Notes on the moments of inertia lab

Please report all values in units of kg and meters. Your moments of inertia should then have units of kg m^2.

Part A:
The goal of this part is to infer the moment of inertia of the rotating cross from kinematic measurements of the motion of the hanging mass. You will do this using three different rotating masses: the cross by itself, the cross plus a disk, and the cross plus a thick hoop. You will repeat this experiment with two different hanging masses and conduct 5 trials for each. From this you can calculate a mean value and standard deviation for the moment of inertia. I conducted these measurements and got values in the neighborhood of 2×10^{-2} kg m^2.

Unlike the uncertainty analysis in last week's lab (ballistic pendulum) where we calculated derivatives to propagate the uncertainty through our equations, that technique does not work so well here because the things that we measure (t and y) don't enter the final equation for the moment of inertia in simple multiplicative way. Meaning, there is that pesky -1 term in the equations that complicates the derivative. Instead of doing that, we are going to just calculate a value for the moment of inertia for each of the trials. Then, for each set of 5 measurements, you can report a mean value of the moment of inertia and the standard deviation of those values.

m_{disk} = 4.77 kg
$m_{thick\ hoop}$ = 4.20 kg

Part B:
The goal of this second part is to infer the moment of inertia of the hula hoop, the baseball bat, and the brass ball by measuring the period of oscillation of each. You should then compare the measured moment of inertia against the theoretical value for each. You can use the equations in the book to find the appropriate moments of inertia for the brass ball and the hula hoop. You can use the following equation, derived from considering a cone, as an approximation for the moment inertia of the baseball bat.

$$I_{bat} = \frac{3}{5} m_{bat} L_{bat}^2$$

Note that the length of the bat is not the same as the center of mass distance, so don't mix those up (L_{bat} = 85.5 cm). If you do this right you can easily get agreement of experiment and theory to within about 15 for the ball and hula hoop, and about 15% for the bat.

Extra credit:
Derive the result for the moment of inertia of a bat by performing the moment of inertia integral.