# PHY 122 LAB 1: Single-value measurements

## Introduction:

In this lab, we look at random errors in single-value measurements. We will use a photogate detector to measure the time that a light beam is blocked off due to passage of an opaque object (your finger, in this case). Such instruments can be used for velocity measurements, as in baseball batting cages. We aim to quantify and understand: mean and standard deviation and histogram.

## Equipment Notes:

Be careful not to bash the photogate detector as you whiz your beefy digits through the gap. You should gently press the base against the tabletop with your other hand, and watch your moving fingers (not the computer screen).

## Procedure:

1) Open the program Graphical Analysis. It will be used later. Now open the template file "PSCF Courses\ PHY122 \ phy122Lab1.sws". This should start the Science Workshop (SW) program with preset parameters for data acquisition. Each lab partner will do all of the following steps.
2) Measure the width of your index finger (sideways – the wide way) using the Vernier calipers. Measure where you think the light beam will hit it. An error bracket can be established by multiple independent readings over the taper of your finger.
3) Start run#1 by pressing "run". This is essentially a practice run. The computer is waiting, and will record the length of time that the beam is interrupted. Each separate interruption is a new data point in the "run", which continues until you hit "stop". You can over-write the previous run#, if desired, however, we want to save each good run. Your run numbers may differ, depending on practice runs, so note the run numbers (and filename) carefully in your notebook. Zip your index finger through the beam a few times, and see that the time interval is tabulated automatically. Next, zip your entire hand a *single time* through the beam with fingers spread open. You should get 4 separate data points. Practice as much as you like/need.
4) Start run#2 (real data). Wave your opened hand steadily back and forth through the beam 25 times to get 100 data points. The pace should be about 1 complete over/back cycle per second. Stop the run. Save the data file (all runs are included). Copy/paste run#2 into Graphical Analysis and make a histogram (see below) to see that your data look reasonable. Copy this data (the GA file) to floppy, then let the next lab partner measure.
5) Get as far as you can in class with the analysis.

## Analysis:

Analysis is best done using the Graphical Analysis (GA) program. We only need data for run#2. You can copy/paste data from SW into GA. Both are available outside class at any campus computing site. See notes on website. Open both GA and your SW data file. You

can copy 1 run at a time from SW (select Run# in the data table, DATA button, drop-menu for RUN#), select whole column by click at top, then EDIT/COPY. Open GA program, click in table, EDIT/PASTE. Assign names, etc as appropriate.

1) From the calipers data, find the mean and SDM for the width of your index finger.
2) Compute the velocity of your hand for the first time your index finger passed the beam. (Which data point is this?). Include an error bar, assuming the time interval has zero error. Hint: $\Delta v/v = \Delta w/w$, where "$w \pm \Delta w$" is the width of your finger.
3) Based on the first pass of your hand (first 4 data points), find the mean width and SD for your 4 fingers, again assuming a constant velocity. Note this is the SD, not SDM this time. Why is this?
4) Working in GA, select run#2, entire column. Turn on statistics by: DATA \ STATISTICS. Then make a histogram by select column \ GRAPH | NEW HISTOGRAM. You may need to set the graph attributes, especially bin size, by 2-click the graph. You should choose bin size to get a nice looking histogram, with about 5 counts in the peak. Find the mean and standard deviation and standard deviation of the mean for this run. The first two are output by the program, the last must be calculated by you. Print the histogram and mark these values on the plot, showing how the SD and SDM intervals bracket the data. Hand markings are fine.
5) Is the majority of spread in the histogram of times due to variation in velocity or finger width? Explain.
6) Did you get tired (ie slow down) during the run? This can be determined by comparing the mean time for the first half of the run with that for the second half. Are these numbers *experimentally* different? In GA, you need to copy the appropriate half and paste into a new column (manual). Do this by drag through the desired data points in the table, then EDIT/COPY, then DATA/NEW COLUMN (Manual) – label "first half" – then EDIT\PASTE. Then look at statistics for each half separately. Histograms are not necessary.
7) Find the number of events within $\pm 1\sigma$ of the mean, and also the number of events within $\pm 2\sigma$ of the mean. This is facilitated by first sorting your data – (careful that you do part 4 above before sorting!): select the entire column then DATA \ SORT. Do you find the appropriate number of events for a Gaussian distribution? (see error analysis handout).

## Report:

Your abstract should consisely state what you did, how you did it and your main results (just for parts 3-6, this time).
Do not attach the table of raw data – the information is contained in the histogram.
To help you with your first report, we include an explicit listing of scoring points, as used last semester. This may vary somewhat between TAs. Each item below is worth 2 points:
Formatting (10 points)

1) Abstract
2) Significant Figures
3) Units
4) Format of errors

5) Charts, tables.

Content (10 points)
Mostly answers to specific questions in the handout.
Quality of data and narrative.

Prelab Quiz PHY122 Lab1

Name_____ Section Time/day_____

1) State the number of significant figures in each of the following numbers:
   a) 23.60
   b) 0.0378
   c) 4500
   d) 3.2600
2) Perform the indicated operations to the correct number of significant figures using the rules for significant figures.
   a) 23.12 * 3.27
   b) 54 / 2.39
   c) (3.45 + 1.2) + 39.27
3) Calculate $\mu$, $\sigma$ and $\sigma_m$ (mean, standard deviation, standard deviation of the mean) for the following set of data using a hand calculator or spreadsheet, but not a canned macro for STDEV(). Show your work. Data: (7,7,8,6,5,6,8,6,7,5,6,8).