Physics 480W, Experimental Modern Physics

Dr. Greg Severn
MWF 1:25-2:20 ST252, ST285 (Lectures & Tutorials) R 9:15am-12:05pm
ST290 & ST 287 (Laboratory experiments)
(Dated: Fall 2017 **Draft Version 2.0**)

Professor: Dr. Greg Severn, ST285 x6845, **severn@sandiego.edu**

Office Hours: TW 2:30-4:00, R 2:30-4:30, & by appointment. Appointments are always possible.

Catalog listing: `EXPERIMENTAL MODERN PHYSICS Units: 4, Prerequisites: PHYS 330 (Quantum Mechanics), A laboratory-based course focused on the introduction to principles of research techniques with an emphasis on modern physics. Experiments illustrate physical phenomena pertaining to core areas of physics: quantum mechanics, atomic and nuclear physics, laser physics and plasma physics. Analog and digital data acquisition instrumentation, high-resolution optical and laser technology, and phase sensitive detection technology will be explored. This course is the required writing-intensive course for physics majors and fulfills the upper-division core writing requirement. Students write papers up to professional standards required of publication in physics research journals, learn to write mathematical prose, engage in the peer review process, and learn to code LaTeX.`

Class meeting schedule: Typical large group lecture topics include but are not limited to a) writing mathematical prose, b) professional standards for writing in physics c) LaTeX and mathematical composition d) the peer review process in physics, with practice at revising patches of papers taken from student and profession submissions, e) advanced concepts in quantum theory, plasma physics, and laser spectroscopy, and f) historical examples of experimental design problems in experimental physics as illustrative of the process of design. See table I.

Text: *Experiments in Modern Physics* 2nd Ed., A.C. Melissinos and J. Napolitano, Academic Press, 2003.

Lab Manual(s): Reprints, lab handouts, and supporting documentation for each experiment will be posted to our website or placed in the filing cabinet in ST290.

Web pages: Our course has a public web page, see `http://www.sandiego.edu/~severn/p480W`, as well as a Blackboard site. LaTeX Dec. be used online at `www.sharelatex.com`.

Learning outcomes: By the course's end, the student will demonstrate

1. a thorough knowledge and comprehension of core concepts of classical and modern physics, especially in the specific areas of quantum mechanics and plasma physics.

TABLE I. Meeting schedule for Experimental Modern Physics (EMP). The individual experimental research groups meet tutorially, and of course in Lab. We'll meet together as a large group only once a week.

Course and Time	Room	M	T	W	Th	F
EMP (1:25-2:20)	ST252	Tutorial Group I		Tutorial Group II		Professional Writing Standards in Physics
EMP-L (9:15am-12:05pm)	ST290, ST 287				GI&II	

2. demonstrate competency (defined by rubrics) in
   (a) writing research papers up to the standards of the physics profession as formulated and maintained by the American Physical Society and the American Institute of Physics
   (b) reviewing, refereeing research papers up to the professional standards maintained by those same societies
   (c) designing experiments that enhance signal relative to noise through a variety of contemporary techniques, among other laboratory skills
3. the ability to apply their physics experience and knowledge to analyze new situations, each related to advanced topics in quantum mechanics and plasma physics
4. the ability to articulate the nature of research in physics and its development through scientific methods
5. A recognition of the need for, and an ability to engage in life-long learning

As an upper division experimental modern physics course, it emphasizes the execution of laboratory experiments (we have 4 experiments, shown in table III and a paper is due for each one) and what one can learn from them. Each illustrates very deep physical phenomena pertaining to core areas of physics: quantum mechanics, atomic and nuclear physics, laser physics and plasma physics. Attention to the practical side of testing advanced modern physical theories in the laboratory is an important part of the course, as is grasping the integration and interplay of theory and experiment. Coming to understand how theory and experiment relate to each other in carefully designed experiments is an essential part of understanding how science advances. And for all these reasons, this course is a good introduction to the world of physics research.

TABLE II. List of Experiments

Experiment Code	Topic & Laboratory
OP	High resolution optical spectroscopy, Zeeman effect and Hyperfine structure (hfs) in *Rb*
NMR	Nuclear Spin Echoes and estimating spin-spin relaxation times.
PW	Plasma discharge physics, the Langmuir Probe, and Ion Acoustic Waves in laboratory plasmas
LS	High resolution laser spectroscopy and *Rb* hfs [New this semester]

The writing (& reviewing) process: Mastery of experimental and theoretical ideas will be demonstrated through well written research papers. These will conform to current standards for research papers in Physics, and this writing intensive course is the first course in our curriculum in which this skill is inculcated. Above all, the student is introduced to the review process to which all contributions to the scientific literature (worthy of the name) are subjected, as set by the standards of the American Physical Society and the American Institute of Physics. Students will learn to write mathematical prose, and will be aided using (learning) the software program LaTeX. Papers are reviewed and scored according to the rubric found on our public course website, reflective of professional standards. Due dates for each of the 4 papers are shown in table III, which gives the tentative schedule for all experiments.

Students are introduced to the peer-review process, whereby, at the time of their first submission, they are assigned a manuscript submitted by another student (from a different group number), and are given a rubric in order to complete a report. Each student receives 2 review reports, one from a fellow student and one from the 'tyrant journal editor', the instructor of the course. The student uses these reports to refine, rewrite, edit, and so forth the original manuscript to produce a final submission (which is then graded according to the rubric). The final submission (the first and final submission dates can be found on the tentative schedule below-final submission are due one week after the first submission date is given, and please note that there are 4 papers) is to be accompanied by a cover letter in which the student details significant changes in the text as prompted by the referee reports, rebutting requested changes that the author feels are unnecessary, and observing where accepted alterations have been made. Please see the public course website for more details.

TABLE III. Tentative schedule of meetings] The dates for all 4 paper submissions are given in footnotes. **NB: date is the Lab day of the week: Thursday**. Tutorial meetings occur on M & W's. Large group meetings are Friday's with occasional meetings on W (FDOCs), also as needed; **NL-no lab, OP-optical pumping, NMR, PW-plasma waves, LS-laser spectroscopy**

Week	Date	Group I	Group II	Friday Topic
I	7 Sept	NL	NL	Orientation to the writing process, LaTeX
II	14 Sept.	OP	NMR	Writing & reviewing, More on Mathematical Prose
III	21 Sept.			Examples, good and bad
IV	28 Sept.[a]			Quantum Mechanics of two state systems I
V	5 Oct.[b]			QM 2 state systems II
VI	12 Oct.	NMR	OP	Diagnostics & Design I
VII	19 Oct.			Diagnostics & Design II
VIII	26 Oct.[c]			Diagnostics & Design III
IX	2 Nov.[d]			Intro to Plasma Physics I
X	8 Nov.	PW	LS	Plasma Physics II
XI	16 Nov.			Plasma Physics III
XII	23 Nov.[e]	NL[f]	NL	
XIII	30 Nov.[g]	LS	PW	Design a New Experiment
XIV	7 Dec.			
XV	14 Dec.[h]			Design an Old Experiment[i]

[a] First submission, Paper #1 this week; also submit reviewers comments.
[b] Final submission, Paper #1
[c] First submission, Paper #2 this week; also submit reviewers comments.
[d] Final submission, Paper #2
[e] First submission, Paper #3 this week; also submit reviewers comments.
[f] **Thanksgiving break!**
[g] Final submission, Paper #3
[h] First submission, Paper #4 this week; also submit reviewers comments. Final submission, 22 Dec. day of scheduled final exam.
[i] Friday LDOCs

Tutorials: teaching in PHYS 480W for two of the 3 weekly lecture meetings occurs in small group meetings as described above (see table I). The list of tutorial questions posted on the public course website is intended to prompt individual preparation for each session. The student is responsible for *all* of the questions. I urge students to write out solutions (sketches, diagrams, algebra, sentences, etc.) in their lab notebooks for reference. Please see the public course website for more details.

Grades: The breakdown of the final grade will be as follows: Papers - 70%, Tutorial & participation assignments 20%, Final Oral Exam 10%. Roughly speaking, I assign letter grades according to the scale, 85/75/65/50/0.