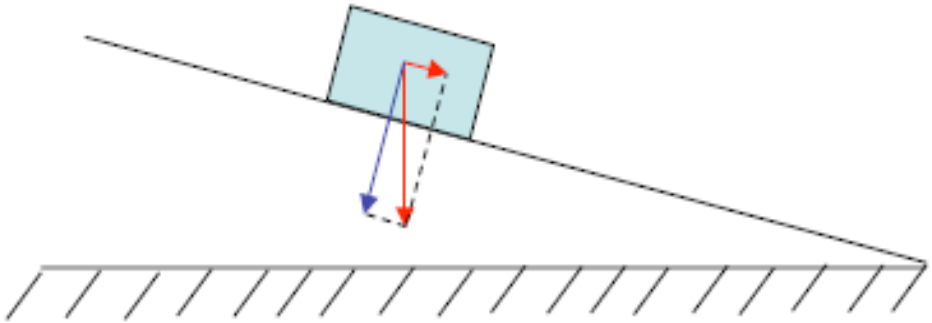
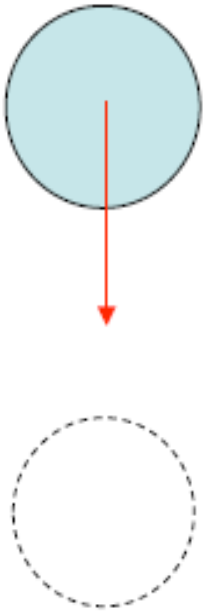
PHYS 275 – Experiment 5
Free Fall of a Mass

Experiment Summary

- Today we will study the motion of a free-falling mass
  - The physics is very simple: one dimensional motion, gravitational force acts on the mass
    - Very similar to last week's experiment
- We will focus on understanding experimental uncertainties
  - Today's focus is on error propagation: learn to identify the dominant uncertainty
    - Important lesson: you want to spend your time improving the part of your experiment that has the largest impact on the precision and accuracy of your results

Air-Track vs. Free-Fall





- Last week:
  - $\mathrm{F} = mg\sin\theta$
  - $x = x_0 + v_0(t - t_0) + \frac{1}{2}g\sin\theta\,(t - t_0)^2$
- This week:
  - $\mathrm{F} = mg$
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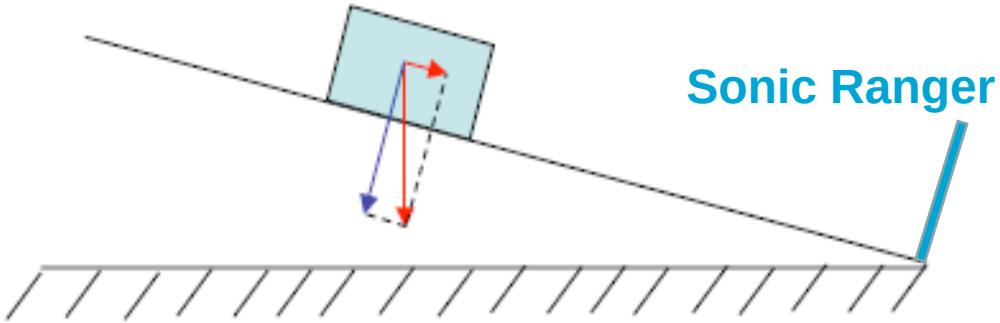
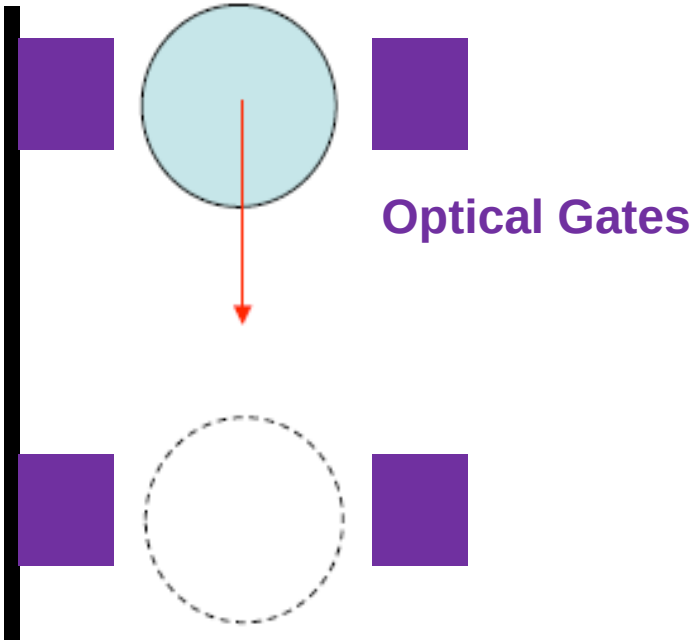
Air-Track vs. Free-Fall





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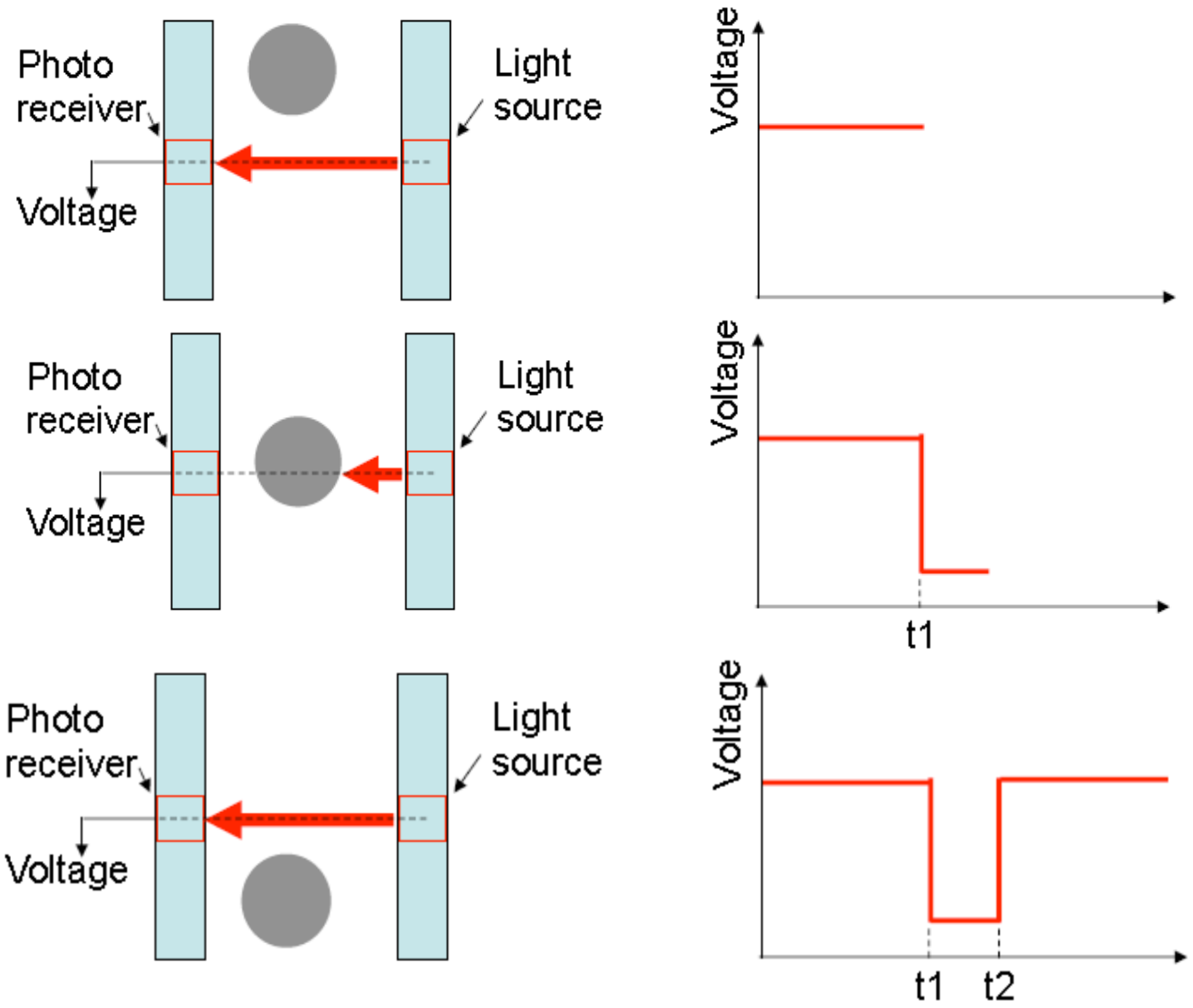
Today's Lesson

- Propagation of uncertainties:
  - Let the quantity Z be a function of A and B: Z=F(A,B)
  - Then: $\delta Z = \sqrt{\left(\frac{\partial F}{\partial A}\right)^2 (\delta A)^2 + \left(\frac{\partial F}{\partial B}\right)^2 (\delta B)^2}$
- χ^2 tests
  - How to determine degrees of freedom
  - Calculate normalized χ^2
  - Calculate Prob(χ^2,ν)

Suggestions

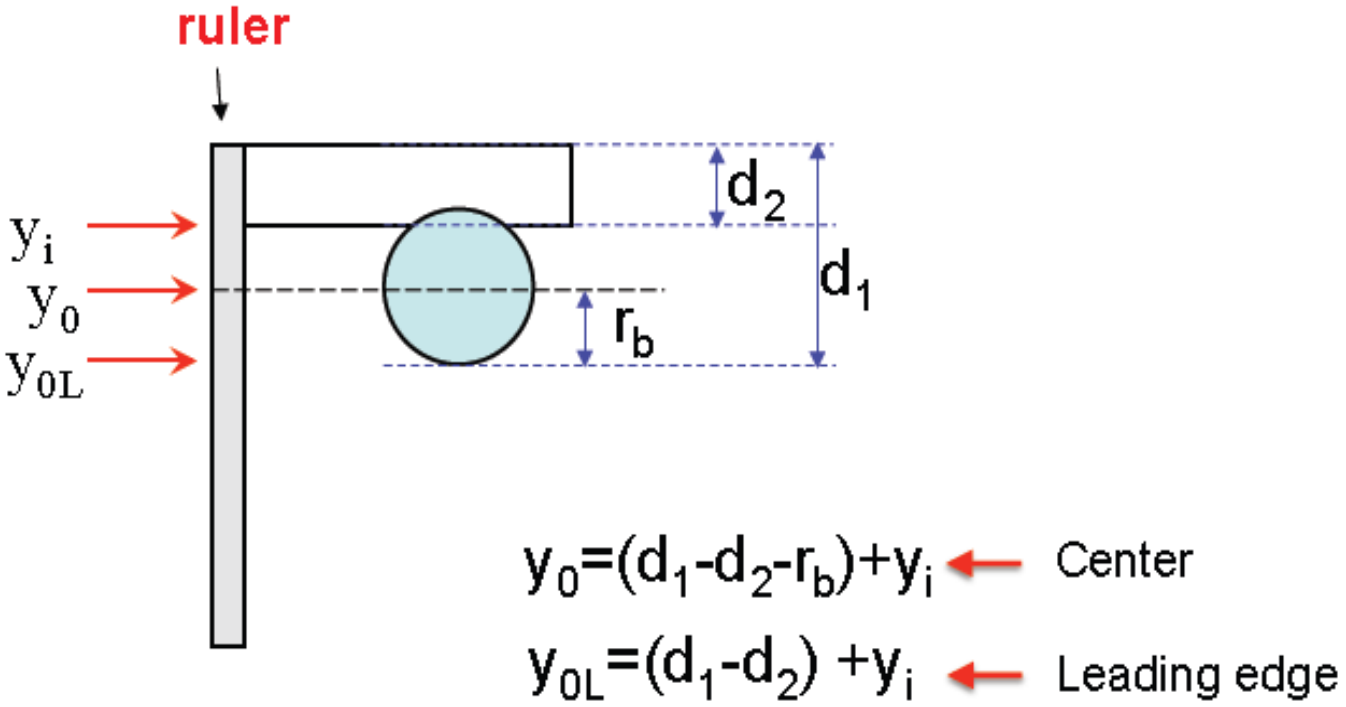
- Get familiar with equipment
  - Support stand with electromagnet
    - Take a careful look at how the ball is positioned: you want it to be set properly, not holding by an edge…
    - Also check that the stand is level, using the bubble level
  - Electromagnet controller
  - Optical gates
    - Can assume that the gate is half-way through the transparent plastic holder
  - In LoggerPro Experiments folder: Free Fall

Measurement Schema



More Suggestions

- Careful with caliper (edges are pointy)
  - Make sure, when combining measurements, to propagate uncertainties



Yet More Suggestions

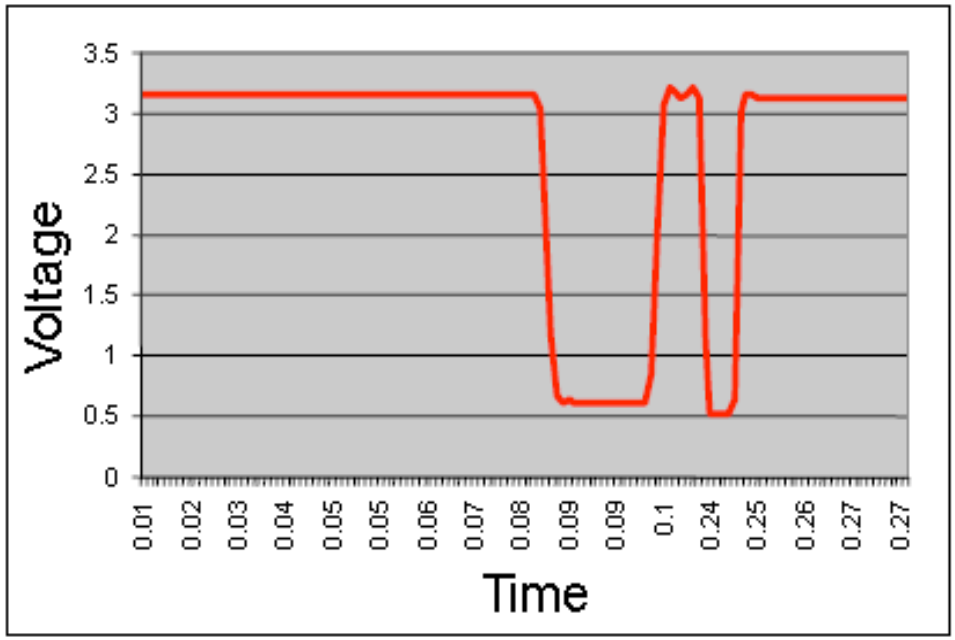
- LoggerPro: when you click on “collect”, wait until the “stop” icon appears, before releasing the ball
  - A trigger signal generated by the control box will get LoggerPro to start taking data
- Caliper usage: make sure it is zero-ed correctly
  - And be careful handling it: it is delicate!
- Units and significant digits
  - You will be using different tools with different precision; make sure to write your results with the correct units, uncertainties, and significant digits
- Improving your measurements
  - When multiple tools are available, learn to choose the best one
  - Repeat measurements N times and take their average to improve the measurement precision

Technical Suggestions (1)

- Page 46, sketch of magnetic mount
  - You can either use the sketch pad, and draw directly on the Excel spreadsheet, or draw on the back of the checksheet and turn it in (in this case, also take a picture of the sketch and keep a copy for yourself)
- Page 49, Part B
  - You need to move only the second gate, but make sure to record position and crossing time of both gates A and B: you will need this for part C
  - When moving gate B, try to use the whole range of the support stand to improve your measurement
- Page 49, Part C
  - ParaFit allows you to force parameters to 0: think about which parameter(s) you could fix

Technical Suggestions (2)

- Typical data appears as follows:



  - Note the difference between the first and second pulses: what is it due to? Which part of those pulses do we care about (i.e., which part corresponds to the leading edge of the ball crossing the gate?

Notes and Reminders

- 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!