Graphing Motion. 23 Jan 2018

The objective is to: Student 003

1. Analyze the motion of objects. Phy 2400
2. Analyze and interpret motion in kinematics graphs.

Materials:

Computer

Vernier computer interface (Labquest 2)

Vernier Motion Detector

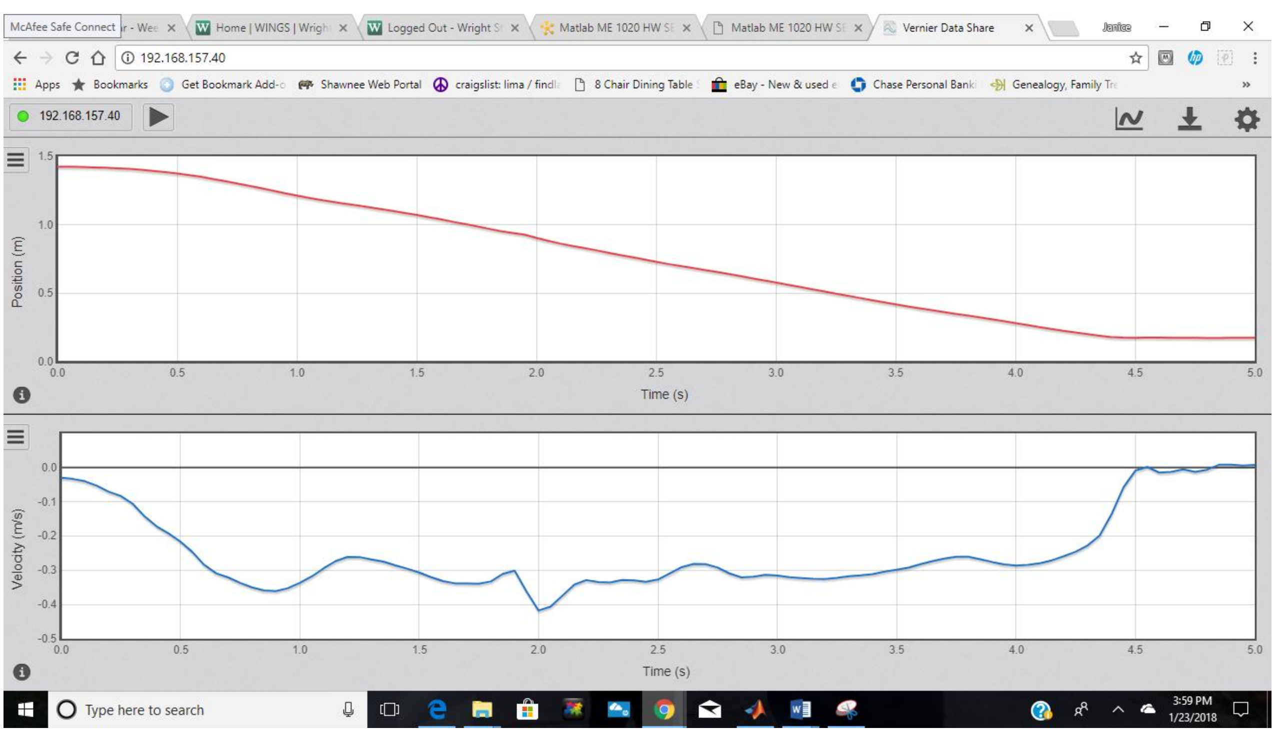
Notecard, and object to act as a pendulum (a purse with a shoulder strap works just fine)

Procedure:

Connect the motion detector and Labquest devices. The labquest has a data share website. For the particular device used today it was http:// http://192.168.157.40/. Each graph generated by the device is displayed on any laptop with this address entered in a browser. All graphs in this document are screenshots of that website.

Motion One: Moving closer

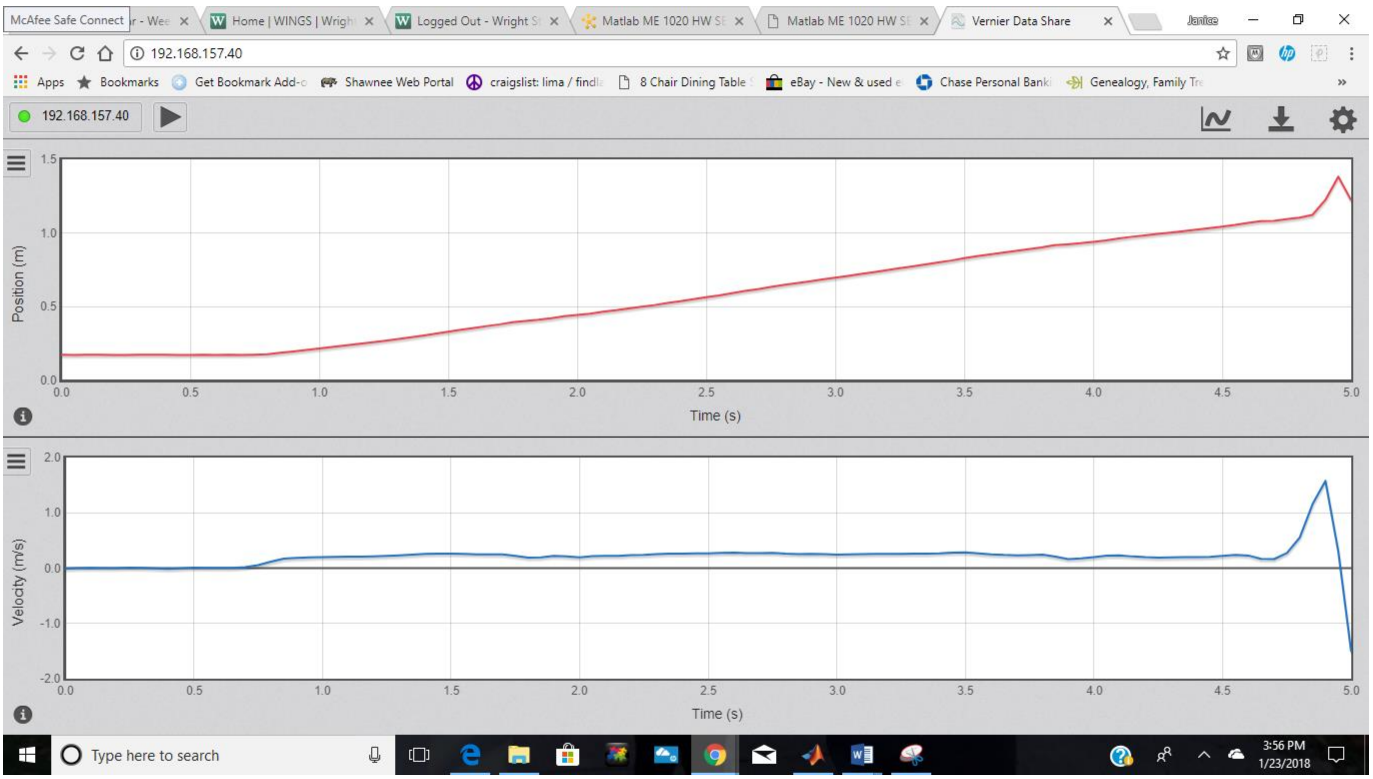
To generate the first graph, the motion detector was held about 1.5 meters from the table. The device was brought toward the table at a slow and steady rate while the data collection ran. The entire motion took slightly less than 5 seconds. After several trials, the best graph shows a distance curve that starts at position slightly less than 1.5 meters when time = zero. Velocity and acceleration are nearly zero at first, then as the position graph becomes nearly linear through the middle of the motion, velocity is between –0.3 and -0.4. Near the end of the 5 seconds, the meter touched the table for about half a second. Velocity, distance and acceleration all became zero. The graph appears below.



Disappointment: Trials were made both bringing objects toward the detector, and bringing the detector toward the objects. After many trials, even when the position graph is convincingly linear, a more constant velocity graph proved elusive.

Motion two: Moving away

The second motion attempted is movement with positive velocity, starting with a notecard close to the detector and carrying it away, or starting with the detector on the table and lifting it up in a smooth and steady motion. Due to a shortage of hands, and a lack of coordination, the latter method proved most useful. After several trials, an acceptable graph was produced. Notice in the graph below that between 1 and 4.5 seconds, while the position curve is linear with a shallow slope, the velocity graph is nearly constant at about 0.2 meters per second. When position over time is linear, velocity is constant and acceleration (represented here by the slope of the velocity curve) is zero.



Suggestions for future experimentation with linear position graphs:

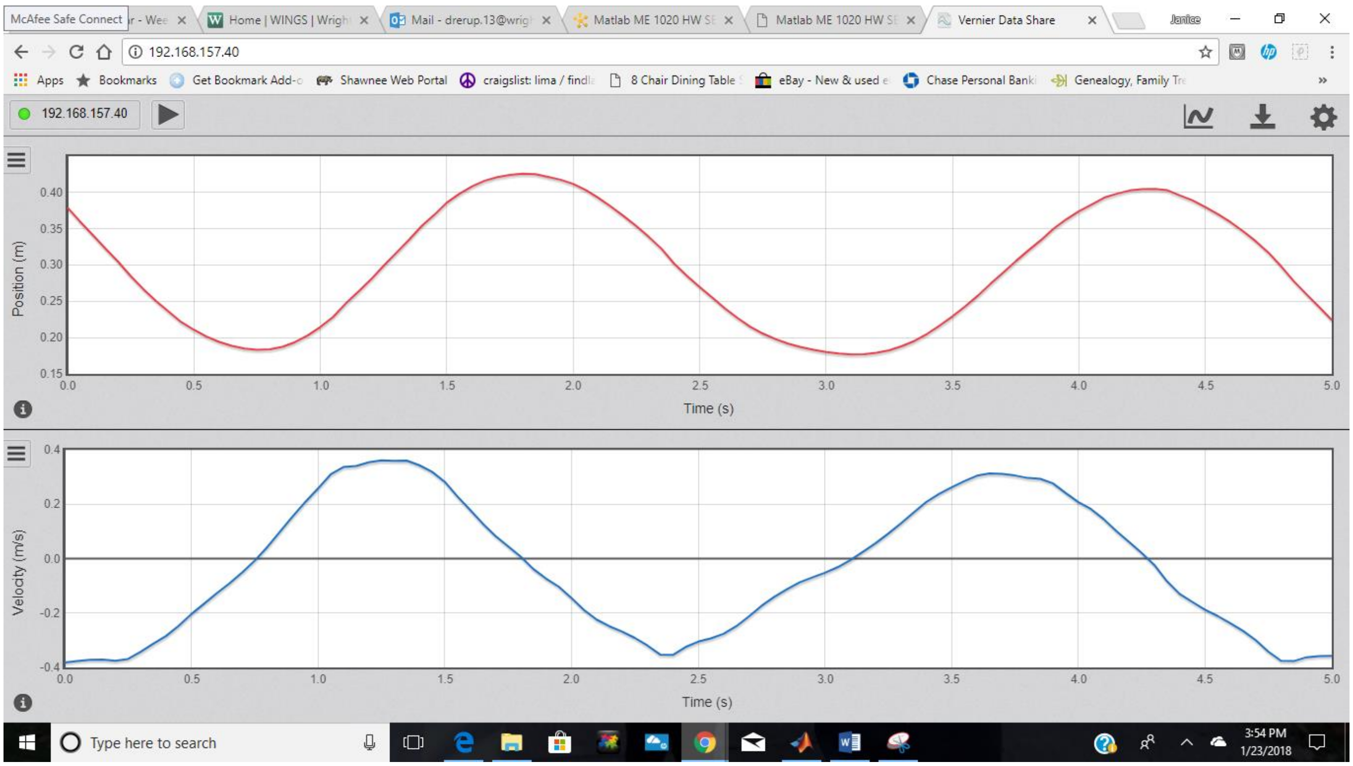
For both graphs of linear motion, it proved difficult to make a linear graph especially at the ends of the motion. In all trials, there was an obvious lag at the beginning of the motion and an irregularity at the end. To obtain better results, a new experiment might be designed with two changes.

1. The use of wheels on the position object might help generate smoother lines.

2. Based on the graphs collected today, it appears that if a graph of constant velocity is desired, it is necessary to start the motion first, and wait at least a second before data collection begins. It might also be advisable to end data collection before the object nears its final position.

Motion Three: Sinusoid

The motion detector was held above and pointing towards the table. The detector was moved in a circular fashion with period about two seconds. An attempt was made to keep the center of the circle at about 30 cm, and to keep the radius near 20 cm. After many trials, the best graph was saved and is shown below.

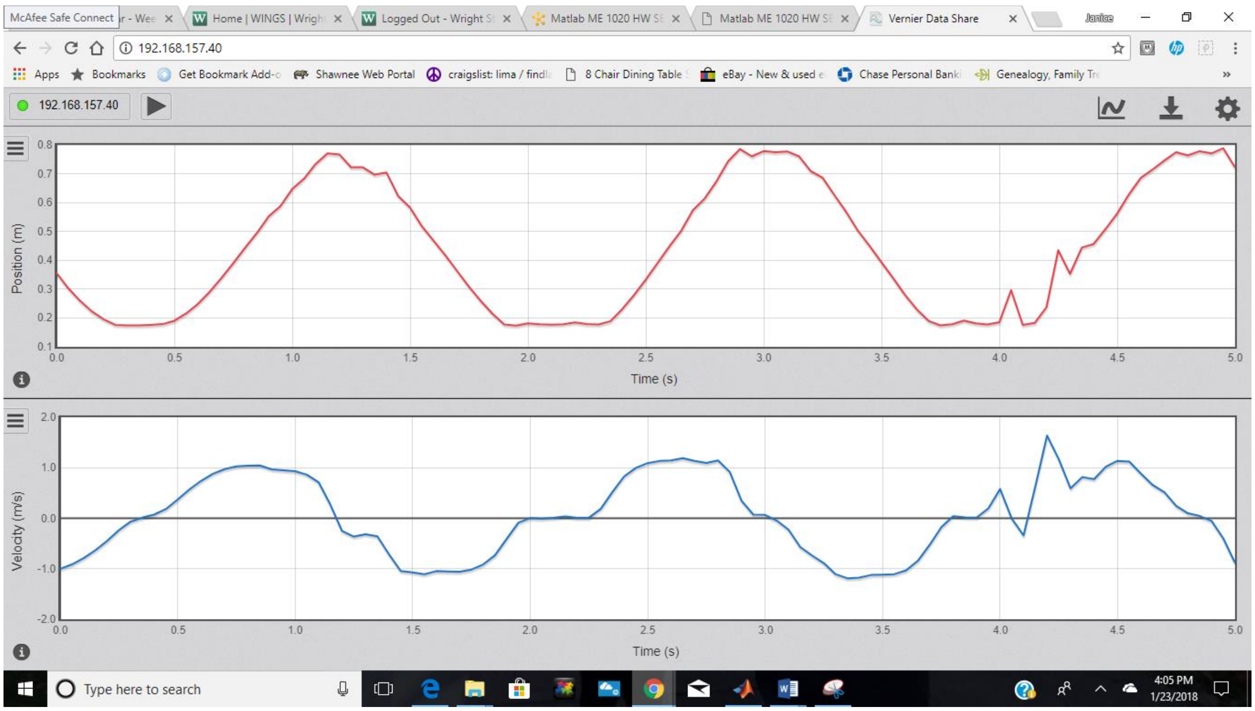


This graph pair, though imperfect, illustrates beautifully the relationship between position and velocity over time. For example, if we look at position between about 1.25 and 3.75 sec. It appears to be one beautiful period of a sine wave. Notice that the velocity graph over the same period makes a convincing cosine wave. Indeed cosine is the first derivative of sine.

Between about 0.75 and 3.15 seconds, the position graph is one period of a negative cosine wave. The velocity graph over the same time is one period of a sine graph. Indeed, the first derivative of negative cosine is sine.

Motion four: Sinusoid reprise

To generate a sinusoid using a pendulum, an object to act as a pendulum was needed. After trials of headphones, weights on rubber bands and strings of various school supplies, the most meaningful graph was attained by use of a purse. A purse was held about 50 cm in front of the detector and set to swinging. The data collection was started and the following pair of graphs was obtained.



A purse proved harder to control than anticipated. Perhaps the irregularity in the graph is due in part to the irregularity in the shape of the purse, or to the fact that the purse wanted not just to swing, but to spin. In any event, after trying many objects, but only one purse, this is the best graph obtained.

The position graph is again a convincing sinusoid. The velocity graph is loosely sinusoidal as well. Note the relationship between the position graph and the velocity curve. Between 0.6 seconds and 2 seconds position over time makes one period of negative cosine. Velocity over the same period is approximately a sine wave. Indeed, the first derivative of negative cosine is sine.

Between 0.75 and 2.6 seconds, the position over time graph appears to be one period of sine. The velocity graph over the same time is sloppy, but still recognizable as cosine. Indeed, the first derivative of position over time is velocity, and the first derivative of sine is cosine.

This is why we do math. Math without application would be only fun.