Team Physics 312 Names: ____
Short Mini-Lab 1B
Date: ___________ Table/Team: ________________________

Measuring π

Each group will hand in <u>one</u> report along with one <u>hand-drawn</u> graph at the end of class.

Materials/Equipment:

At least 5 disks, rings or other circular objects
Spiffy new digital calipers
Meter stick, rulers, etc, anything else you might need – just ask.

Objective:
Is the circumference of a circle really π multiplied by its diameter? Your team will experimentally answer this pressing question and measure the value of π.

(Ok, everybody knows what π is, but the real purpose here is to check some basic experimental techniques and review the handling of uncertainties).

Procedure:
1) Measure the diameters of your circular objects. If you use the digital calipers, zero them first. Use a process that will maximize the accuracy of your results. For example, you might have all team members measure each object and then use the average values for each diameter. <u>Summarize your process in one or two sentences:</u>
(Space for data tables on the other side of this sheet)

2) Measure the circumferences of the objects. One way might be to carefully roll the object along paper for one rotation, marking the end points on the paper, but students have come up with dozens of better ways, sometimes even surprising the TAs. As always, try to maximize the accuracy of your results. <u>Summarize your process in one or two sentences:</u>
(Space for data tables on the other side of this sheet)

3) Estimate and record the uncertainty of each diameter and each circumference. If you need a quick review of uncertainties, see lecture #2 of the online notes for Phys 311 at

people.rit.edu/gjtsps/courses/311-043Lecture/

4) Record your measurements, averages and uncertainties in tabular format on this page (or on another sheet of paper and attach it or a copy of it to this lab report). Each column heading should include the units of the numbers in that column. Remember that uncertainties have units, that uncertainties should have only one or two significant digits, and that a quantity should always be rounded off according to its uncertainty. <u>This is the main area where people tend to loose marks on labs.</u>

Data Tables:

5) Plot a graph of circumference versus diameter **<u>by hand</u>** on graph paper. [Terminology: *A versus B* means A is plotted on the vertical axis and B on the horizontal axis.] Label the axes with names and units, and give the graph a descriptive title. Data points should have uncertainty bars on them for both axes if they're large enough to show up on the graph. Staple the graph to this report.

6) With a clear ruler, draw a straight line that looks like a best fit to all the dots you plotted. Choose two widely-spaced points on the line that are *not* data points (you don't want to be biased here) and use them to calculate the slope of the line. Indicate those points on the graph. Show the details of the calculation here:

7) There was probably some shiftiness or uncertainty to your choice in (6), and you had to fiddle by eye with your choice for a few moments. Use this to determine the uncertainty in the slope by calculating the minimum and maximum slope you might have tolerated in your choice and using those to estimate a single ± bounds (1 sig. fig.) on your slope. Show the details of the calculation here (or on an attached page):

8) Compare the theoretical value of π to your measured value. Do they agree within the uncertainties you determined? If not, have you proven that millions of mathematicians are wrong, or have you, much more likely, underestimated some of the uncertainties in your measurement? (If they are not in agreement, check to make sure that you haven't made a mistake before rushing to publish, and possibly take a second look at your uncertainty estimates and experimental procedure).

Theoretical: 3.141592…

Experimental: ________________ ± __________________

Do they agree within the stated uncertainty? _____________

If they don't agree, that's technically ok, just state that's what your result was, but try to offer reasons about what could have happened to account for the discrepancy. And never use the term 'human error'. It is technically meaningless. Any mistakes should be traced back to their experimental origin and corrected.

9) The equation for a circumference, $C = \pi D$, is a *proportionality*. How can you recognize a proportionality by looking at its graph? [Is it a straight line, a curve, what should it look like?]

10) In the space below, write an **abstract** of this lab report. The word 'abstract' means a **concise** scientific paragraph or two that cuts to the core of a report in very few words, and you'll see them at the beginning of all real-life technical reports. Talk among your group about how to word it as concisely as possible. Start with a one-sentence overview of the whole thing. Then write a sentence about the mathematical or theoretical background. Describe in one or two sentences how you made the measurements and analyzed them. In one sentence, explain what caused the largest uncertainties. In another sentence, give your final result with its uncertainties. State whether or not your result agrees with the mathematical value of π within the uncertainties. If it does not, add another sentence explaining which uncertainties may have been underestimated, or possible suggestions about what might have gone wrong (this is also done in the real world).

Remember to be concise. Pretend this is like a classified ad where you're getting charged for every letter used. It should be one paragraph only and not even close to running off the end of this page.

(In a real report, this would go at the very beginning of the scientific paper, but we're just getting some practice here)

ABSTRACT: