Physics 122:
Experimental Techniques

Introduction

Course Aims

Logistics

Experimental Techniques

- Covers skills you might use in practical lab settings
- Let's say you want to participate in physics research at UCSD…
- You will be asked: what can you do?
  - program?
  - electronics?
  - mechanical design?
  - optical design?
  - vacuum systems?
  - computer interfacing?
- What will your answer be?

Topics Covered

- Mechanical Design
  - designing/machining parts, mechanical flexure
- Thermal Design
  - understanding heat flow
- Optics
  - geometrical optics/raytracing
- Vacuum and Cryogenics
  - requirements and techniques
- Analog Electronics
  - power supplies, op-amps, LEDs, transistors
- Computer Interface
  - Raspberry Pi; ADC/DAC; mag-swipe; Python in Unix environ.

Overall Goal

- Learn practical real-world experimental skills
  - more to the word "learn" than meets the eye
- Question: what physically happens when a student learns?
  - a student walks into a classroom, and emerges later having learned something
  - what physically has happened; how has the Universe changed?

Tricky to Get Right

- Hard to strike balance in designing lab activity
  - too prescribed: cookie cutter; follow recipe; autopilot
  - too open: students struggle and give up
- Struggling is the only *real* way to learn and internalize material
  - you *own* it after the struggle
- Shortcuts hurt you, in the end
  - avoid the temptation to grab pre-made solutions
  - not a path to ultimate success

Low Level Approach

- Tendency to dig into nitty-gritty
  - where the monsters live
  - break away from GDUA mold
- Some parts may seem tedious
  - so are musical scales, and this is how excellence is born
  - don't be too eager to get past it all; experts took their time
- Some labs deliberately "slow you down"
  - to help critical material sink in
  - looking to internalize techniques and information

Why You Should Work Hard

- You can get shortchanged by going to a research university
  - professors are primarily interested in research
- How to offset: participate in research!
- But there's a barrier: experience
- This class *can* provide some of this needed experience
  - but only an initial exposure
  - realistically, a one-quarter course can't do it all
- So you win big if you put a lot in
  - as with many things: you get out what you put in
- And aside from research, mastering these skills makes you an asset to employers

My Experimental Background

- Relevant because my expertise is limited
  - only so much experience/exposure through research/hobbies
- Astronomy
  - telescopes, optics, detectors, photography, machining, LN_2 cryogenics
- Lunar Ranging
  - lasers, picosecond timing, thermal, interfaces, digital electronics, some LHe cryogenics
- Other (hobby, business, misc.)
  - photovoltaics, batteries, electronics, RF electronics, FPGA, SPI, I^2C, serial, other interfaces…
- But lots I haven't seen

Still, Plenty for a Quarter

- Even though incomplete, impossible to do it all in one quarter
  - I learned these skills over many years
  - always fun to learn new stuff in this mode
  - not as natural/fun in class setting
  - think of as a cursory introduction; easier to master later

An Invitation to Explore

- Allow your natural curiosity to guide you
  - if the lab inspires a question, think of ways to answer the question
    - what could you measure?
    - how would you measure it?
  - the lab sequence closely mirrors my own exploration and questions I wanted to answer along the way
    - use it as a model for how to learn on your own
  - little side-projects may be more valuable to your learning than the "main" task at hand
    - at least half of my learning in college was from exploration beyond class work
  - seek help on how to explore further

Grading Scheme

- What's important in the grand scheme is how much you *learn*: how much you *understand*; how much you can *do*
  - this is more important than the grade (really!)
- Grades based 80% on labs/projects via indiv. write-up:
  - completion, success, demonstrated verbal understanding
  - some supporting calculations accompany each project
  - write-up describing the point, the critical concepts, data/results, and what you learned from the experience
  - less structured than cookbook lab reports
  - but clear communication is *very* important: do a good job!
- 20% in exam in December

Late Policy

- Changing topics every week, mostly
- Need benches clear for on-time “departure” each week
- Lab write-ups therefore due by 2PM Wed. one week after lab activity
  - in slot at rear of MHA 3544
- Late labs (up to a week) only count HALF credit
  - even an hour late gets hit
  - not accepted after one week

Thanksgiving Logistics

- T-day is week 9
- Staying until 6PM on Wed. may not be popular
- Week 8 lab designed to take 2 weeks
  - write-up due Wed. of week 10; no report due week 9
- Options for second half of lab
  - during regular Wed. section in week 9 (preferred)
    - full support
  - do early, before Thanksgiving break (second best)
  - scramble to do at beginning of week 10 (not recommended; little support/leeway)

Resources

- Professor:
  - Tom Murphy; SERF 336; 534-1844; tmurphy@physics.ucsd.edu
  - Office hours Tu 3–4, or by appointment
- Teaching Assistant:
  - Natalie Agre & Adrian Wong; nagre@ucsd.edu & asw012@ucsd.edu
  - Office hours M 3–4:30 and Tu 3–4:30 (in lab)
- Lab Partner:
  - work cooperatively on lab portion
  - can discuss write-up, but must be **your own words/effort**
  - copying text/sections will result in grading penalty
- The Lab (MHA 3544/3574):
  - available throughout quarter with ID card access

Lab Access

- The lab hours are officially 2–6 PM Wed.
  - Natalie, Adrian, and I will be present during these times
  - Useful Intro, tips, etc. at beginning of each session
  - Previous week's lab also due by 2PM sharp
- But you may spend as much time as you like/need to get the job done
  - please coordinate with partner, otherwise problems
- Will borrow ID cards in first lab session to establish access
- Please do not remove equipment from the lab
  - tempting as it may be!
  - accidental damage/loss could cause problems

Website

- The course website is at:
  - https://tmurphy.physics.ucsd.edu/phys122/
- The website resources contain:
  - course syllabus and related course info
  - lectures (PowerPoint and PDF), typically prior to class time
  - information on labs (procedures, write-ups, requirements)
    - supplemental info like datasheets, etc.

Text

- This course uses no text book
- But you may find the following a useful supplement
- Building Scientific Apparatus, 3rd or 4th edition
  - by Moore, Davis, Coplan
  - decent resource for physics experimentation
  - a wide range of topics, and good pointers to additional resources
  - suggested reading will be provided for both editions