Physics Galore with the PocketLab Swing
Teacher's Guide
by Richard Born

To determine the velocity of Voyager as it leaves the swing:

Method 1: Conservation of Energy

Neglecting energy losses during the swing such as friction at the pivot point and air resistance, we can say that the gravitational potential energy lost during the downward swing should equal the kinetic energy gained:

$$mgh = \frac{1}{2}mv^2$$

where m is the mass of Voyager, h is the distance fallen by its center of mass, and v is the speed at the bottom of the swing. We wind up with

$$v = \text{sqrt}(2gh)$$

where we can take g, the acceleration of gravity, as a known quantity (~9.81 m/s^2).

Method 2*: *By making use of the distance traveled by Voyager until it comes to rest, coupled with the acceleration and time required to come to rest on the platform

Figure 1 shows the orientation of Voyager on the swing. The y-acceleration is of interest here.

Figure 1

Here, we make use of the well-known kinematics equation for uniformly accelerated motion:

$$d = v_o t + \frac{1}{2}at^2$$

where d is the distance that Voyager travels along the wood platform, v_o is its velocity as it leaves the swing, a is the acceleration (negative) as Voyager slows down under friction with the platform, and t is the time required for Voyager to traverse its path along the platform. The value of d is measured by the meter stick, and the values for a and t can be determined from the PocketLab app's acceleration vs. time graph. Solving the equation for v_o will allow determining the velocity. The top graph in Figure 2 shows y-acceleration vs. time and explains how to compute the values for t and a.

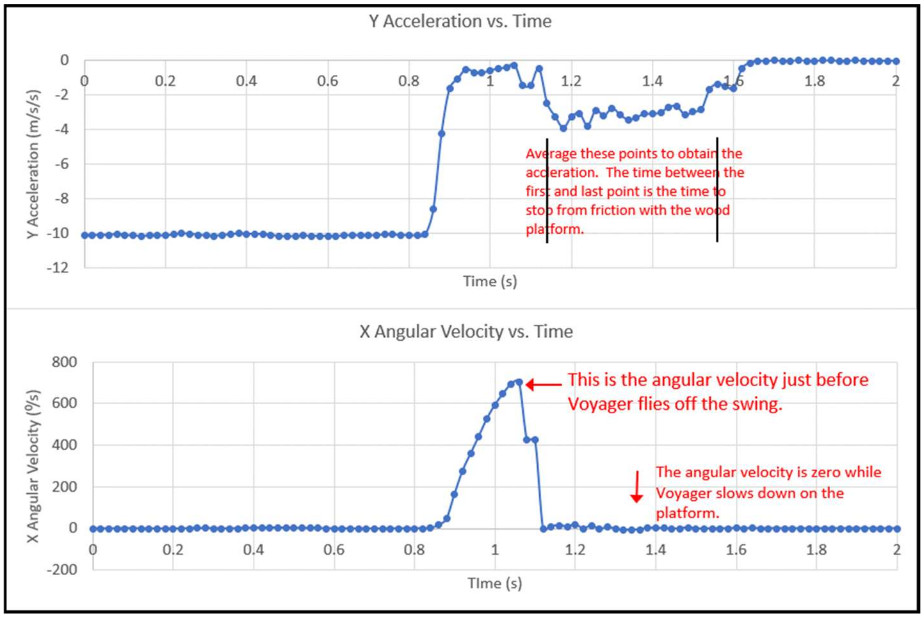

Figure 2

Method 3: From the moment arm and angular acceleration of Voyager as it leaves the swing

While the swing falls, the x-angular velocity is of interest here, and can be obtained from the PocketLab app. The bottom half of Figure 2 shows a typical graph of x-angular velocity versus time. The moment arm *r* of Voyager is the value of *h* obtained from Method 1. Students will need to convert degrees per second from the app to radians/s. Then using the formula $v = \omega r$, the velocity *v* just before leaving the swing can be determined.

Determining the Force of Friction and the Coefficient of Kinetic Friction

While sliding to a stop due to friction with the wood platform, Voyager experiences a change in momentum equal to the impulse:

$$F\Delta t = m\Delta v.$$

We can solve this for the force *F* to obtain the force of friction. By definition, $F_f = \mu N$, where *N* is the normal force and μ is the coefficient of kinetic friction. Since Voyager is traveling on a level surface, $N = mg$. Therefore,

$$\mu = F_f / (mg).$$

We can take *g* as 9.81 m/s/s, and can measure the mass *m* of PocketLab with a balance.