8.2: Activities

Things You Will Need

Nothing! All the data has been meticulously collected for you.

Finding Moment of Inertia Two Ways

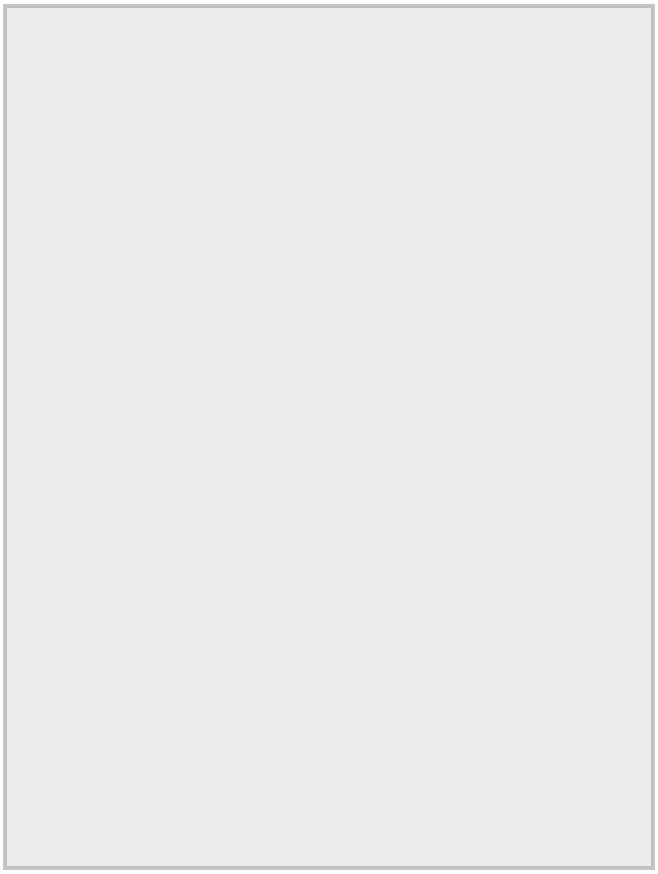
Once again we undertake to measure a physical quantities with two methods. In this case, it is moment of inertia of a thick circular ring, and we are doing it by direct measurement of its mass and dimensions, and also by analyzing it dynamically. As usual, you are expected to estimate uncertainties for each experiment, determine the "weakest link" percentage uncertainties for each experiment, and draw a conclusion at the end about whether the two experiments agree with each other to within the overall uncertainty.

The Data

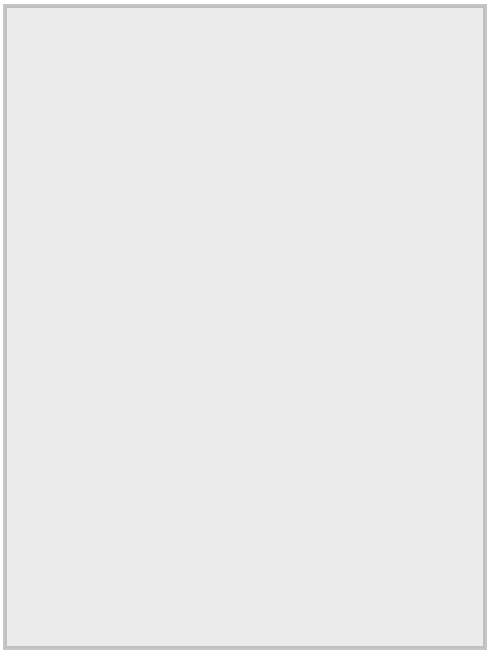
All of the measured values are given below, either explicitly, or in the form of pictures/videos.

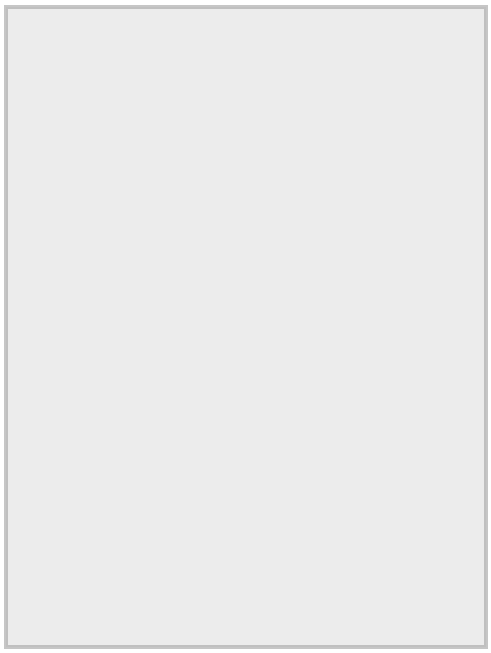
Direct Measurement

- **mass of the ring** – Read this quantity (in grams) directly from the scale.



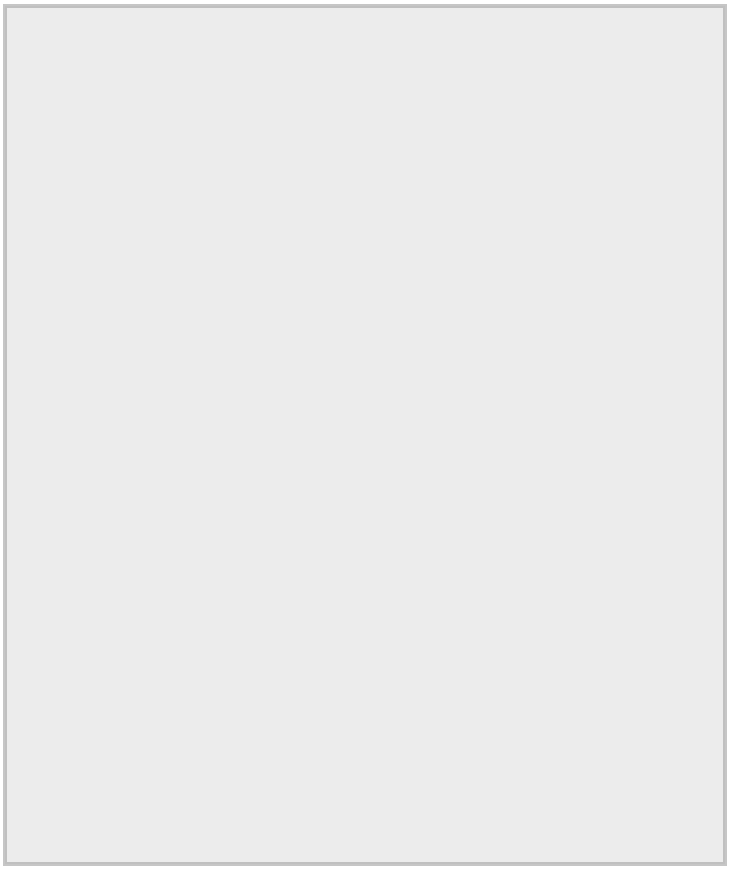
- **inner and outer diameters of the ring** – Note that the meter stick lies across the center of the ring such that one side of the measurement is aligned with the 30 cm hash. This allows us to not only measure the distance across the inside edges of the ring, but also the thickness of the ring, giving both the inner and outer diameters.





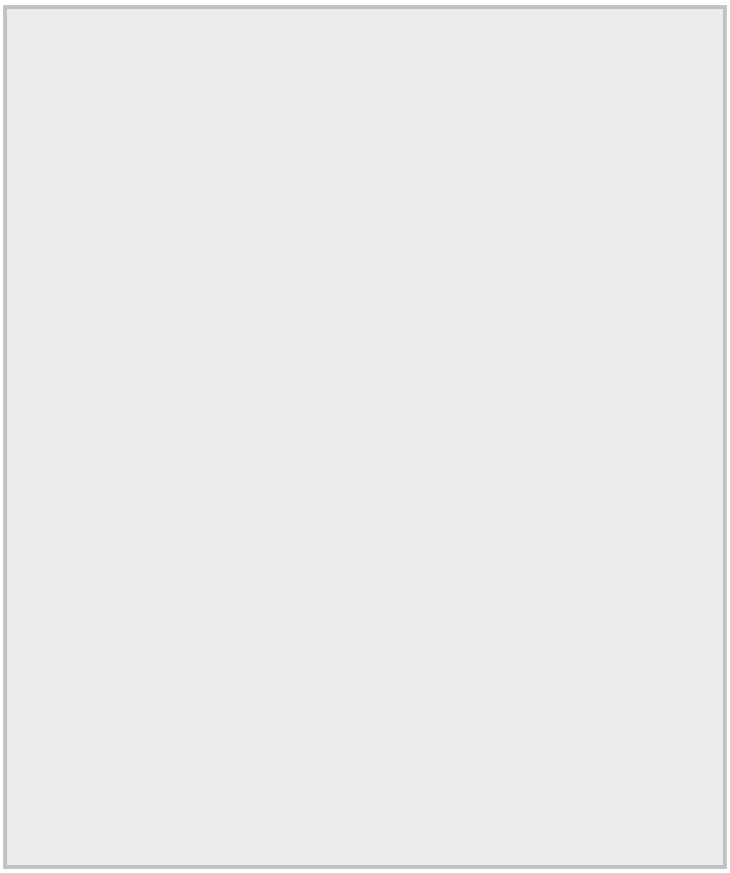
Experiment, part 1

- **mass hanging from string** – 205 grams
- **radius of the hub around which the string is wound** – 2.38 cm
- **the physical process** – The mass is released from rest, and the ring is in the cradle. The large number markings on the meter stick occur every 10 cm.



Experiment, part 2

- **mass hanging from string** – 55 grams
- **the physical process** – The mass is released from rest, and the cradle spins by itself, without the ring present.



Data Analysis and Additional Discussion

1. Direct Measurement – computing the moment of inertia from the mass and dimensions
   a. Use the data provided above to compute the moment of inertia of the ring.
   b. Compute an estimate for the percentage uncertainty of the moment of inertia.
      - The digital scale measures mass to the nearest gram.
      - While it isn't clear from the pictures provided, there is some difficulty in getting the locations of the edges of the ring, due to the effects of parallax on the thick meter stick. Moving the camera only slightly can give a reading that differs by as much as a couple millimeters. Correctly centering the meter stick is also difficult to do. These are considerations you can only truly judge by being present to do the measurements, so in absentia, you will have to be satisfied with **estimating the absolute uncertainty of the diameter to be 2 millimeters**.
      - With percentage uncertainties for both diameters, use the one that is the "weaker link."
      - Don't forget to include the effect of raising uncertain measurements to a power (see here for a reminder).
2. Experiment – testing the moment of inertia dynamically
   a. In the Background Material, we derived an expression for the moment of inertia in terms of the hanging mass, the radius of the hub, and the acceleration of the hanging mass. We have direct measurements of the first two of these quantities. Determine the acceleration from the data given for each of the two parts of the experiment.
   b. Compute the moment of inertia of the ring. Explain why the two parts of the experiment are needed.
   c. Compute an estimate for the "weakest link" percentage uncertainty of the moment of inertia. The hanging mass is certain to within about 2 grams (it would be lower, if not for the accumulation of hanging string as the weight descends). The radius of the hub is certain to within about 0.5 millimeters. Repeats of the experiment (which are not shown here) indicates that the time measurement appears to be accurate in both cases to within about 0.04 seconds (thanks to video recording). This uncertainty in the time measurement more-or-less takes into account the uncertainty in the starting and ending positions of the descending mass, so the distance the mass falls can be treated as exact.

3. Compare the result of the direct measurement to the experiment , and determine whether they are in agreement to within uncertainties.

Lab Report

Download, print, and complete this document, then upload your lab report to Canvas. [*If you don't have a printer, then two other options are to edit the pdf directly on a computer, or create a facsimile of the lab report format by hand.*]
