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Simple Harmonic Motion

Purpose:

To learn more about how mass, length, and height affect the period and amplitude of an object in simple harmonic motion by proving that Period is independent of mass and amplitude.

Procedure:

To begin this lab, we set up a ring stand and clamped it to the edge of a table. We then attached a wooden dowel to the ring stand and attached a force sensor to the dowel so that the force sensor hung over the edge of the table. We then attached a 110cm piece of string from the force sensor to a hard baseball as seen in Figure 1. We measured the radius of the baseball to add it to the length of our pendulum for our calculations later. We then Let the ball swing for at least 20 cycles at a starting angle of 2, 30, and 60 degrees and recorded the tension in the string with the force sensor over these periods. We then used the same set up and hung a small metal ball and a golf ball from the string and took the period of that. Next, we used a heavy ball and swung it at three different lengths of string and compared the period. Finally, we attached a rotary motion sensor to the dowel where the force sensor was previously and screwed a meter stick to it. We used the sin fit function to measure the period.

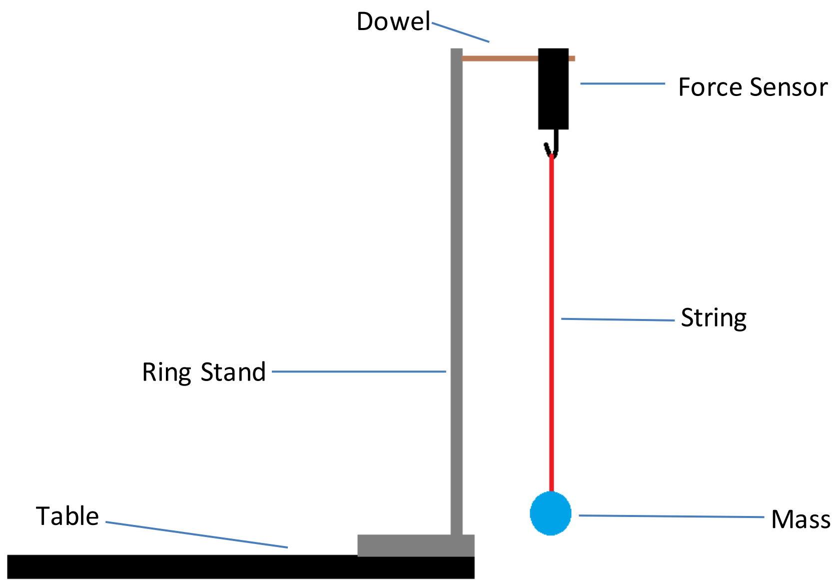

Figure 1. Part A and B Setup

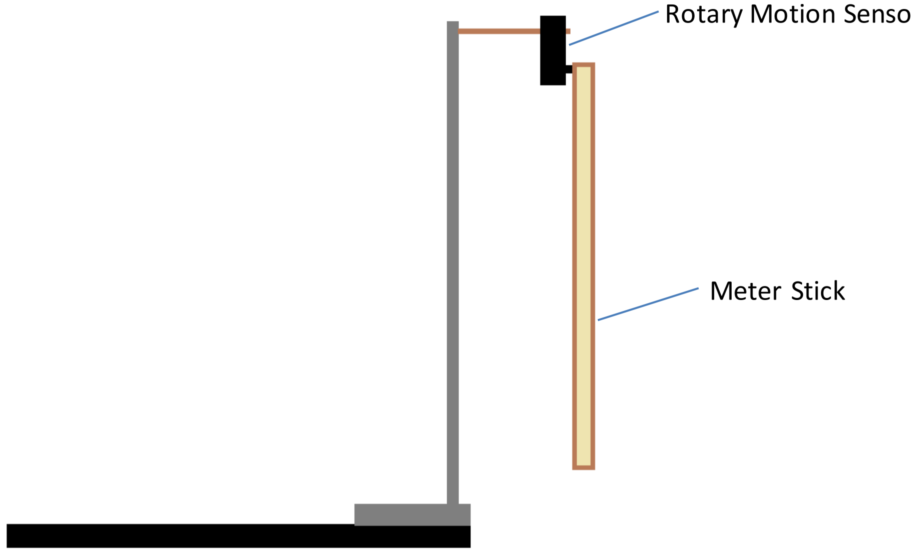

Figure 2. Part C Setup

Data:

Table 0. Materials

Ring Stand
C clamps
Computers
Wooden Dowels
Stand Clamps
Medium Thread
Meter Sticks with Holes in Them
Force Sensor
Rotary Motion Sensor
Baseball
Golf Ball
Lead Sinker/ Steel Ball

A.

Table 1. Radius

Object	**Radius (cm)**
Baseball	3.525
Golf ball	2.14
Sinker	1.52

B.

Table 2. Period and mass of other objects with same length (101cm)

Object	**Mass (g)**	**Period (s)**
Golf Ball	45.81	2.062
Sinker	50.13	2.034

Table 3. Period of sinker with different lengths

Length (cm)	**Period (s)**
27.52	1.054
31.14	1.150
102.53	2.030

C.

Table 4. Meter Stick Period

Center of Gravity (cm)	Period (s)
49	3.360

Results:

A.

Table 5. Amplitude and Period

Amplitude (degrees°)	Period (s)
2	2.024
30	2.084
60	2.108

C.

Table 6. Moment of Inertia of Meter Stick

Mass (kg)	Period (s)	Moment of Inertia ($kg \bullet m^2$)
.149	3.36	0.2046

Calculations:

1. Radius of hanging objects (baseball)
   $R = D/2$
   $= 7.05cm / 2$
   $= 3.525cm$
2. Total length from pivot to center of mass (sinker)
   $L = L_s + R$
   $= 26cm + 1.52cm$
   $= 27.52cm$
3. Distance from motion sensor to center of mass (meter stick)
   $R = L/2 - p$
   $=100cm/2 - 1cm$
   $=50cm - 1cm$
   $=49cm$
4. Period (baseball at 30 degrees)
   $T = (\Delta t/cycles) * 2$
   $= ((61.374s-28.026s)/32cycles) * 2$
   $= (33.348s/32cycles) * 2$
   $= 1.042s * 2$
   $= 2.084s$
5. Moment of inertia (meter stick)
   $I = (T^2 * M * g * d)/(4\pi^2)$
   $= (3.36s^2 * .149kg * 9.8m/s^2 * .49m)/(4\pi^2)$
   $= (8.078kg * m^2)/(4\pi^2)$
   $= 0.2046kg \bullet m^2$

Questions:

1. Because $T = 2\pi * sqrt(L/g)$, we can rearrange this to find $g = 4\pi^2L/T^2$. Because $g = 4\pi^2L/T^2$, this shows that g is larger for objects with larger masses because larger masses have shorter periods based on my result. This also shows how the objects with larger radius will have smaller g values because they have larger periods, most likely due to the extra air resistance. According to our equation, the g value is directly higher for objects hanging further from the pivot. And finally, as we can see from the data, higher amplitudes cause very slightly higher periods, which lead to a slightly smaller measurement of g.

2. The average value for g in Table 3. Is $9.63 m/s^2$.
   % difference = [(Accepted - Experimental)/((Accepted + Experimental)/2)] x100
   $= [(9.8 m/s^2 - 9.63 m/s^2)/((9.8 m/s^2 + 9.63 m/s^2)/2)] \times 100$
   $= [0.17 m/s^2 / 9.715 m/s^2] \times 100$
   = 1.75% difference
   The Percent difference between my experimental values of g and the accepted value of g is 1.75%.

3. For a thin rod pivoted around a point, $I = 1/3\ M L^2$. So, the theoretical value of moment of inertia for the meter stick would be $I = 0.0497\ kg \bullet m^2$. Percent deviation is % = [(Mean Deviation from Average)/Average)] x 100
   $= [|(((.2046\ kg \bullet m^2 + .0497\ kg \bullet m^2)/2) - 0.2046\ kg \bullet m^2)| / ((.2046\ kg \bullet m^2 + .0497\ kg \bullet m^2)/2)] \times 100$
   = 60.93% deviation.

4. The Percent Deviation of the moment of inertia of the meter stick is 60.93% which is very high. One reason for the high deviation could be because the meter stick is more of a thin plate than a rod. It could also be because the pivot was 1cm into the stick instead of at the very end of it.

Conclusion:

In this lab, we proved that period of a pendulum is only dependent upon the distance the center of mas is from a pivotal point, and the acceleration due to gravity. We were able achieve our purpose to learn more about simple harmonic motion because as seen in Table 2. And Table 5., there is close to no change in the period due to a change in amplitude or mass.

The most major source of error in this lab was air resistance. In Table 2. We see that the larger object had a slightly shorter period, which we can probably attribute to it getting more drag from the air around it. Overall, our instrumentation was good and our experimental value of g is very close to the actual value. The little difference between them is most likely also caused by air resistance. The most accurate part of the lab, I believe was the baseball being swung at different amplitudes because we can clearly see almost no change in period, and we did not have to change any parts or remeasure or retie any string, so it was kept consistent throughout our tests. In order to obtain better data and improve our experiment, we need to get objects with smaller diameters and higher mass. As it is, we see from our graphs how the pendulum spirals in a cone like shape until it eventually stops. A heavier and smaller object would allow this cone shape to elongate much farther so that the effects of air resistance are nearly negligible. However, the lab as a whole was rather good, as can be seen by the sensibly low margin of error.