Phys650 - Special Topics in Experimental Atmospheric Physics (Spring 2009):
(future PHYS 427/627: *Atmospheric Physics Measurements: Instrumentation and Techniques*)
http://userpages.umbc.edu/~martins/PHYS650/

Instructors:

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Credits: 3

Undergraduate Prerequisites:

PHYS 303: Thermal Physics
PHYS 340L: Electronics for Scientists
PHYS 324: Modern Physics
PHYS 407: Electromagnetic Theory
MATH 225: Differential Equations

Overview:

This course covers the design, simulation, and execution of experiments in atmospheric physics and earth sciences using teaching and research instrumentation. The students will be exposed to the processes of development, construction, calibration, and application of instrumentation for the measurement of relevant parameters of the atmosphere. Students will also use state of the art instrumentation from the atmospheric research laboratories connected to the department.

Main Objectives:

- Bottom up development of experimental techniques starting from basic physical concepts through the development of a dedicated apparatus, its calibration, measurement, data analysis and interpretation;

- Provide training in advanced laboratory techniques on current research instrumentation for atmospheric physics;

- Introduction to the development, design, and execution of Ground Based, Aircraft, and Satellite Missions.

Schedule and Course Structure:

- **Location:** Physics 213 or other scheduled location for specific experiments.
- **Regular Classes:** Wednesday 9:00 – 11:30AM
    - 9:00-10:00 Discussion of previous experiment and student reports (PDF file sent by students the day before), theory and discussion of next activities
    - 10:00-11:30 Hands on activities

- **Open Lab:** Wednesday 11:30-15:00 the lab will be open for students to work on their projects or on their weekly experiments. This is equivalent to homework and library work in theoretical classes. Additional laboratory time can be scheduled if needed.

Instrumentation Project: Each student is supposed to design, build, calibrate, and use instrumentation to measure optical properties of the atmosphere. A term paper and an oral presentation of the project will be required at the end of the course.

Course Grading:

- Class participation and short weekly reports (typically 3-5 pages including figures and tables) of relevant results and analysis should be sent to the instructors in a PDF file the day before class until noon. These results will be discussed during class (50%).
- Project execution (25%).
- Oral presentation of the project in the last class (10%).
- Term paper describing the project and main results in a format similar to a Journal publication (15%).

Hint: Start early and keep up with the Course Project! The project is a great tool for learning and to expose you to new challenges. Work as much as you can with the course instructors in order to develop, design, and execute your project.

Outline Syllabus:

- Advanced statistical methods for Data and Error Analysis
- Instrumentation Design and Specification
- Introduction to Atmospheric Radiative Transfer concepts and simulation techniques
- Basic concepts and techniques for In situ measurements and remote sensing of atmospheric properties:
- Measurement of atmospheric aerosols, gases, and cloud properties (in situ and remote sensing)
- Measurement of Physical properties of the atmosphere (temperature, pressure, humidity, wind, radiation, etc.): surface, aircraft, and radiosonde instrumentation.
- Spectroscopic measurements of gases and physical properties of the atmosphere

Potential Laboratory Experiments:

- PM10 and PM2.5 Local Aerosol Characterization
- Scanning Electron Microscopy
- Radiometric Calibration of Optical Instruments
- Light Scattering - Laboratory and Remote Sensing

- Integrated Scattering and Phase Function of aerosols and Clouds
- Use and analysis of IR spectrometric data
- BRDF and Spectral Reflectances
- Physical parameters of the Atmosphere (temperature, pressure, RH, wind, radiation)
- Radiometry from Space: Mission Design and Requirements
- Invited Lecture: Backstage of a Space Mission

Course textbooks and references

Handouts, articles and references will be provided for each class. There is no assigned course textbook for this class. There are, however, several highly recommended references that will be discussed during the classes. We always recommend you to read something about the subject before the following class.

Lab Notebooks[1]

You are required to obtain and use a standard laboratory notebook for this course. The best ones typically have a brown hard-paper cover, and roughly 100 sheets of ~ 9 1/4 X 11 3/4 inch graph paper. *The UMBC bookstore sells laboratory notebooks for $16*; they can also be obtained at many office supply stores.

Laboratory notebooks are an essential part in any experimental research. It's not easy to get in the habit of writing everything down, but it's incredibly worthwhile. You'll learn it first-hand when you sit down a few days later to write up your lab reports. *Before leaving each week, I may want to sign-off on your lab notebooks*. You should make every effort to record and describe everything you are doing (a good model is to assume you will return to your notebook after 10 years, and then eventually be willing to reproduce, or understand your results!). Write down anything and everything that seems important, including some stuff that doesn't seem so important (personal notes, opinions, ideas, etc.). Your lab notebook should look more or less like the one pictured in Figure 1, full of notes, numbers, data, *and lots and lots of figures*. Draw or take pictures of everything! Any printed output, like digital pictures, graphs and tables should be printed and taped in. Notice that lab-notebooks have numbered pages. This eases cross referencing and avoids ripping pages out. And a last advice: don't erase any notes out. Just cross them out. They may be useful sometime.

[1] Adapted from Dr. Todd Pittman , PHYS 330L, UMBC Optics Laboratory

Figure 1. Photograph of a lab notebook. Note that there are lots of figures, data, and plots. Good lab-notebook techniques are an important part of your professional skills!

Reports

Short weekly pdf reports: You have to write short weekly lab reports (with relevant pictures, data and data analysis) for each experiment. A pdf file of these short reports should be sent by e-mail to the instructors until noon, the day before class. Highlights of all pdf reports will be discussed in class. While it is not always necessary to get a "right answer" to receive a high grade, poorly written reports will ensure a poor grade.

Project term paper: You have to submit a term paper, and prepare an oral presentation about your project. *The term paper will be due one week after the oral presentation*. The grading will be based on the quality of the experimental work, the technical writing and your oral presentation. Though the project and the oral presentation will be developed in group, the term paper is individual and should reflect your own writing style and comprehension. The paper is to be written for an audience of the area that is assumed to have some scientific background, but do not know your particular experiment or ideas. There are many resources on the net on how to write a report or a term paper. We strongly recommend you to search for them.

Safety [2]

Although we do not anticipate any problems, it is important to realize that we will be working in an active laboratory environment which can always pose certain risks. **Our primary goal is to ensure our safety in the lab.** Some of the equipment relies on high voltages and current and proper precautions must be taken at all times. If you are unsure about the operation of *any equipment or tools*, please ask the instructor or support staff for help. The basic rule is to be over-careful.
Some of our experiments will involve the use of lasers and UV light sources. **No matter how "weak" the source seems to be it can always cause serious damage to the human eye. Never look directly into a laser beam, no matter how many times it has been reflected or how small a laser system is (even a laser pointer). Always wear laser goggles when they are needed. Do not take shortcuts with laser safety**.

[2] Adapted from Dr. Todd Pittman , PHYS 330L, UMBC Optics Laboratory

For some of our calibrations and experiments we may also use other light sources like integrating spheres, special lamps, fiber illuminators, etc. Never underestimate the potential for eye damage of any light source. Many of these sources are important source of UV radiation and must be properly handled. **Always wear safety goggles as instructed.**

1. When using a laser or an UV source, be sure to turn on the "Laser In Use" sign that hangs outside the lab. This will alert visitors to the fact that a laser is turned on inside the laboratory.

2. Familiarize yourself with the location and contents of the first aid kit. It is mounted on a wall in the Foyer area of Rooms 213 & 214, and contains bandages, cleansers, etc.

3. The labs are equipped with a master "kill switch'". Familiarize yourself with the location of these switches. They are the big red buttons located just inside the laboratory doors. Pushing this button cuts off all power to the room. Don't worry, they do not shut down the entire building! In the event of an emergency, please use the "kill switch'" if appropriate.

Multi-user laboratory work needs some kind of "*good neighborhood code*".

1. Return all used materials to their original location. Keep the laboratory and specially your working area clean and organized. Return all tools to the tool box after use.
2. If you have to keep some material or instrument leave a note on the material's original location indicating your name, date of removal, and a phone number to contact you; Many laboratories have a "lend book" where you are supposed to make a note of any material taken from the lab.
3. No food, drinks, etc in the laboratory;
4. Try to read the manual BEFORE turning on any unknown equipment;
5. Draw special attention to chemicals, mercury (thermometers), radioactive materials. In case of a spillage, look for knowledgeable help (do not improvise!).
6. Accidents happen. If you break an instrument (for whatever reason) or you find out it is not working properly, leave a note on the instrument indicating clearly what is not working and assure the instrument is directed to maintenance; Much worse than breaking something is not telling anybody!

Error analysis[3]

Error analysis is a key part of any experimental work. You are expected to perform error analysis for your results. Results should always be stated in forms like, "distance Y is (2.0 ± 0.2) m", rather than "Y about 2 m long". You are expected to discriminate instrumental errors, systematic errors, and statistical errors in all experiments. You may use any method for error propagation, as long as correctly applied. The text *Introduction to Error Analysis*, by John R. Taylor, is available in the Alvin Meckler reading room in the Physics Building.

[3] Adapted from Dr. Todd Pittman , PHYS 330L, UMBC Optics Laboratory

Academic Integrity[4]

As with all courses, Academic Integrity is required in PHYS650:

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Directory.

The issue of academic integrity, particularly with regards to plagiarism, can be confusing in writing up lab reports. This is primarily due to the fact that the expectations can be different for different courses. In this course, you are supposed to work together as a team as much as possible on everything except the actual writing of the term paper. The term paper should be written entirely by you. In almost all cases, the members of a team will have the same data in their lab notebooks; It is therefore entirely reasonable that the members of a team will have the same "results". Working together in obtaining these results is encouraged. However, the team members must not share in the writing of the lab reports. Each person must write up her or his lab report by themselves. This is a key part of your educational experience in this course. Do not forget to include adequate references in your lab reports. Remember that using but forgetting to cite a reference could be seen as plagiarism.

[4] Adapted from Dr. Todd Pittman , PHYS 330L, UMBC Optics Laboratory