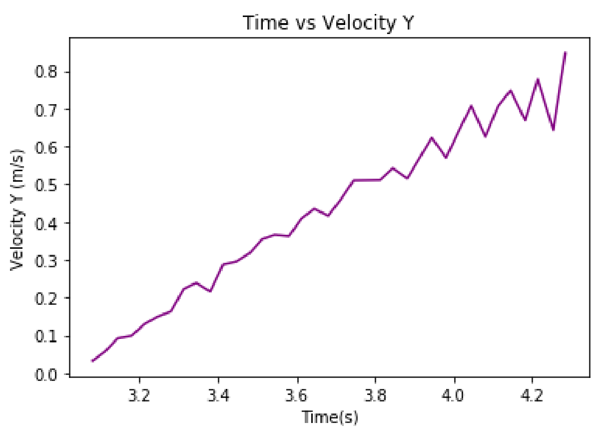
**Calculations:**

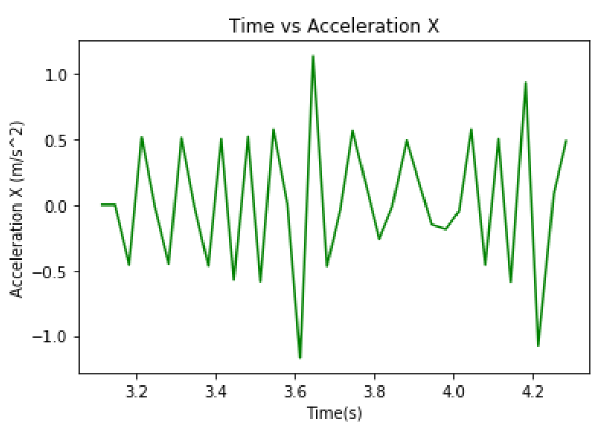
First, the timestamp, which was recorded in milliseconds, was converted to seconds to ease the calculations for velocity and acceleration. Next, the displacement between recorded frames was found in pixels in both the x and y directions. Then, dividing the displacement by the time elapsed, the velocity was found at each point in the trial. Concurrently, pixels were converted to meters, using the ratio found at the beginning of this lab to convert to centimeters and then dividing that number by 100 to convert to meters. Next, the velocity calculations were used to calculate the acceleration in both the x and y directions, with the y acceleration indicating the acceleration of the puck down the slope of the incline. This was done by taking the difference in two velocities and again dividing by the time elapsed. Once the accelerations were found at all points for each of the recorded trials, the average was taken to find an estimate of the acceleration of the puck down the slope. After finding that estimate, it is known that the acceleration down the slope of a frictionless incline can be defined as $g*\sin(\theta)$, where $\theta$ is equal to the angle of the incline from the horizontal. Thus, dividing the average acceleration down the slope by the sin of 3.6 degrees resulted in a calculated g of 12.61 m/s^2. The uncertainty of the calculated g was found by taking the standard deviation of the calculated accelerations in the y-direction, and also dividing that by the constant sin(3.6), yielding an uncertainty of 25.53 m/s^2. While that number may seem astoundingly large, the result is expected, as the range in calculated accelerations in the y-direction was quite significant, as seen on the graph on the next page.

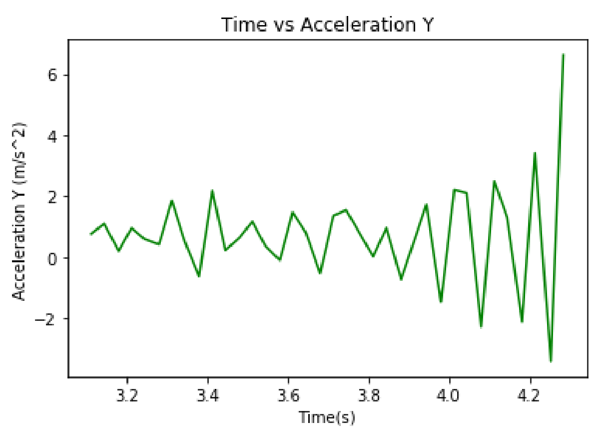



**Conclusions:**

In conclusion, through our experiment, we determined that the function of acceleration is simply the second derivative of position and the function of velocity is the first derivative of the position function.