

Pendulum for Pros (1/6/2017) (1 or 2 Lab Periods)

Learning Goals

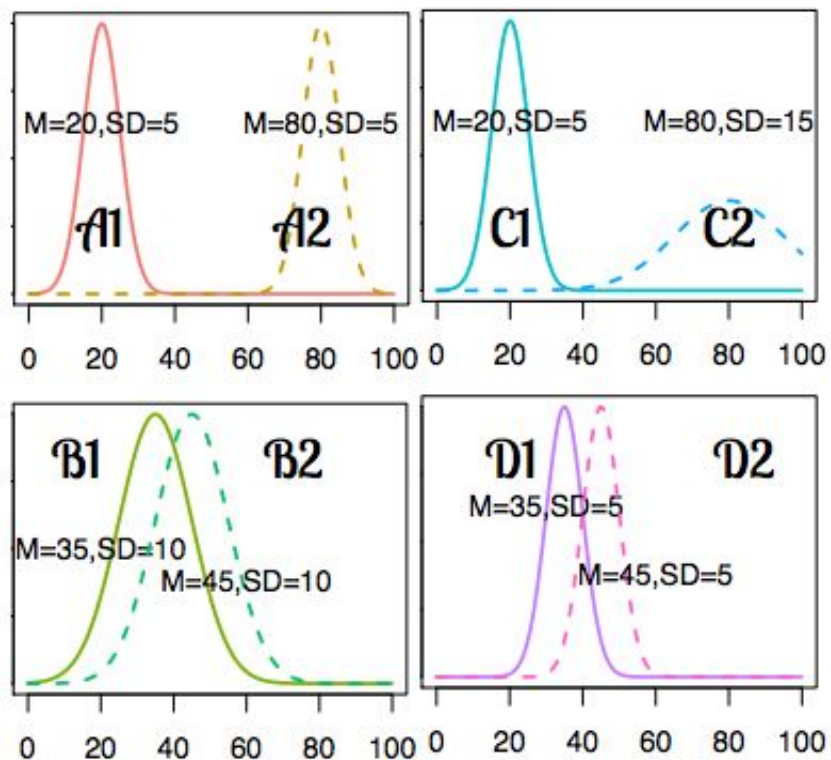
- Use mean, standard deviation, and t '-statistics when comparing data.
- Improve measurements to gain higher precision.
- Build scatter plots using PASCO Capstone software

Provided Equipment

Rod/Pendulum Clamp
String/Massive Plumbob
Stopwatch/Protractor/Motion Sensor
Capstone Data Collection Software

Activity 1: Making Comparisons

In each of the following pairs, write down how confident you are that the measurements are distinguishable (different).



Invent an equation that quantifies your confidence in how distinguishable the two measurements are. The invention should be consistent across cases, so a value in one case can be compared to another.

After a discussion with other classmates, reflect on it and write down what you learned.

Activity II: Period of a Pendulum

Construct a long pendulum, around 1.5 meters in length, with a massive (heavy) plumbob.

Part I

The goal of the experiment is to see if the period of a pendulum depends on the amplitude of the swing. First, write down a plan for a high-precision measurement of the period at both 10 and 20 degrees.

Part II

Based on your result above, write a plan for improving the quality of your measurements. Discuss this plan with every group in the lab, and collect/analyze additional measurements.

Part III

Keep repeating the cycle of comparing and improving, until you are confident that you understand whether or not there is amplitude-dependence in the period.

Activity III

Part A: What is the period dependence on the initial angle?

You need to achieve at least 0.1% precision. Example: If the mean is 100, your values should fall between 99.9 and 100.1 or 0.1% of the mean.

The goal is to take a detailed look at the angle-dependence of the pendulum period. Make high precision measurements 5, 15, and 25 degrees. Produce a histogram and draw a conclusion about the angle dependence. Repeat or improve measurements as necessary and try other angles. Add these to your histogram and write a conclusion. Your conclusion should be based on empirical evidence!

Part B: t' scores

T' statistics are used to determine if there is a difference between two sets of numbers. The results of t' statistics allow for the determination that the probability of data sets are statistically significant. In other words, the t' test is a statistic that determines if two means (averages) are reliably different from each other.

$$t' = \frac{A - B}{\sqrt{\delta_A^2 + \delta_B^2}},$$

T' statistics can be calculated by applying the above equation. A and B represent the mean for each data set and δ_A and δ_B represent the standard deviations for each data set. The means and standard deviations can be calculated using spreadsheets, calculators, or other tools.

Data interpretation:

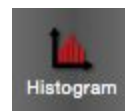
t' score	Interpretation of Measurements	Follow-up investigation
$t' < 1$	Unlikely different, uncertainty may be overestimated	Improve measurements, reduce uncertainty/increase precision
$1 < t' < 3$	Unclear whether different	Improve measurements, reduce uncertainty/increase precision
$3 < t'$	Likely different	Improve measurements, correct systematic errors, evaluate model limitations

Part C: Building Scatter plots with PASCO Capstone

a) Launch Capstone



b) Drag Data Table from the right “displays” column and drop in the workspace.



c) Drag Histogram from the right “displays” column and drop in the workspace.

d) Enter your data for the period(s) of the pendulum at a specific angle in the column.

e) Click “Set”

f) Click “Create New User-Entered Data Set”

g) Enter your data for the period(s) of the pendulum at another angle.

h) Click “Set”

i) Click “Create New User-Entered Data Set”

j) Enter additional data for period(s) of the pendulum as needed.

k) On the histogram graph, click “Select Measurement”

i) Choose any data set.

j) Multiple data sets can be displayed on the graph by clicking on the multi-colored icons
“Activate to view multiple runs; Select visible run(s).



Select data all data sets by checking all runs.

k) Increase or decrease the number of bins as needed to better resolve similarities or differences

in data.



In comparing your data sets, write down how confident you are whether they are similar or distinguishable.