Experiments in Physics – Physics 321 and 322
Westminster College

Pertinent Information

Instructor: Doug Armstead
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Meets: Tuesday and Thursday. 11-12:30pm in Hoyt 110.
Prerequisites: Physics 152 is required.

The Point of this Class

In this course you will grow as a physicist. Up until this point nearly all of the questions that you have tackled have been posed for you. By the end of this course you will be expected to pose and explore your own question. Typically questions don't come from no where, but rather are inspired by reading you do or phenomena you are aware of. Over the course of this year you will begin to learn how to find your way through the academic literature, the laboratory, and into your own questions. While doing this, you will also get practice expressing what you find. The idea is to do this on a small scale so that you will already have practice when it comes time to do you capstone project in your senior year.

Specifically you will be expected to do six experiments over the course of the year. This is to allow enough time to cover an experiment in depth and still do experiments in a wide variety of fields. The first four will be done in the Fall semester and will use apparatus in the lab. There are manuals available to you that describe what the apparatus is for and describes the kind of experiments that can be done with them, but there will not be a recipe telling you what measurements to make and exactly how to do it. In the Spring semester there will be one more experiment of the same kind as the fall, but the and final experiement will be one of your own design. You should expect to start planning your self-designed experiment as soon as the spring semester starts, concurrently with your planning, execution, analysis and writing up of your standard experiment. You will have approximately three weeks to complete each of the five standard experiments and will work in groups of two or three. For each of these standard experiments you will be expected to:

- Do background reading to understand what physics is being explored and to find out how others have carried and analyzed out similar experiments.
- Keep a careful account of what you are doing in your laboratory notebook. This should be detailed enough to allow you to recreate your experimental set-up, make a measurement, or carry out your analysis at the end of the semester using only your notebook as a reference.
- Do a careful and detailed analysis of your data including error analysis. The propagated errors should also appear in any graphs you create as error bars.
- You will write up each experiment in a journal style lab report where you give a proper introduction, description of your procedure, presentation of data, analysis and discussion of the data and its implications, references.

During the Fall semester you will also be expected to choose one of your experiments to give an oral presention of to the physics community on campus. Also during the Fall semester we will spend one or more lab sessions in the machine shop learning how to use the equipment so that you will be able to create pieces of your experiments if need be.

Each student is responsible for researching, devising, planning, executing, analyzing, and writing up her/his own self-designed experiment. You are welcome and encouraged to get help from your fellow classmates, there are times where a second set of eye or hands is really helpful. That being said the work must be substantially your own. Your experiment should largely draw on resources that are readily available but adaquate notice additional supplies may be obtained by the physics department for your use.

Standard Experiments

The following is a partial list of possible standard experiments to choose from. Choose only one from each section, at least one of your experiments must be a high precision experiment.

Constants of Nature

Gravitational constant*
Photoelectric effect (h/e experiment)

Quantum Mechanics

Quantization of atomic energy states (Frank-Hertz)
Measurement of sodium doublet*
Electron diffraction
X-ray scattering

Superconductivity

Thermodynamics

Stefan Boltzmann Law
Equivalence of mechanical work and heat
Adiabatic gas law

Materials/Engineering

Young's modulus (stress and strain)
Airfoil in wind tunnel
Faraday rotation
Pressure dependence of n^*_{air}

Electricity and Magnetism

Rotating coil in a uniform magnetic field
Magnetic force experiment
Current balance*
Electric field mapping w/ simulation

Nonlinear Dynamics

Chaos in a Mechanical Oscillator
Chaos in a driven, nonlinear electrical oscillator

* denotes a high precision experiment.

Potential Self-designed Experiments

Determination of a star's spectral type
Kepler's third law for Titan around Saturn
Cosmic ray detection
Hall Effect
Simulation

Grades

Your grade will be based on

Fall semester	
10%	Your participation in class.
10%	A lab practical type quiz to check the quality of your laboratory notebook.
10%	Your oral presentation.
70%	Your grade on the lab reports

Spring semester	
10%	Your participation in class.
10%	A lab practical type quiz to check the quality of your laboratory notebook.
10%	Your presentation (oral or poster) at the Undergraduate Research and Arts Celebration, U
35%	Your grade on the two standard lab reports.
35%	Your grade on the self-designed experiment.

You are expected to be in the lab during scheduled class time. You will also have full access to the lab during for the year. See Mary about getting a key.

Academic Integrity*

Honesty is an essential part of academic integrity and at the heart of scientific research. Scientists and other scholars take pride in ownership of their own work. They do not take credit for the effort or ideas of others and do not tolerate those who do. This includes cheating, plagiarism and not contributing to group projects. This concept is based on mutual trust. If you cheat you are chipping away at your own moral character and undermining the overall integrity of our college society. Violations of this trust are acts of academic dishonesty; offenses will not be tolerated and may result in a zero on that assignment or in failure for the course.

Plagiarism, according to *Webster's New Collegiate Dictionary* is to steal or pass off the ideas and words of another person as new and original an idea or product derived from an existing source. Obviously using work from another student who has previously taken this course is plagiarism.

Group work and group projects are valuable learning experiences, and will be the basis of most lab work. However, it is a form of dishonesty to claim credit for work to which you have not contributed.

I encourage students to work together in discussing methods of solutions to problems in homework assignments. Seek help from the instructor, but only after you have reached an impasse in your own concentrated effort. Much valuable learning can occur in the *active participation* in such discussions. However, because you are placing your name alone on an assignment, you should then write up your own original solutions. You are not being honest if you just copy another's solution without any thought of your own.

READ (and understand) the College's statements and procedures on Academic Integrity in the 2007-2008 Undergraduate Catalog, pages 71-75. Ask the instructor if you have any uncertainty about what is proper and what is not.

*Adapted from Dr. William L. Johnson's statement of academic integrity.

Bibliography

Class Schedule

All dates are tentative.

Data and Error Analysis		
Data Analysis for Physical Science Students	Louis Lyons	QC33.L9 1991
An Introduction to Error Analysis	John R. Taylor	QA275.T38
Experimentation	D. C. Baird	QC39.B17 1995

Computational Techniques		
Numerical Recipes: The Art of Scientific Computing	W. Press	QA297.N866 2007
Mathematical Methods in the Physical Sciences	M. Boaz	QA37.3.B63 2006

Scientific Techniques and Lab Manuals		
An Introduction to Scientific Research	E. Bright Wilson Jr.	Q180.A1.W57
Building Scientific Apparatus	John H. Moore et al.	Q185.M66
Experiments in Modern Physics	Adrian C. Melissinos	QC33.M52
Experiments in Physical Optics	M. Francon et al.	QC385.E913
Landmark Experiments in 20th Century Physics	George L. Trigg	QC33.T74 1975
Instrumentation Reference Handbook	B. E. Noltingk	QC53.I574 1995 (Reference)
Experimental Physics	R. A. Dunlap	QC33D86 1988
Art of Experimental Physics	Preston and Dietz	QC33P74 1991
How to Write and Publish a Scientific Paper	R. Day T11.D33 2006	
The Technical Writer's Handbook: Writing with Style and Clarity	M. Young	T11.Y68 2002
Successful Lab Reports	Lobban and Schefter	Q183.A1.L63 1992

Mechanics		
Vibrations and Waves	A. P. French	QC235.F74
Classical Dynamics of Particles and Systems	Jerry Marrion	QA845.M38 1970
The Physics of Vibration	A. B. Pippard	QC136.P56
Chaotic Dynamics	Baker and Gollub	QA862.P4 B35

Optics		
Optics	E. Hecht	QC355.3.H43 2002
Fundamentals of Optics	Jenkins and White	QC355 J4 1976
Elementary Experiments with Lasers	Geoffrey Wright	QC365.W74

Electricity and Magnetism		
Methods of Experimental Physics	Estermann	QC41.E8
Electricity and Magnetism	Bleaney	QC522.B57

Other		
Berkely Physics Course	Various	QC21.B445 Vol. 1-5

Date	Topic	Due
Sept. 2	Introduction	
Sept. 9	Error Analysis	
Sept. 16	Labview	
Sept. 23		Lab report 1–first draft.
Sept. 30	Shop	
Oct. 7		Lab 1 final draft due.
Oct. 14		Lab report 2.
Oct. 21	Latex	
Oct. 28		
Nov. 4		Lab report 3–first draft.
Nov. 11		Lab 3 peer comments due.
Nov. 18		Lab 3 final draft due
Nov. 25	Thanksgiving	
Dec. 2		Lab report 4.
Dec. 9		Presentation
Dec. ?	Final at ?	Lab practical

Date	Topic	Due
Jan. 18 and 20	Scientific Literature	
Jan. 25 and 27		
Feb. 1 and 3		
Feb. 8 and 10		Lab report 5.
Feb. 15 and 17		Self-designed experiment proposal due.
Feb. 22 and 24		
Mar. 1 and 3		
Mar. 8 and 10		
Mar. 22 and 24		
Mar. 29 and 31		
Apr. 5 and 7		
Apr. 12 and 14		
Apr. 19 and 21		Presentation of results
Apr. 26 and 28		Presentation of results
May 3 and 5		Self-designed experiment Lab report.
May. ?	Final at 3pm	Lab practical