<u>Lab #1 - UNC</u>

(*Updated August 2021*)

Worksheets etc.

There are two different worksheets for this lab, the UNC Worksheet and the Error Analysis and Propagation Worksheet.

It is better NOT to fill in the worksheets as you do the lab. The worksheets need not be turned in at the end of lab and you can complete them more carefully if you delay filling them in until later. All of your data (and analysis) needs to be entered into your notebook anyway. Although the carbon copy of your notebook must be handed in before you leave the lab, you will still have the original copy in your hands and can use it to complete the worksheet.

If you forgot to bring a notebook to lab, ask your TA for some carbonless pages from our spare notebooks. Do NOT use plain paper, even if you plan on making copies later. ***There will be a penalty for borrowing these pages after the first lab.***

Throughout the semester, you will routinely save on the L: drive of the lab server files containing your data and analysis. You can access these files later, from home or from the lab, to complete your work. We recommend that you copy these files to your personal computer as soon as possible. This protects you in case the server crashes at an inopportune time.

Part C.

Here is a picture of the pendulum you will use:

Here is a picture of some of the measuring instruments you will use:

It's often difficult at first learning how to read Vernier scales. There are many helpful tutorials on the web. If you need help, take a look at http://www.saburchill.com/physics/chapters/0095.html. Here is a cute JAVA applet available on the web that lets you practice making real time readings; however it uses a Vernier scale that is set up slightly different from the calipers you will use in lab: http://www.phy.ntnu.edu.tw/java/ruler/vernier.html

To use the stopwatch for single action timing, follow these directions (close-up of stopwatch shows which button is which is below):

1. Press the MODE button until you re in the stopwatch mode. (The stopwatch mode is indicated by flashing bars.)

2. Press the LAP/RESET button to clear the display to zero.

3. The first press of the START/STOP button starts the stopwatch timing. (This is indicated by the blinking colon.)

4. The second press of the START/STOP button stops the stopwatch timing. (This is indicated by the non-blinking colon.)

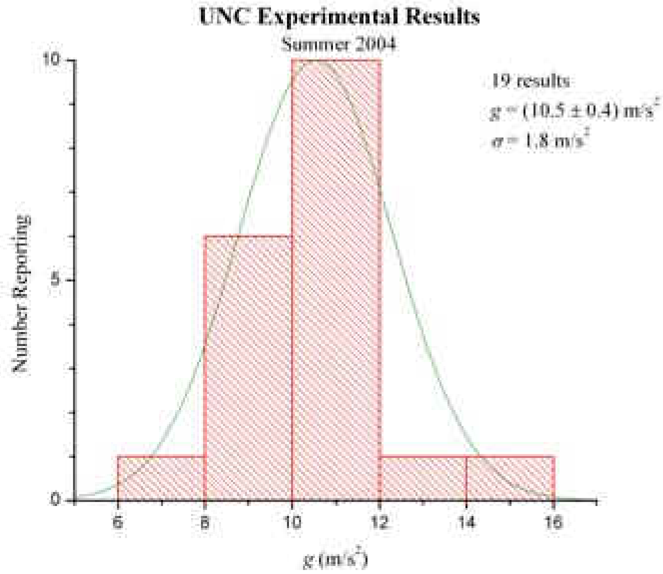
5. After recording the time, press the LAP/RESET button to clear the display to zero. RESET will only clear the display to zero after stopping the stopwatch.

In the basic instructions, the manufacturer claims these stopwatches have an accuracy of 6/1000 of a second at 25º C. Is this a meaningful statement? The manufacturer also calibrated the stopwatches in compliance with ISO 17025. For example, the stopwatch with serial number 230039220 was calibrated on May 30, 2003 with a measured error of +7.367 seconds per 24 hours. Is this a meaningful statement? Is the accuracy of the stopwatch a significant contribution to the uncertainty of your measurements with this device? You should consider how quickly humans (who will be starting and stopping the stopwatch) can react to stimuli.

If it is easier for you, use the stopwatch on your phone.

Statistical Analysis

Below is a histogram of the results for the acceleration due to gravity, *g*, from an older course, plotted together with a Gaussian (or "*normal,*" or "*bell-curve*") distribution. The best estimate for *g* from this combined data is $g = 10.5$ +/- 0.4 m/s^2. The standard deviation of these results is $\sigma = 1.8\ m/s^2$; this result says how much a given group's result typically varies from the average value (and indicates what the uncertainty is on a given group's answer). About two thirds of the students in the class should have obtained a value of *g* within one standard deviation of 10.5 m/s^2. The standard error of our results (or "standard deviation of the mean") is only $\delta = 0.4\ m/s^2$. By averaging the results of 19 groups, we learn the value of *g* (as measured by this experiment) much better (uncertainty is only 0.4 m/s^2) than if we took only one group's result (for which the uncertainty is over 4 times larger). This averaging makes the *statistical* uncertainty of our result very small ($\delta = \sigma$/sqrt(N)).



The discrepancy between the best measured result (g = 10.5 +/- 0.4 m/s^2) and the accepted value (g = 9.81 +/- 0.02 m/s^2) means either gravity has strengthened on the 4th floor of Rockefeller since October 21, 2003, the accepted value is wrong, or there were *systematic* errors in the experiment (such as consistently measuring the length of the pendulum as longer than it really is). Minimizing and estimating the sizes of such systematic errors is a key to successful physics experiments at all levels. One must also note that this average value is about two standard deviations from the accepted value. There is a 10% chance that *random* errors could account for the discrepancy.