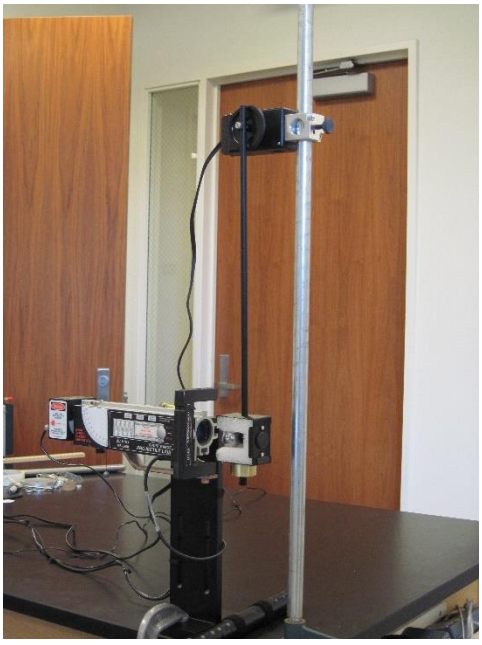
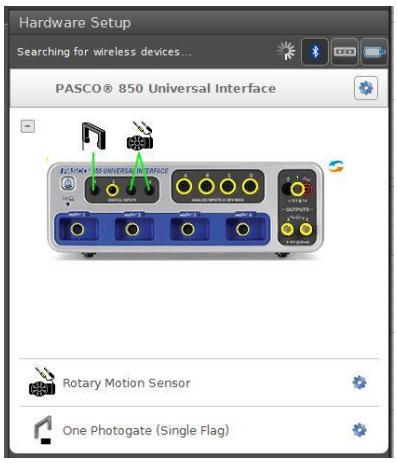
# Ballistic Pendulum Demonstration



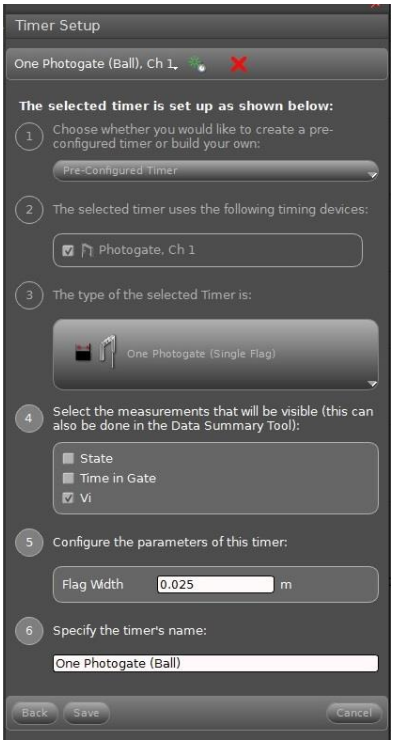
The ballistic pendulum was developed to measure the launch velocity of a high-speed projectile. A launcher fires a ball into a catching cup on the end of a pendulum rod. The pendulum swings up to a maximum angle. Recording this maximum angle and measuring the mass of the ball, the mass of the pendulum and the length of the pendulum, the launch velocity of the ball can be determined.

As a demonstration, we may not want to actually take all of the measurements during class, so the default is to use a pre-created Pasco Capstone template with all of the constants already plugged in to the Calculator.

$m_{ball}$ = 0.0661 kg
$m_{pendulum}$ = 0.1672 kg
$r_{pendulum}$ = 0.355 m




A photogate is used to directly measure the ball's initial velocity $\boldsymbol{v_i}$ (from the time interval during which the 0.025 m diameter ball blocks the photogate light beam.)



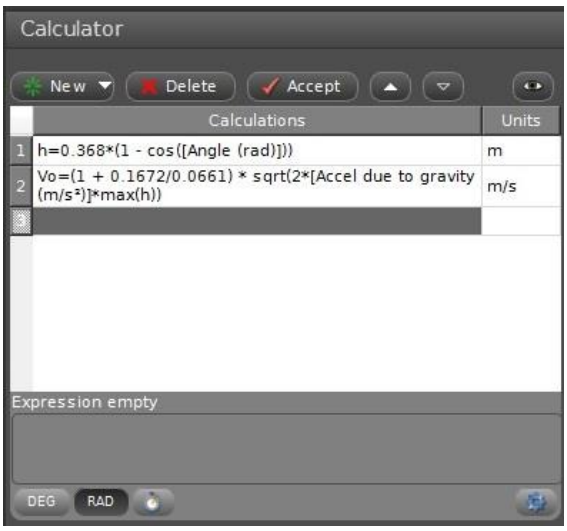

A rotary motion sensor is used to measure the angle of the pendulum $\boldsymbol{\theta}$ as a function of time. The angles are converted to change-in-vertical-distance $\boldsymbol{h}$ and plotted. The graph **max** statistical function is used to find the maximum vertical distance $\boldsymbol{h_{max}}$ (the peak).

$$h = r_{pendulum}\,(1 - \cos(\theta))$$

where $r_{pendulum}$ is the length of the pendulum from pivot point to center of mass of the total (catcher, rod and ball) system.

The "final" velocity $\boldsymbol{v_o}$ is calculated from:

$$v_o = \left(1 + \frac{m_{pendulum}}{m_{ball}}\right)\sqrt{2gh_{max}}$$




To perform the demonstration:

1. Clamp the ball launcher and pendulum stand to the table.

2. Plug the photogate phone plug into DIGITAL CHANNELS 1, and the rotary motion sensor yellow plug into DIGITAL CHANNELS 3 and the black plug into 4. Connect the alignment laser miniature phone plug to the wall wart transformer and plug the transformer into the bench.

3. Set the launcher angle to 0 degrees with the plumb bob.

4. Turn on the alignment laser at the back of the launcher. Adjust the positions of the launcher and pendulum catcher so that the laser beam hits the center of the pendulum catcher cup. Turn off the laser.

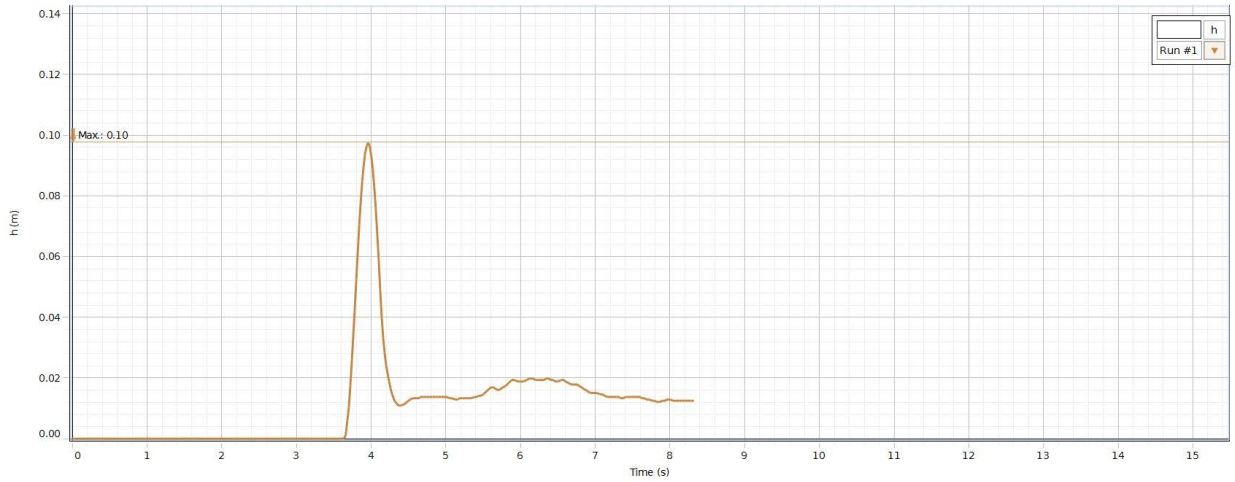
5. Start Capstone and open "Ballistic Pendulum.cap".

6. While holding the pendulum out of the way, insert a 2.5 cm steel ball into the launcher and use the plunger to push it in to the third click "LONG RANGE" position. When you remove the plunger, make sure that the ball remains in position at the back of the launcher.

7. Click on **Record** and pull the launcher yellow lanyard cord. **Make sure you catch the pendulum before it swings back down to the bottom. Do not let it enter the photogate!!!**

8. Click on **Stop**.

9. The Initial Ball Velocity $v_i$ is calculated from the photogate data. The final ball velocity $v_o$ is calculated from the rotary motion sensor data.




Change in Ball Height (h)

Initial Ball Velocity

Speed (m/s) Run #1

4.79m/s

Final Ball Velocity

$v_0$ (m/s) Run #1

4.88m/s