# *Experimental Physics, 2018 Spring*

*Palash Banerjee, Dept. of Physics, UW-Stevens Point*

## 1 *Basic information*

| | |
|---|---|
| Course title | Experimental Physics, PHYS 470 |
| Instructor | Palash Banerjee, B125 Science |
| Contact | 715–346–4187, palash.banerjee@uwsp.edu |
| Office hours | MTWF, 1 — 2 p.m. |
| Laboratory hours | Open 24 hours a day |
| Pre-requisite | PHYS 300 *is* required |
| Textbook | *Experiments in Modern Physics*, Melissinos and Napolitano, |
| Required | Research laboratory notebook |

## 2 *Laboratory notebook*

The bookstore should have a proper cloth bound research grade notebook with numbered pages. The page size should be $11\frac{3}{4} \times 9\frac{1}{4}$ inches. Your notebook should look like this: `http://amzn.to/XRk7hD`. Please *do not* buy a cheap notebook.

Figure 1: Your research laboratory notebook available at the UWSP bookstore.

## 3 *Course description*

Physics 470 is a capstone course that introduces you to experimental physics by teaching you certain specific skills. In this hands-on course, you will learn how to design physics experiments, learn contemporary methods used to acquire data, learn the methods used for data reduction and analysis, and finally learn how to communicate your findings by writing detailed technical manuscripts. These specific skills are intended to round out your undergraduate physics education and prepare you for the professional world. You may find these skills extremely useful if you choose to go to graduate school, or take up a technical position in an industrial setting. Even if you choose not to pursue physics as a career, you will find that this course will sharpen your hands-on, analytical and written skills and make you stand out amongst the competition.

## 4 *Course objectives*

1. Gain familiarity with some common instrumentation found in a physics laboratory and learn how to build a basic data control and acquisition system.

2. Understand the limitations of any experimental apparatus.
3. Learn graphical techniques for data analysis.
4. Learn to maintain a complete research notebook that documents your scientific work.
5. Learn to write a clear technical narrative of your work.

## 5 *Course assignments*

1. **Homeworks:** I will assign homeworks based on the content of the lectures and your experiments. Your written solutions must be turned in by the due date. Please respect the deadlines — late solutions will not be accepted.
2. **Reports and manuscripts:** You will write reports for each junior exercise and a full length manuscript for each senior project. The manuscript must be written according to the style of an "American Journal of Physics" article.
3. **Laboratory notebook:** A very important part of being a scientist is to maintain a laboratory notebook that documents your work, ideas and thoughts clearly. You will turn in your notebook for evaluation after each experiment. Please be conscientious in maintaining a detailed notebook as you work. Your notebook **must** be up to date at all times — do not finish your experiment and then "work on" your notebook. Such a practice is considered unacceptable in a graduate setting or an industrial laboratory.
4. **Exams:** The midterm exam will be based on your homeworks and the junior exercises. The final exam will be based on your homeworks and senior projects.

## 6 *General course policies*

1. Food and drinks are absolutely **not** permitted in the laboratory.
2. No make-up labs will be offered; no make-up exams will be offered. I will accept **only one** late assignment per student during the course. No excuses are needed. A second late homework will receive no more than 80% credit. Subsequent late submissions will not be accepted.
3. Make-up work will only be accepted in the case of excused absences. Excused absences include death in the immediate family, illness with a note from the appropriate health care professional,

religious observance, an event in which you officially represent the University of Wisconsin-Stevens Point and the event directly conflicts with an exam or lab. Excused absences must be approved with documenting materials prior to the date of absence.

4. *All* your assignments count and I will *not* drop any "lowest score" assignment. All the exams count. If you miss any exam, you will receive a zero for that exam.

5. The schedule for the finals is set by the University. I will not schedule an early final exam for whatever reason. Please don't ask.

6. I *do not* assign work for extra credit. There are *no* bonus points that you can earn. **Once you hand in your final exam, there is nothing more you can do to change your grade**.

## 7 *Grading and evaluation*

I will calculate your grade based on a weighted percentage of your scores as follows:

| Assignment | Value |
|---|---|
| Junior exercise reports | 15% |
| Laboratory notebook evaluations | 20% |
| Homeworks | 15% |
| Senior project manuscripts | 25% |
| Midterm exam | 12% |
| Final exam | 13% |

Your final grades will be determined as follows:

| Total score | Grade |
|---|---|
| 90% and above | A |
| 87–89% | A- |
| 83–86% | B+ |
| 80–82% | B |
| 77-79% | B- |
| 73–76% | C+ |
| 70–72% | C |
| 67–69% | C- |
| 60–66% | D+ |
| 50–59% | D |
| below 50% | F |

I do *not* grade on a curve. Scores will be rounded up according to the following example: 86.6 – 86.9% will be rounded up to 87% and become a B+, but 86.0 – 86.5% will remain at 86% and will earn a B.

## 8 List of experiments

The following experiments are available.

1. Junior exercises (you must do all of these)
   (a) Atomic spectroscopy of sodium and hydrogen using a grating spectrometer.
   (b) A dc bridge to measure small changes in resistance.
   (c) Introduction to the LabVIEW programming environment — how to build a basic data control and acquisition system.
   (d) The frequency dependent response of a LCR circuit driven by an ac voltage source.
2. Senior projects (choose any three)
   (a) Interaction of radiofrequency waves with a 2-level spin system — electron spin resonance.
   (b) Interaction of polarized electromagnetic waves with a transparent material — the optical Faraday effect.
   (c) The relativistic collision between high energy photons and electrons — gamma ray spectroscopy.
   (d) An ultrasensitive optical interferometer to study the picometer scale displacements of a large mirror — recreating the LIGO experiment at UWSP.
   (e) Electrical transport in semiconductors — the Hall effect in germanium.
   (f) Quantum mechanics with photons — the bizarre case of a single photon interfering with itself.
   (g) Interaction of a magnetic moment with a magnetic field.
   (h) Interaction of photons with a metallic surface — the photoelectric effect.
   (i) A scanning Fabry-Perot cavity to measure the wavelength of microwaves.

## 9 Academic misconduct

Please *do not* copy each others homeworks, class assignments, laboratory reports, and examinations and pass them off as your own. Any confirmed incidence of academic misconduct, including plagiarism and other forms of cheating will be treated seriously and in accordance with University policy.

## 10 Course schedule

This is a tentative course schedule which might change if I feel it necessary.

| Week of | Laboratory times Mon 2 – 5 p.m. & Thu 3 - 5 p.m. |
|---|---|
| (1): Jan 21 | Theory: how to estimate and report on experimental uncertainties; Laboratory: Using converging lenses and RC circuits as introductory experiments to build good Physics 470 habits. |
| (2): Jan 28 | Theory: Propagation of uncertainties; Laboratory: Junior Exercise 1 (J1) – Atomic spectroscopy of sodium and hydrogen. |
| (3): Feb 4 | Theory: Statistical analysis and the Normal distribution; Laboratory: (J2) – A dc bridge to measure small changes in resistance. Intro to LabVIEW programming. Report from J1 due Thu. |
| (4): Feb 11 | Laboratory: Examples of LabVIEW programming; building a basic data control and acquisition system to calibrate a solenoid. Report from J2 due Thu. |
| (5): Feb 18 | Laboratory: J3 – LCR circuits and the connection between electrical circuits and mechanical systems. |
| (6): Feb 25 | Laboratory: J3 continued. catch up with programming, homeworks, reports etc; choose Senior Project 1 (S1). |
| (7): Mar 4 | Theory: The Poisson distribution and the uncertainties in a counting experiment<br>Laboratory: Begin S1 (3 weeks) Report from J3 due Thu. |
| (8): Mar 11 | Laboratory: S1 (continued) |
| (9): Mar 18 | Laboratory: S1 ends. Thu: Midterm exam 1, 3 – 5 pm in the lab. |
| (): Mar 25 | Spring break. |
| (10): Apr 1 | Laboratory: Begin S2 (3 weeks); Manuscript from S1 due Mon. |
| (11): Apr 8 | Laboratory: S2 (continued) |
| (12): Apr 15 | Laboratory: S2 ends; |
| (13): Apr 22 | Laboratory: S3 begins; Manuscript from S2 due. |
| (14): Apr 29 | Laboratory: S3 continues. |
| (15): May 6 | Laboratory: S3 ends; Review etc. |
| (16): May 13<br>Finals week | Final exam, Thu May 17, 8:00 – 10:00 a.m. Manuscript from S3 due. |