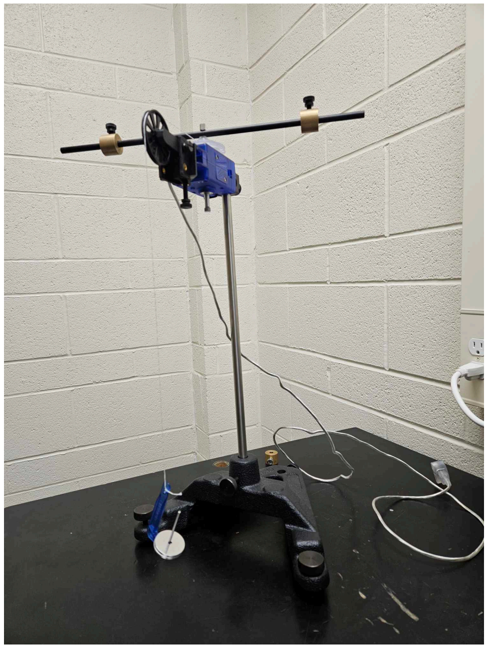
# Physics 1D03: Lab 3

## MOMENT OF INERTIA

# Lab Objectives

- Observe how Moment of Inertia affects rotational motion within a laboratory setting.
- Learn how to effectively use Vernier Calipers.
- Systematically calculate the Moment of Inertia through two different methods.
- Use the standard deviation as a form of uncertainty analysis.
- Develop your own plots within Microsoft Excel.
- Verify the theoretical relation for Moment of Inertia of point masses.

# Equipment



Cross-bar system

Vernier Caliper

# Part 0: Using a Vernier Caliper

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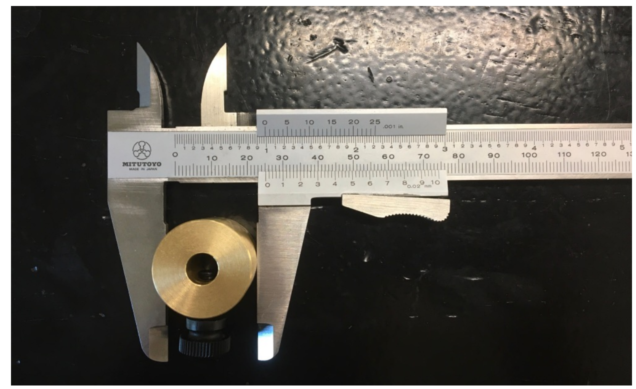
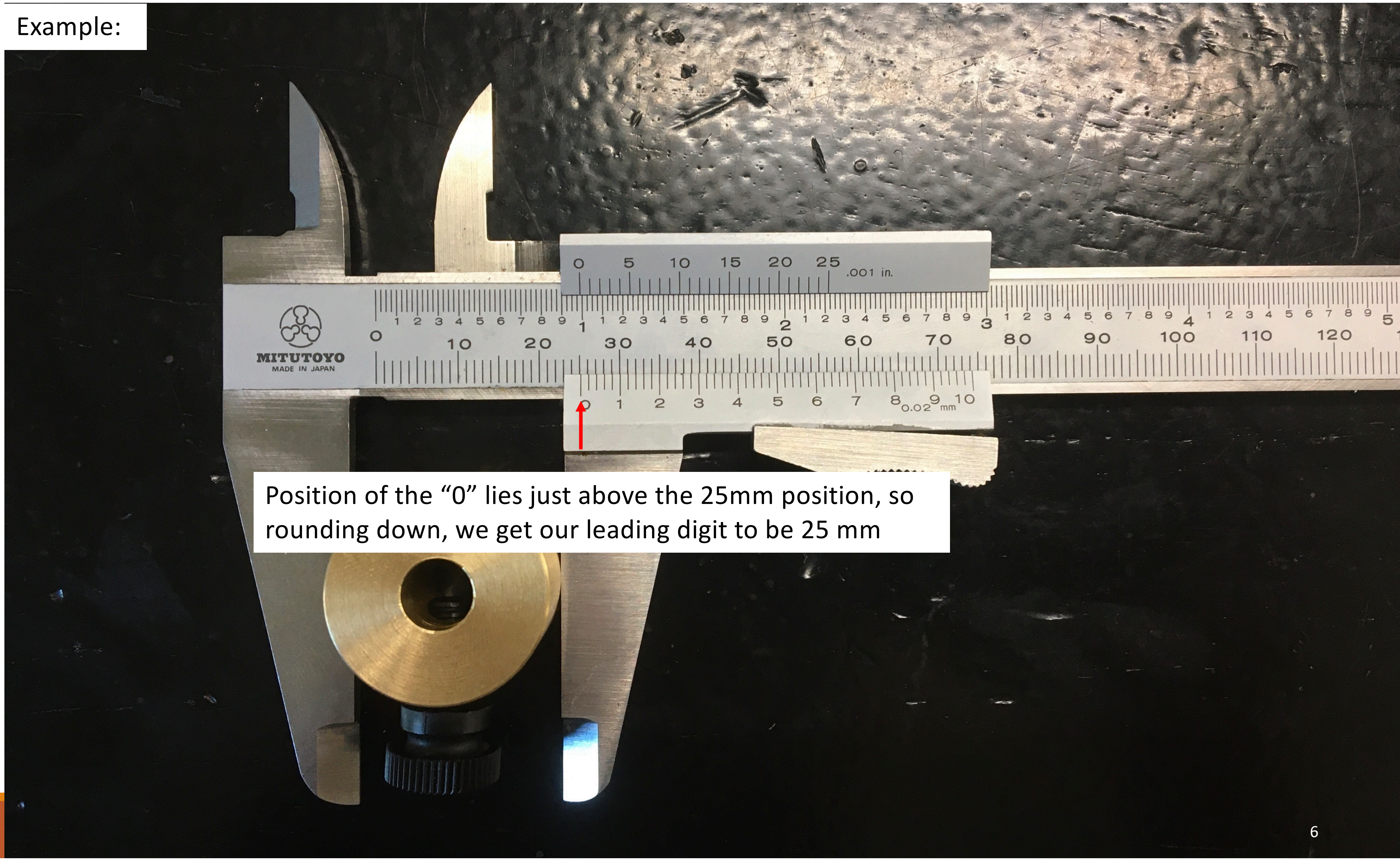
- Once the clamps of the caliper around the object you want to measure, find the “0” position on the slider
  - Round the value down to the closest tick mark on the fixed ruler
  - This will give us our leading digit in the measurement



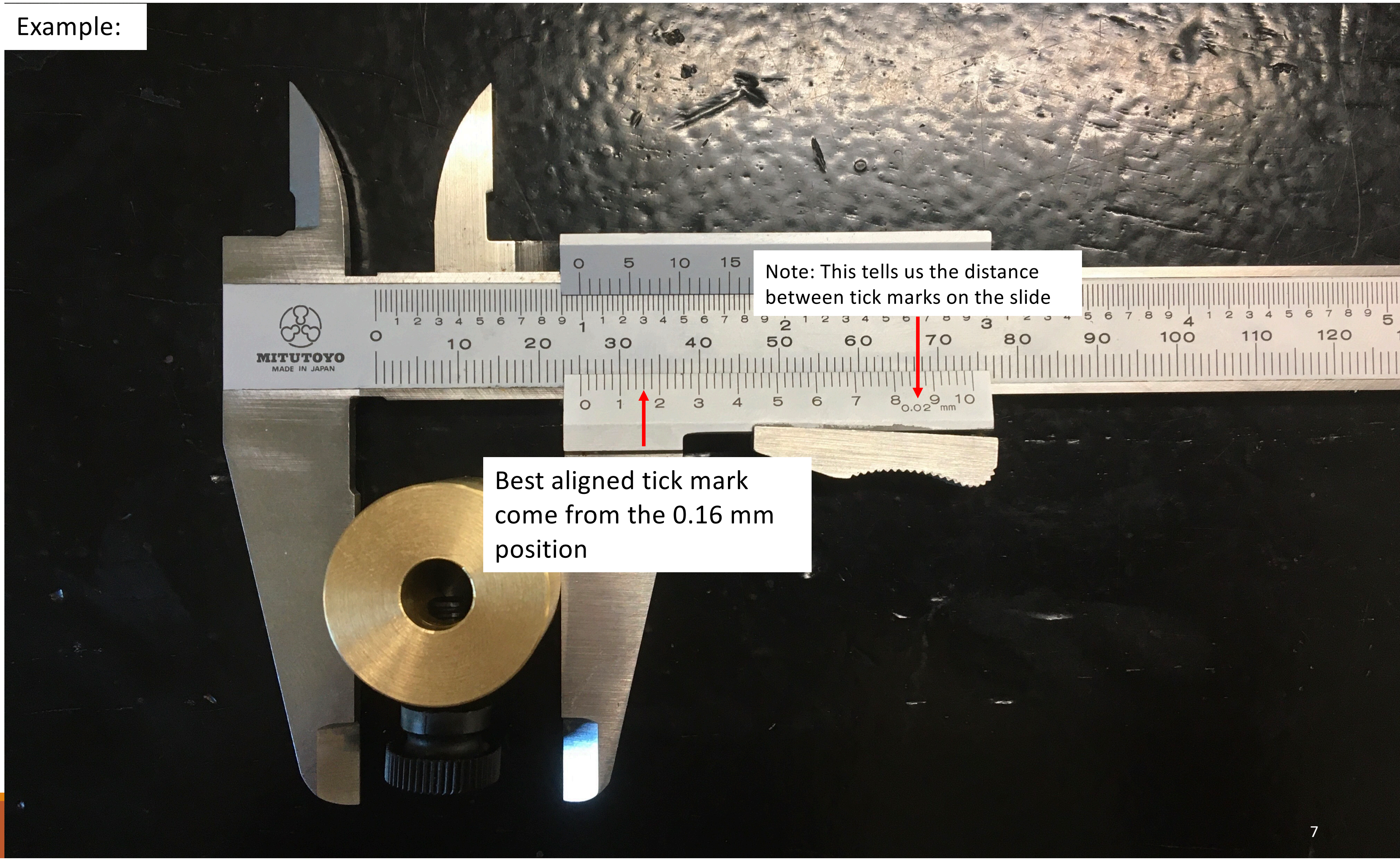
- After, find the tick marks on the slider which best aligns with the ticks on the ruler
  - This will give us the decimal corrections to our leading digit

Example:

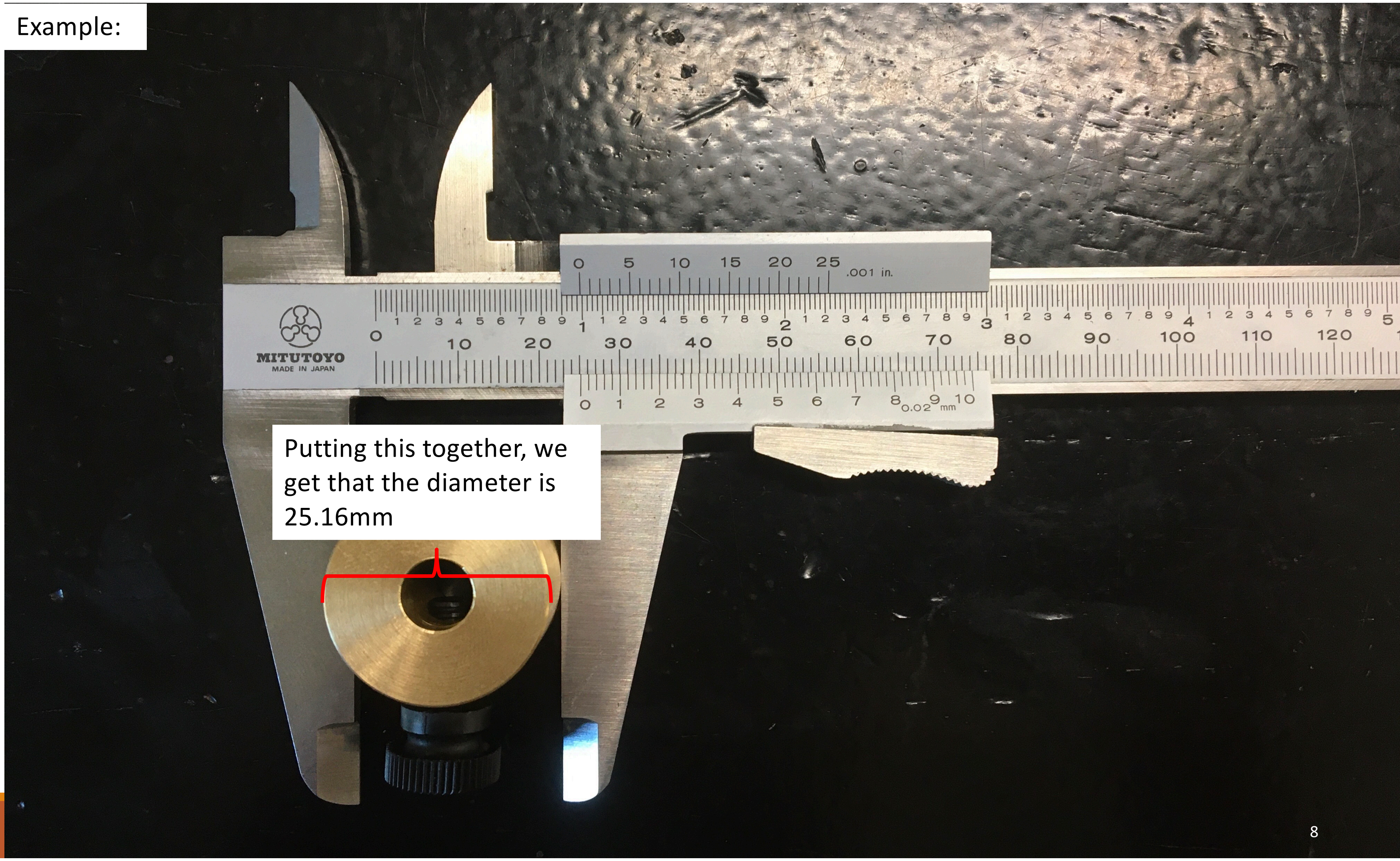



Position of the “0” lies just above the 25mm position, so rounding down, we get our leading digit to be 25 mm

Example:


Note: This tells us the distance between tick marks on the slide
Best aligned tick mark come from the 0.16 mm position
MITUTOYO
MADE IN JAPAN
0.02 mm

Example:




Putting this together, we get that the diameter is 25.16mm

# Part 1: Measuring the Radius

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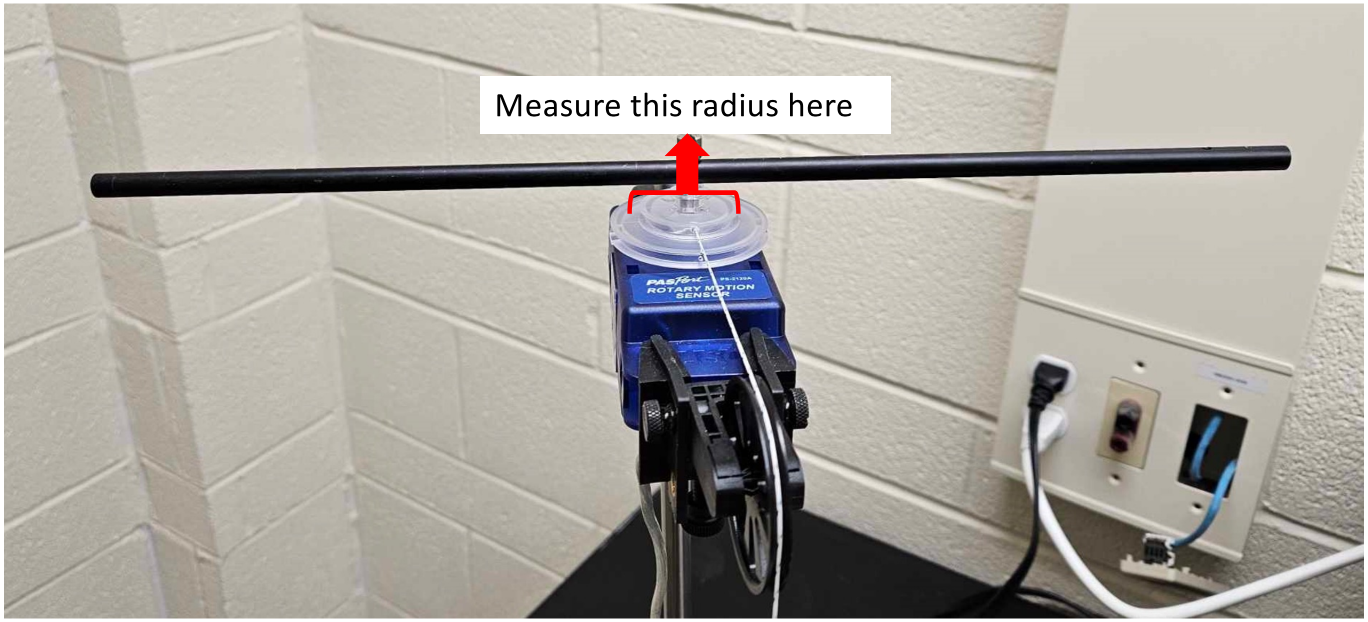
- Using the vernier caliper, measure the ***radius*** of the wheel which winds the string
  - Record this value in the lab report



# Part 2: Determining $\boldsymbol{I_0}$

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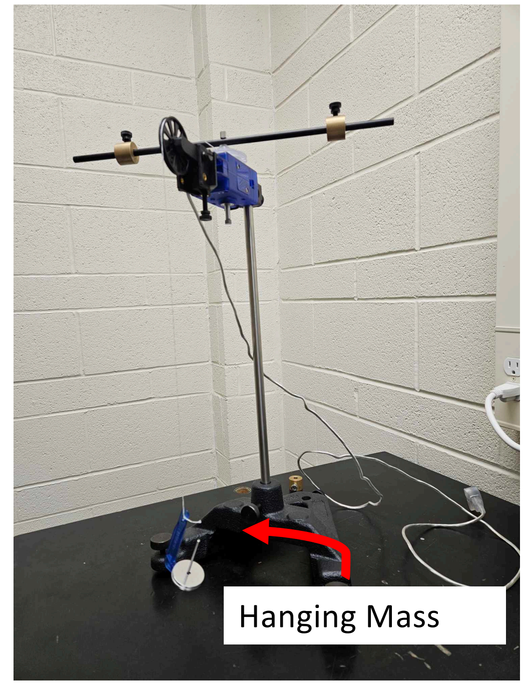
- Goal is to determine the moment of inertia of the cross-bars, $I_0$ (without any masses on them)

- To measure $I_0$ , we will be dropping the hanging mass and measuring the position, linear velocity, and angular velocity of the cross-bar

- Set up the PASCO software, with the proper configurations described in the report
  - This will give you three graphs of position, linear velocity, and angular velocity versus time

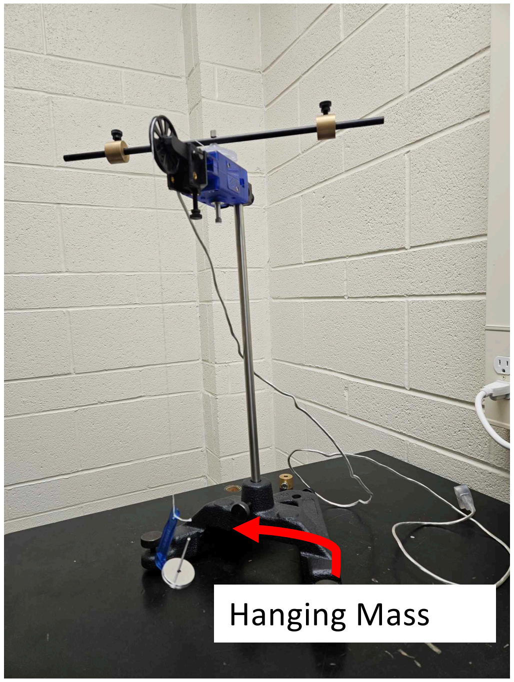


# Part 2: Determining $\boldsymbol{I_0}$

- ***Important:*** Make sure the hanging mass is dropped from the same height every time!
  - We recommend winding the cross-bar three times to do this

- Once everything is set up, press "***Record***" on PASCO, and drop the mass to collect the data

- Now we want to analyze the data!



# Part 2: Determining $I_0$

- Using your plot, determine the position where the hanging mass is released, then where it was at its lowest position
  - Hint: Consider what the sensor is really measuring, and how the motion of the hanging mass affects it
- Using the data, find the difference in time from when the mass was dropped, $t_0$, to when it reaches its lowest point $t_1$ (ie. Find $t_1 - t_0$)
- Find the position, linear/angular velocity at $t_1$ and record these values under the "*Part 2*" cell in Excel

***Note: Make sure you verify your results with a TA before continuing***

# Part 2: Determining $\boldsymbol{I_0}$

- Excel will compute $I_0$ (and its uncertainty) using two different ways

*Method 1:*

$$I_0 = Mr^2\left(\frac{gt^2}{2h} - 1\right)$$

*Method 2:*

$$I_0 = \frac{2M}{\omega^2}\left(gh - \frac{v^2}{2}\right)$$

(which do you think is more accurate in our case?)

- Do a sample calculation by hand and compare your results with Excel
- Re-run everything 5 more times (for a total of 6 measurements) and enter your results into Excel and the report

# Part 3: Determining $I_m$

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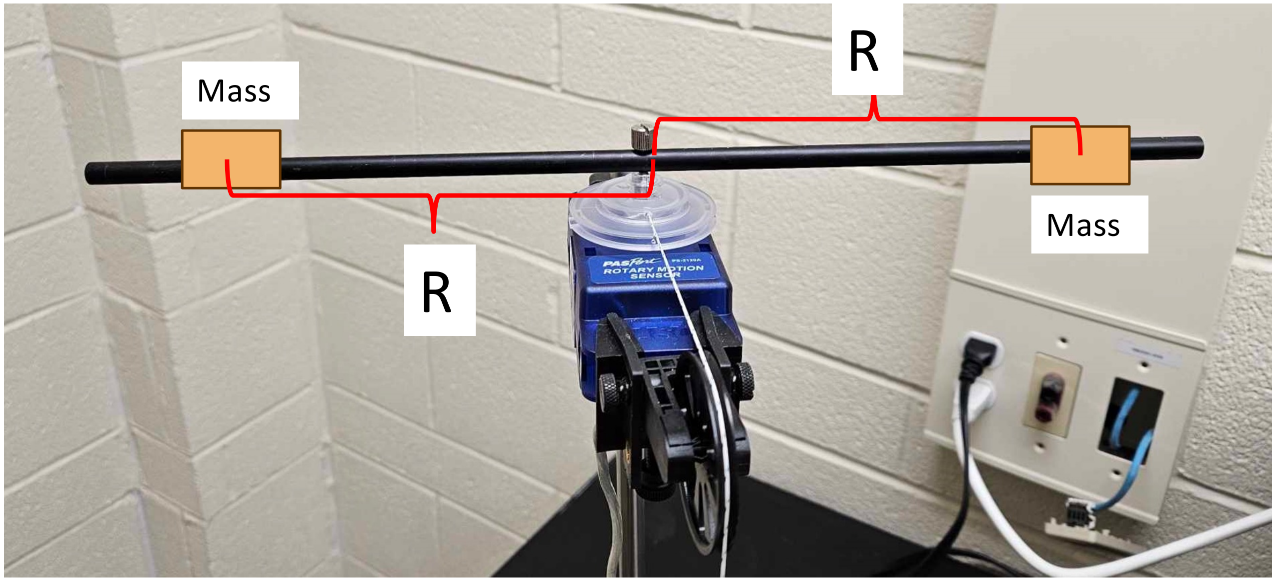
- Now want to measure the moment of inertia of cross-bar with masses on it, $I_m$
- Place our masses at a distance $R$ from the center shaft
  - You can pick what value of $R$ you want to start with



## Part 3: Determining $I_m$

- Repeat the steps from Part 2 by dropping the hanging mass and finding the position, linear/angular velocity, and time

- Repeat using five different values of $R$ along the cross-bar (for a total of six measurements)

- Record these values under the "*Part 3*" cell in Excel
  - Excel will also calculate $I_m$ for you in each of these runs

- Remember to copy all your data into your report after

# Part 4: Analyzing the Data

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- Using Part 3, we can see how well our data is described by theory
- Open the *"Part 4"* cell in Excel and create log($I_m$) versus log($R$) plot
  - The data from the Part 3 cell will automatically be transferred to this cell
- Include a line of best fit and record the relevant values in your report
- Repeat the above steps, but now for an $I_m$ versus $R$ plot

# Good Luck!