Lab #2: Percise Measurement of Gravity Using Kater's Pendulum

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INTRODUCTION

Prior to the creation of Kater's Pendulum, the best measurement for finding the local value of gravity was using an almost massless thread that was fixed at one end and have a metal sphere connected to the other. This method yielded a result to the values of gravity although this method had one major flaw, angular momentum. When the metal sphere swung from the cord, sometimes the sphere would wobble due to many external factors and cause some of the pendulums energy to be lost to angular momentum [?]. This reason caused captain Henry Kater to devise and create his own pendulum in 1817[?]! His new pendulum had two major improvements to the old design, being fixed and being compound. Instead of having to swing from a cord, the pendulum was solid metal rod, so none of the energy was lost to angular momentum. This alone made the measurement much more precise! The pendulum was also compound, meaning it has two weights, instead of one, that could offset each other and add more mass to the system to negate air friction and like retardant forces. The two weights consisted one one heavy, fixed one at one end and a small, movable one at the other. This allows the one small weight to be adjusted, either on a macro or micro scale, to influence the center of mass of the pendulum.

THEORY

We know from the lab manual that "if the period of oscillation of a physical pendulum about one axis a distance l_1 from the center of mass (i.e., the radius of gyration) is T_1 while the period of oscillation about the other pivot a distance l_2 from the center of mass is T_2, then the acceleration due to gravity is given by[?]"

$$\frac{8\pi^2}{g} = \frac{T_1^2 + T_2^2}{L} + \frac{T_1^2 - T_2^2}{l_1 - l_2} \tag{1}$$

where g is the local gravity, T_1 is the upright period measure, T_2 is the upside-down period measure, L is the length of the rod, l_1 is the length to the adjustable weight from the top knife-edge, and l_2 is the length from the adjustable weight to the bottom knife-edge. This is true of all physical pendulums, although it requires the measurement of four different quantities to determine g. If we adjust the small, movable weight to make the periods, T_1 and T_2, equal each other, we can cancel one of the fractions and drop the number of values we must measure to 3! The periods being equal makes equation 1 become

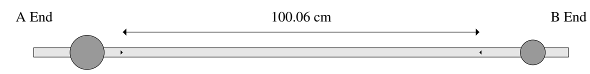

FIG. 1. This figure is a schematic of the Kater's Pendulum device. Three important notes are the two masses at each end (the B side mass is movable), the two knife edges at end end, and the distance between the knife edges being a known 100.06cm.

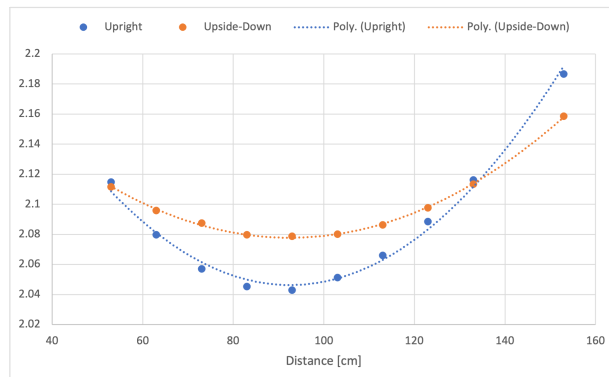

FIG. 2. The Graph of Large Movements in the Small Weight

$$\frac{8\pi^2}{g} = \frac{2T^2}{L} + 0 \tag{2}$$

where $T = T_1 = T_2$. We can now rearrange equation 2 to solve for g:

$$g = \frac{4\pi^2 L}{T^2} \tag{3}$$

EXPERIMENT

At the heart of the Kater's Pendulum experiment is the Kater's pendulum device, seen in Figure 1.

DATA ANALYSIS

For the first measurement, to obtain the rough estimate of where $T_1 = T_2$ was located, we obtained Figure 2.

CONCLUSION

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