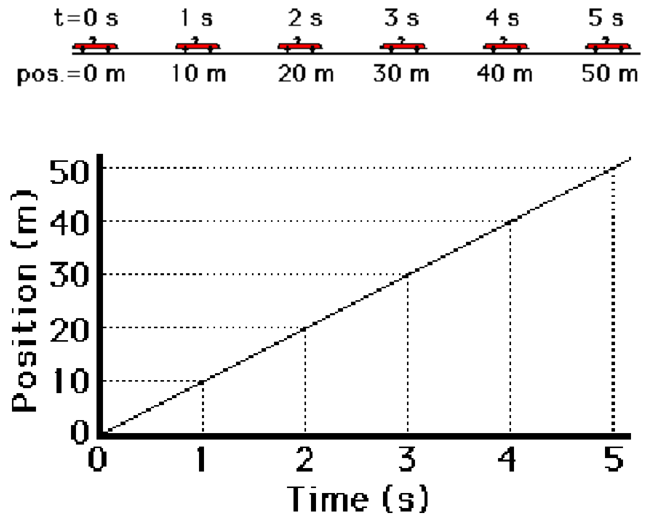
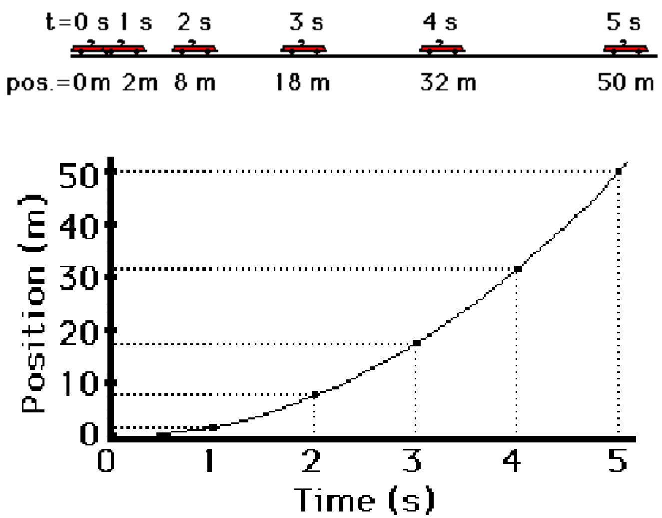
PHYS 275 – Experiment 4
Position, Velocity, and Acceleration

Experiment Summary

- Today we will study the motion of a mass on a tilted air track
  - The physics is very simple: one dimensional motion, gravitational force acts on the mass
- We will focus on understanding experimental uncertainties
  - Learn how to recognize random and systematic uncertainties
  - Understand the difference between accuracy and precision

Quick Review of 1-D Motion





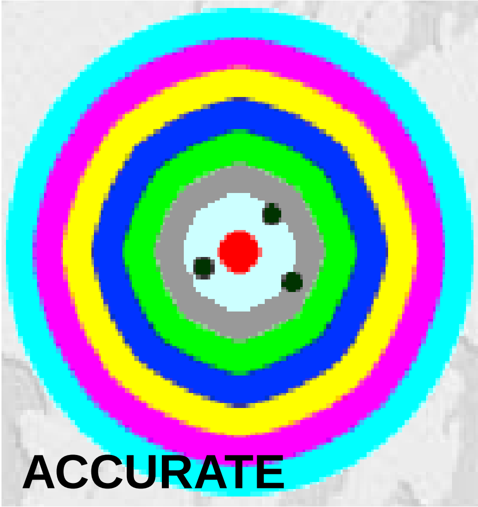
- No forces
  - $x = x_0 + v_0(t - t_0)$
- Constant force
  - $F = ma$
    - On our tilted air-track: $F = mg\sin\theta$
  - $x = x_0 + v_0(t - t_0) + \frac{1}{2}a(t - t_0)^2$

Classification of Uncertainties

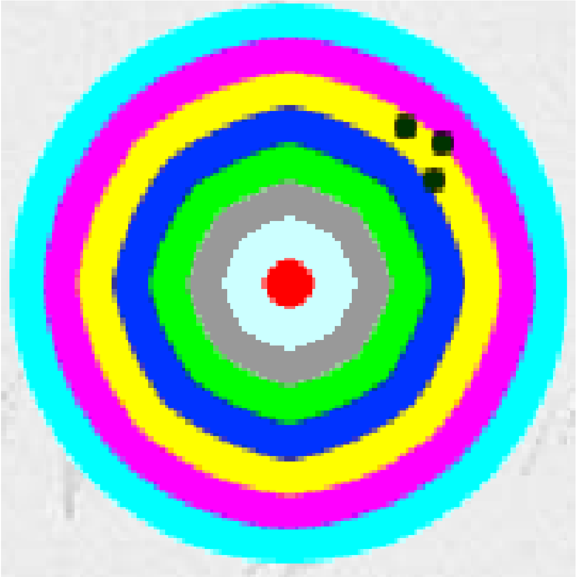
- Systematic uncertainty
  - Systematic uncertainties tend to shift all measurements in a systematic way so their mean value is displaced
  - Possible reasons: ill calibration of equipment; consistently improper use of equipment; failure to properly account for some effects; or other external effects
    - E.g.: imagine using a metal bar for length measurements; if the temperature is larger than the temperature at which the bar was calibrated, all your measurements are systematically shifted to a smaller value
- Random uncertainty
  - Random uncertainties fluctuate from one measurement to the next; measurements are displaced in an arbitrary direction
  - Possible reasons: lack of sensitivity; noise; statistic processes such as the roll of dice;…
    - E.g.: when I use again my metal bar, and stare at it from the top, sometimes my eye sees the edge to the left of a tick mark, and sometimes to the right

Precision vs. Accuracy (1)

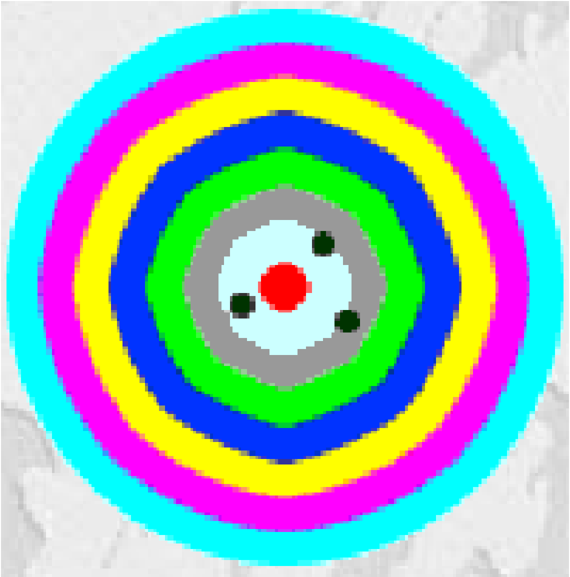
- We do not know the "true" value of a quantity, and our measurements give us an estimate
  - Precise measurements are close to each other
  - Accurate measurements are close to the true value
- Precision
  - The degree of refinement in the performance of an operation, or the degree of perfection in the instruments and methods used to obtain a result
  - This is an indication of the uniformity or reproducibility of a result. In other words, the precision is just the standard deviation in the measurements.
- Accuracy
  - The degree of conformity with a standard (the "truth")
  - Accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result is obtained



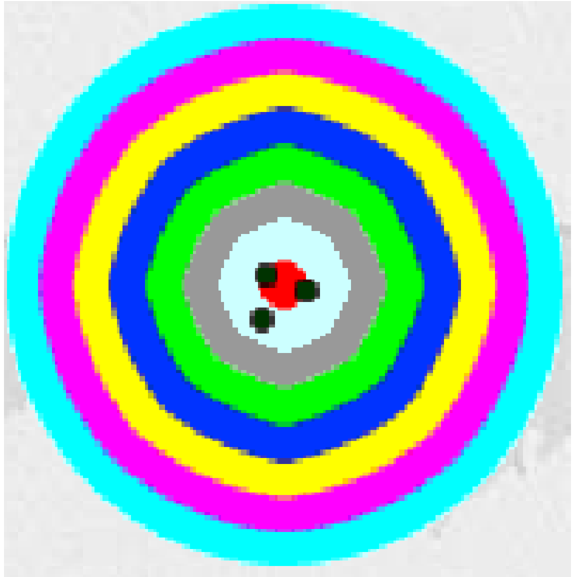
Precision vs. Accuracy (2)



Good precision, poor accuracy



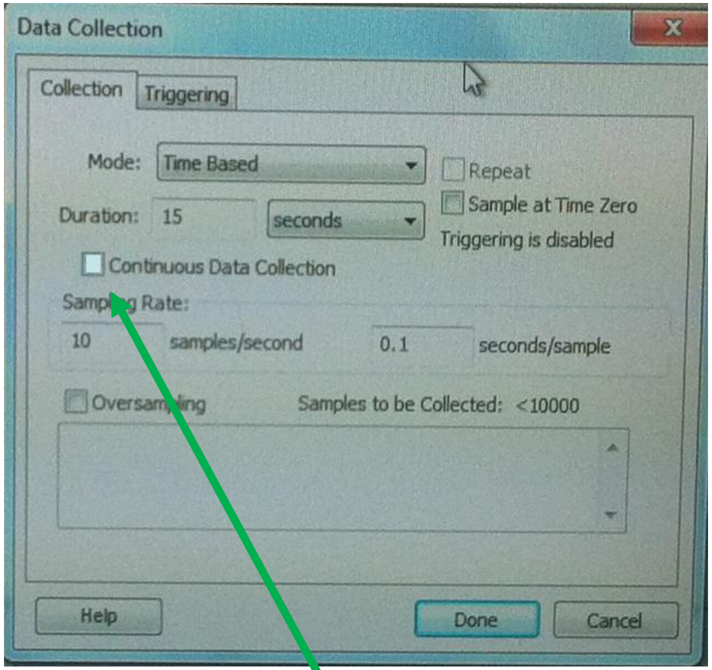
Good accuracy, poor precision



Good accuracy and good precision

Suggestions (1)

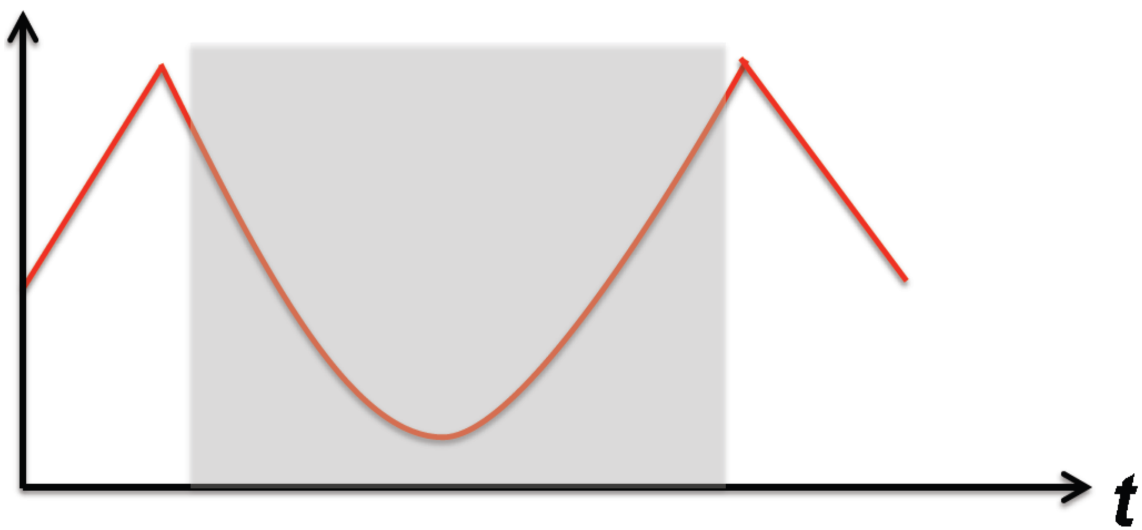
- Page 36: Equipment
  - The SonicRanger does not work well with objects closer than ~0.5m: do not use data in that range
  - The SR detects its closest object: careful with swinging arms or obstacles on its way
  - The deflector is (supposedly) well aligned, but you may need to move it a bit if the data do not look satisfactory. If there is a problem with alignment, no worries: it will be really clear from your data. Ask instructors for help!



Make sure the "Continuous Data Collection" option is disabled

Suggestions (2)

- Page 38: Calibration
  - Turn the air supply off, and make sure not to drag the glider along the air track to avoid scratching it
  - Use the front edge of glider for reading and alignment
- Page 37: Data collection
  - Start collecting data when the cart approaches the end of the air track



Suggestions (3)

- Page 41: Using Solver
  - Available under the Data submenu
  - Make sure to indicate that it has to minimize χ^2: by default it will try to maximize it!
  - It is crucial that Solver is provided a good estimate of the initial parameters. Plot your measurements and theory in the same scatter plot to see how Solver gets the minimal χ^2

Notes and Reminders

- Crucial note!
  - Part I: the manual suggests to do one among the three options; we ask you to do Option #1 and one between Options #2 and #3
- Important reminders
  - Submit your Excel spreadsheet on ELMS and turn in your check sheet before leaving the lab
  - Complete the final version of your report by 1pm next week
  - Finish the homework set in Expert-TA by 2pm next week
  - Save your data on the local disk frequently!