Advanced and Intermediate Physics Lab

Andrei Gritsan

Johns Hopkins University

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Goal of the Course

- Learn scientific research
  - through exposure to a number of prominent experiments
  - that set the stage for our understanding of modern physics
- learn theoretical background and history of experimental discoveries;
- obtain hands-on experience in performing physics experiments;
- improve data-analysis skills and learn analysis techniques;
- work on presentation and communication skills (written and oral);
- learn software programs for data acquisition, data handling, publication, and presentation.

Reading material

- No required textbooks
  - extensive reading material **BEFORE** each lab !!!
  - will find on course web page:

    http://www.pha.jhu.edu/∼gritsan/2010.173.308/

- Useful reference on error treatment and data analysis:

Philip Bevington and Keith Robinson,
"Data Reduction and Error Analysis for the Physical Sciences,"
ISBN 0-07-247227-8.

- More references on software
  - Latex
  - Root or other analysis packages
  - Openoffice, Powerpoint, etcı

What you are required to do

- eight (8) experiments
  required to be performed by each student;
- lab reports for five (5) experiments
  required to be written to be graded;
- first three (3) lab reports
  reviewed for the "W" requirement;
- one (1) lab experiment
  presented orally.

Experiments

1. Muon lifetime;
2. Photo-electric effect;
3. Pulsed NMR;
4. Franck-Hertz experiment;
5. Nuclear spectroscopy;
6. Rutherford scattering;
7. Brownian motion;
8. Hall effect;
9. Zeeman effect (not in operation today) ;
10. Millikan oil drop experiment (not in operation today).

What you have to do THIS week

- get an overview of the lab course;
- obtain card access to the lab and computer accounts;
- get organized into the teams and understand the schedule;
- read material for the first lab to be performed on the following week;
- make data analysis example and paper templates work
  (to make sure your computer setup is ready)
  to be found on the course web page

Tentative Class Schedule

	Date	Events
1	Jan.25	Introduction lecture
2	Feb.1	LAB1, lecture
3	Feb.8	LAB2, lecture
4	Feb.15	extra time for LAB1 and LAB2
5	Feb.22	LAB3, 1st report due
6	Mar.1	LAB4
7	Mar.8	LAB5, 2nd report due
8	Mar.15	Spring break, no labs
9	Mar.22	LAB6, students present
10	Mar.29	LAB7, 3rd report due, students present
11	Apr.5	LAB8, students present
12	Apr.12	followup LAB, 4th report due, students present
13	Apr.19	followup LAB, students present
14	Apr.26	followup LAB, 5th report due, students present

Group Organization

	exp#	1	2	3	4	5	6	7	8
1	Jan.25								
2	Feb.1	G1	G2	G5	G6	G3	G4	G7	G8
3	Feb.8	G8	G7	G4	G3	G6	G5	G2	G1
4	Feb.15	G1/8	G2/7	G4/5	G3/6	G3/6	G4/5	G2/7	G1/8
5	Feb.22	G5	G6	G1	G2	G7	G8	G3	G4
6	Mar.1	G4	G3	G8	G7	G2	G1	G6	G5
7	Mar.8	G2	G1	G6	G5	G4	G3	G8	G7
8	Mar.15								
9	Mar.22	G7	G8	G3	G4	G5	G6	G1	G2
10	Mar.29	G6	G5	G2	G1	G8	G7	G4	G3
11	Apr.5	G3	G4	G7	G8	G1	G2	G5	G6
12	Apr.12								
13	Apr.19								
14	Apr.26								

Deadlines

- Report deadline at 11:59pm on Monday, see earlier Table
  - Eastern Standard Time email report in pdf format

    to the TA and the instructor

    file name: `labNumber_YourLastName.pdf`, e.g. `lab3_Smith.pdf`
- Late report rules – no later than one week:
  - full credit if there is a written confirmation of a medical event;
  - only 50% credit within a week otherwise;
  - 0% credit for missed report, count late report towards next.
- Follow-up review when iteration on report requested – same rules
  - iterations needed to satisfy your "W" review, not for data analysis
  - failing to pass "W" on time will affect your score

Grade rules

- The final grade is based on the following:
  - pass on writing requirements in the first three lab reports
    more than one iteration may be required
    but you should aim at having the first version to be the final one
  - pass on performing all eight experiments;
  - 70% – score of the best five lab reports which the student turns in;
  - 20% – oral presentation in class (20 minutes);
  - 10% – participation and lab notes, judged by the instructor and TA

Oral presentations

- Oral presentation models presentation at a conference
  - you have 20 minutes, pick one experiment to present:

    motivate your experiment

    describe apparatus

    discuss data and results

    give a summary or outlook.

- Time for questions: everybody should attend
- Software of your choice (Powerpoint, Openoffice, Latex, etc).
- Your laptop, or transfer pdf file to department laptop in advance
- Instructor will assign time in a few weeks

Lab Reports

- The typical lab report should include sections on:
  - Introduction and motivation for the experiment, some history;
  - Theory behind the experiment and what was expected to measure;
  - Experimental apparatus;
  - Data and conditions under which these data are collected;
  - Analysis of the data and results;
  - Discussion and conclusion.
- Must be written in Latex, creat pdf file, send by email
  – examples and templates on the web

Experiments

- What needs to be done
  - start with manual and background reading, use `Google` if needed
  - we suggest a few basic areas to go
  - you decide what the interesting physics is and what you need to do
  - however there is some absolute minimum you need to do
  - in the end you should get an interesting and complete paper
- Respect your team members and instructors
  - read supporting documentation before coming to class
  - make your time in the lab and time of others efficient

Some Experiment as an Example

- Introduction

In 2010 somebody decided to measure dependence of y on x.

- Theory

There is deep theory behind this measurement. It was shown that y and x are related as

$$y = a + b \times x, \tag{1}$$

where a and b are fundamental constants of great importance.

- Experiment

We have repeated the experiment suggested by the original authors.

Some Experiment as an Example II

- Data

The measured values of y and x, including statistical and systematic errors, are given in Table 1. These data are also shown in Fig. 1.

Table 1: Measured values of x and y in five experiments discussed in text.

x	y
1.00 ± 0.10	1.15 ± 0.20
2.00 ± 0.10	1.81 ± 0.20
3.00 ± 0.10	2.85 ± 0.20
4.00 ± 0.10	4.27 ± 0.20
5.00 ± 0.10	4.80 ± 0.20

Some Experiment as an Example III

- Results

In order to extract the values of a and b, we perform the least-χ^2 fit to our data with a linear function according to Eq. (1). The fit is shown in Fig. 1 and the results are shown in Table 2.

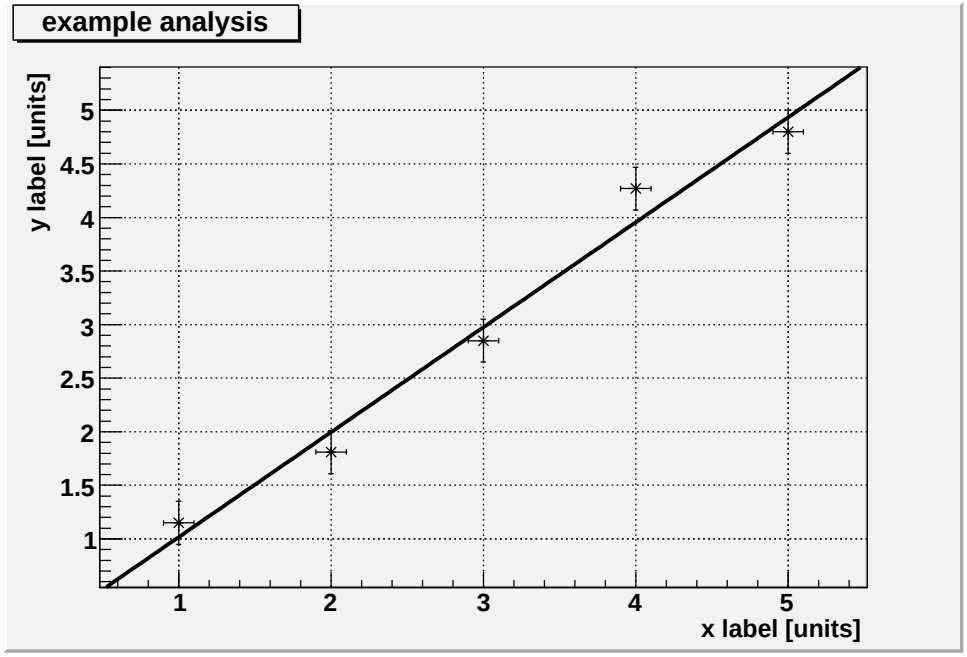

Figure 1: Measurements of x and y, and the least-χ^2 fit to the data with a linear function.

Some Experiment as an Example IV

Table 2: Measured and expected values of a and b.

parameter	measured value	expected value
a	0.04 ± 0.23	0.00
b	0.98 ± 0.07	1.00

- Conclusion

As it is evident from Table 2, our measured values of a and b are in good agreement with theory. This confirms the theory behind this measurement.

Software

- You are free to choose your analysis and presentation software
  - except: you must use Latex for lab reports (e.g. APS journals)
- Instructor is using the following:
  - LaTeX – A document preparation system,

    http://www.latex-project.org/

    see also REVTeX 4.1 macros

    http://authors.aps.org/revtex4/
  - ROOT – Data Analysis Framework

    http://root.cern.ch/
  - OpenOffice.org – The Free and Open Productivity Suite

    http://www.openoffice.org/

Safety

- Please keep both yourself and lab equipment safe
- Your safety. All equipment should be safe, but usual guidelines
  - observe emergency exits and procedures
  - be careful with electricity, keep all equipment grounded
  - radioactive isotopes: shielding, do not hold long, wash hands
  - be careful with sharp edges (e.g. glass, dispose correctly)
- Equipment safety
  - do not drop, do not lift when not intended
  - do not exceed specified current or voltage, read and ask if in doubt
  - turn off when not in use
  - observe polarity of all connections
  - be careful with fragile samples (foil, probes)
  - open vacuum chamber slowly

Contact Information

- Instructor: Prof. Andrei Gritsan

  office 433, phone 410-516-5070

  email: gritsan@jhu.edu

- TA: Jingsheng Li

  office 467, phone 410-516-7206

  email: jsli@pha.jhu.edu

- Location: Bloomberg 478 (here)

- Time: Mondays, 9–11:50am or 10am–12:50pm (morning) (?)

  and 1:30–4:20pm (afternoon)

Presentations and lectures will be in the first hour
(relevant only for the first and last parts of the semester)