PocketLab Voyager: Deceleration of an Air Disk

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Introduction

A very popular air disk is the *Air Power Soccer Disk*, available at a variety of locations including Amazon, Walmart, and Educational Innovations, Inc. at prices ranging from about $5 to $17. Powered by four AA batteries, it rides on a cushion of air on any reasonably smooth surface. While kids love to kick it around like a soccer ball, it is also a great companion for PocketLab Voyager when studying physics principles.

In this lesson, students quantitatively investigate the deceleration of an air disk as it revolves in a circle on a table top, as shown in the bird's eye view of Figure 1. There is also an accompanying video showing the motion and the associated angular velocity and tangential acceleration from data collected by the PocketLab app.

Figure 1

Voyager is mounted to the disk with removable mounting squares. A piece of clear fishing line is attached at two locations near the perimeter of the disk using black electrical tape. The fishing line, which loops around a ring stand pole, is used to reduce the friction at the central pivoting point of the disk. The disk is given an initial tangential push (upward in Figure 1) to get it into a circular orbit about the ring stand. With Voyager mounted as shown, the two things of interest are the z-component of angular velocity and the x-component of the tangential acceleration. The disk continues orbiting until it comes to rest due to a variety of frictional forces tending to slow it down.

Students are asked to investigate the angular and tangential deceleration of the disk from data collected by Voyager and the PocketLab app.

Typical Results

The chart at the top of Figure 2 is an Excel graph of the angular velocity of the air disk. This data was obtained from the csv file produced by Voyager and the PocketLab app. The disk is initially at rest. At about 5 seconds, the disk is given a push to get into orbit. From about 5 seconds until 11 seconds the disk slows down while orbiting. The chart at the bottom of Figure 2 is an enlargement of the region in the red square of the top figure. A trend line of the regression type “linear” shows that the angular acceleration is -23.84 °/s^2.

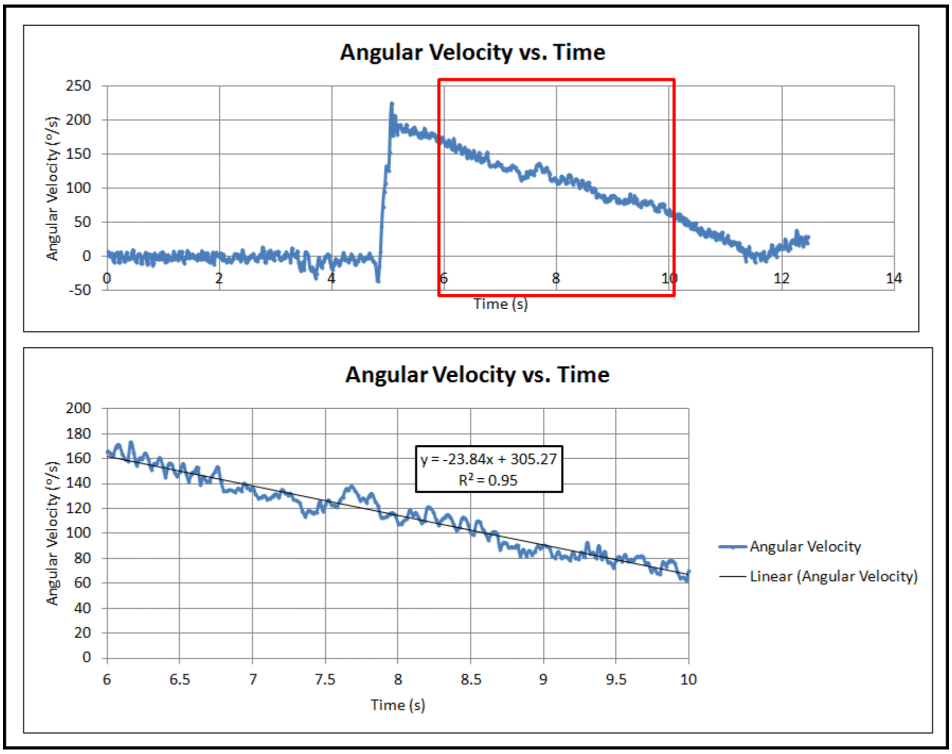

Figure 2

The chart at the top of Figure 3 is an Excel graph of the tangential acceleration of the air disk. Once again, the region where the disk is slowing down while orbiting (highlighted in a red square) is enlarged and shown at the bottom of the figure. The tangential acceleration is slowing down at a rate of about 0.0492 m/s^3 as indicated by the slope of the straight line of best fit, but this was not particularly suggested by the angular velocity graph of Figure 1. Never-the-less, the *average* tangential acceleration was about -0.14 m/s^2.

It would be instructive for students to compute the average tangential acceleration from the angular acceleration of -24.84 °/s^2 obtained from Figure 2. We know that $a = R\alpha$, where a is the tangential acceleration, R is the radius of the orbit, and α is the angular acceleration. Therefore, with the radius R from the center of the disk to the pivot point being 0.33 m:

$$A = R\alpha = (0.33\text{ m})(-23.84\ °/\text{s}^2)(\pi/180\text{ rad}/°) = -0.14\text{ m/s}^2.$$

This agrees with the average tangential acceleration computed from the data from Figure 3!

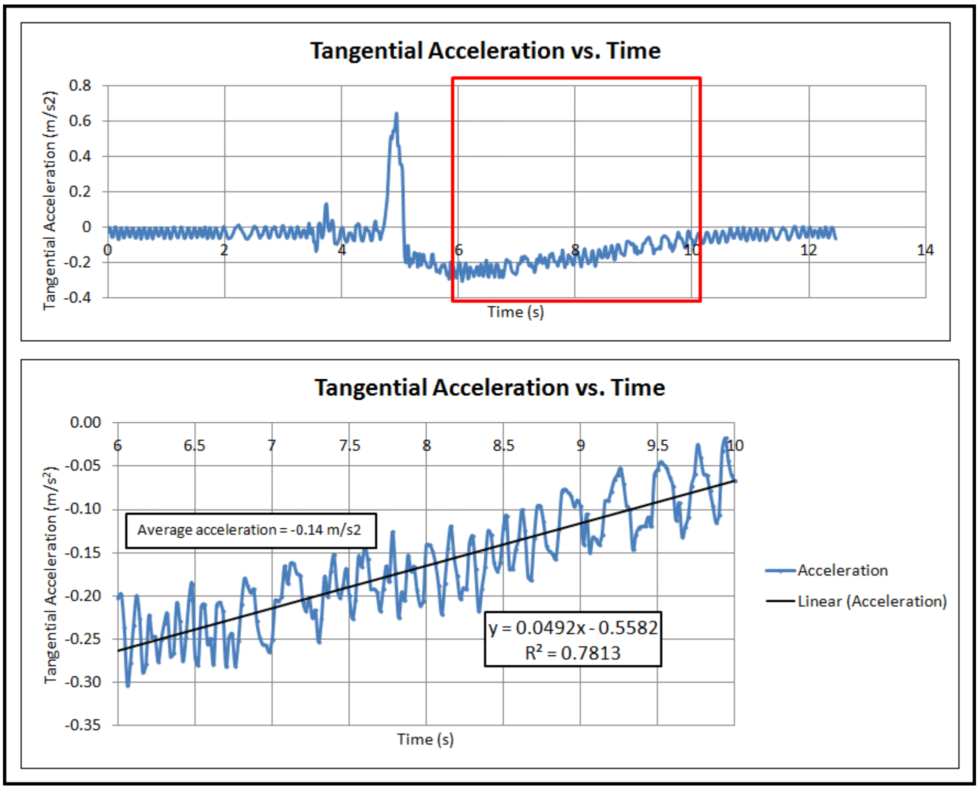
Tangential Acceleration vs. Time
Tangential Acceleration (m/s2)
Time (s)
Tangential Acceleration vs. Time
Average acceleration = -0.14 m/s2
y = 0.0492x - 0.5582
R² = 0.7813
Tangential Acceleration (m/s²)
Time (s)
Acceleration
Linear (Acceleration)

Figure 3