

# **METEO 431 - ATMOSPHERIC THERMODYNAMICS**

*Spring 2005*

**Instructor:** Jerry Y. Harrington

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**Class Meetings:** 112 Walker Building on Mon., Wed., and Fri. at 2:30 pm - 3:20 pm

**Office Hours:** 3:30pm - 4:30pm on Mon. and Wed.

2:30pm - 3:30pm on Thurs. (Open Door Policy, see below).

**Course Textbook:** *Atmospheric Thermodynamics*

C. Bohren and B. Albrecht

**Course Web Site:** Off of my main site: <http://www.meteo.psu.edu/~harring>

**Organization and Grading:** 3 - credit course, primarily lecture

Mid-term 1: Feb. 8 (Wed.), 7 - 9pm, location TBD	20%
Mid-term 2: March 22 (Wed.), 7 - 9pm, location TBD	20%
Final	25%
Quizzes (every Friday)	15%
Homework (~every 1.5 weeks)	15%
Participation	5%

**Recommended Books:** On 2-hour reserve in Earth & Mineral Sciences

Library - 105 Deike Building. (Books I have found useful)

<b>Title</b>	<b>Author(s)</b>	<b>Call Number</b>
<i>Atmospheric Thermodynamics</i>	Iribarne and Godson	QC880.4 T5I74 1981
<i>Thermodynamics of Atmospheres and Oceans</i>	Curry and Webster	QC880.4 T5C87 1999
<i>Atmospheric Science</i>	Wallace and Hobbs	QC861.2 W34 1977
<i>Physical Chemistry</i>	Atkins	QD453.2 A88 1994b
<i>Understanding Thermodynamics</i>	van Ness	QC311.V285 1983
<i>Thermodynamics, Kinetic Theory, and Statistical Mechanics</i>	Sears and Salinger	QC311 S42 1975

# **METEO 431 - ATMOSPHERIC THERMODYNAMICS**

## *Classroom Policies and Other Notes*

**Course Objectives and Expectations:** This course is designed to provide undergraduate Meteorology students with a foundation in the thermodynamics of the atmosphere. In order to undertake this venture, it is expected that you have a reasonable understanding of mathematics (through differential equations), and physics (mechanics, electricity and magnetism). Students with weak backgrounds in these fundamental disciplines are advised to either: (1) postpone enrollment in this course, (2) get up to speed *now!* Because thermodynamics is so general, it tends to be hard to grasp. Hence, your ability to understand the material depends *greatly* on how well you remember your math and physics. This course will be an excruciating ordeal if you are not up to speed (don't say I didn't warn you!)

**Office Hours:** These are hours that I have set aside during the week when I will drop what I am doing to assist you with any questions you may have about class (or other academic matters). However, I tend to keep an "open door" policy at all other times. In other words, if my door is open, please do not hesitate to stop in if you have questions. As a caveat, please understand if I am too busy at some (non-office hours) time to take your question. Sometimes, things come up which require my immediate attention. Although this is rare (I usually shut my door when I do not wish to be disturbed), I do hope you will understand if I ask you to come by at a later time (of course, I will not do this during my posted office hours). If my door is closed: please do not knock!! During this semester, I am teaching 3 classes, hence I will be unusually busy. Because of this, you should make use of office hours as much as you possibly can (since finding me in my office at off-hours will be very difficult this semester.) To help mitigate potential problems, I will have regular review sessions (every Thursday from 5pm to 6:30pm) at an as of yet unspecified location.

**Homework, Quizzes and Tests:** As you can see from the grade breakdown, homework and quizzes are an important part of your grade. It is very difficult to learn the material in any class unless you spend a significant amount of time thinking about the subject matter and actually using the ideas. *I am here as a guide through the material, but it is you who must do the learning!!*

**Homework** is designed to get you to practice the material and to help you learn the subject matter. Typically, homework is due, in class, 1 week after the assigned date (although this will vary). I accept late homework without grade-reduction only if there are extenuating circumstances. Otherwise, I deduct 10 points (out of 100) for each day the homework is late. Students can work in groups, however your final paper must be your own. I will award zero points for instances of obvious copying!! **Quizzes** will be given each week and are, in truth, a tool for me to get you to study the material on a regular basis! Ten minutes will be given for each quiz. I will drop the lowest quiz score when computing your grade and, because of this, there will be no make-up quizzes. **Tests** provide an opportunity for me to gauge your knowledge of the course material and your ability to solve new problems. Tests will be given at night so that you have plenty of time to work all of the problems. All tests given in this course will be closed book, however you may bring a 3"x5" note card of information (front and back may be used) and a calculator.

**Participation:** Participation includes asking questions in class, responding to questions posed by me, and coming to see me and/or the TAs outside of class. This is an important component of your education and I hope that you will take advantage of in, and outside, class time to ask questions no matter how "simple" you think they might be. Typically what you will find is that other students are also confused about exactly the same issue. In order to assign participation points, I start all

students at zero. Then, I count up the number of times you've come to see me, asked/answered questions, the enthusiasm you've shown for learning the material, etc. All of this goes into participation. **How is this figured into my final grade?** I compute final grades first without participation included. Then, I add the participation points back in at the end. That way, participation can't hurt you, but it sure can help you!

**Textbooks, Readings, and Notes:** Bohren and Albrecht's book is about the best Thermodynamics book I have ever read (and I have read a LOT of thermo books). I think you folks are lucky to have such a good book. I had a TERRIBLE book (but almost all *were* terrible) when I was an undergraduate. In addition to the course book, I also suggest purchasing/reading van Ness's, "Understanding Thermodynamics." This book helped me a great deal when I was first learning thermodynamics. Readings listed in the outline are mandatory and should be read prior to class. In addition, there are a number of books in the EMS library and reading from these books is essential for a full grasp of the material. Experience suggests that rewriting your class Notes within a day or so of each lecture significantly enhances understanding of complex material. Please take this suggestion! I didn't when I was younger & later learned that it actually saved me time!!

**Academic Integrity:** This is an issue that is of the utmost importance. It is not only ethically wrong, but also dangerous, to take the work of other people and attempt to pass it off as your own. Plagiarism and cheating are offenses that can, and will, result in either the failing of a homework/project/test or the entire class, depending on the offense. You can check out Penn State's official position on intellectual integrity at the following site: <http://www.ems.psu.edu/students/integrity/index.html>.

**Grading:** What most students are really interested in (unfortunately)! You may ask how I go about assigning grades in a course like this? Well, here's how: I take all of the total scores for the class and make a grade distribution. I then compute the mean score of the distribution. The mean score is the lowest B- in the course. I then assign the rest of the grades by looking at both the standard deviation around the mean and by looking for natural breaks. A constant question that I receive is: How do I assign A's and F's? An "A" grade means someone has demonstrated superior knowledge of the course material. Hence, I only assign an A grade to students who have really excelled in the course. As for "F" grades: A score of less than 50% in the course automatically earns an "F." Do not expect a passing grade if you have done poorly on the homework, quizzes and tests, have not come to see me, and have missed classes. I will not pass anyone who has not demonstrated to me that they, at least, understand the basics of thermodynamics and how thermo is used in Meteorology. Your best bet: Come to see me and the TAs!! It is much easier for me to gauge your seriousness as a student if you come and talk with me. If you don't, I only have your raw scores to go on when assigning a grade.

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## *Course Outline*

### **I. OVERVIEW**

- A. Atmospheric Context [Sect. 1.1, 1.7, 2.6]
- B. Basic Concepts [Sect. 2.1]

### **II. ENERGY**

- A. Mechanical Systems [Sect. 1.2-1.3]
- B. Interaction Energies [Sect. 1.4, 1.6]
- C. Internal Energy and the First Law [Sect. 1.8]
- D. Zeroth Law and Thermometry [Sect. 2.1]

### **III. GASES**

- A. Gas Laws [Sect. 2.1, 2.2]
- B. Kinetic Theory [Sect. 2.1, 2.3-2.5, 5.4]
- C. Gaseous Mixtures [Sect. 2.7-2.8, 3.7]

### **IV. HEAT CAPACITIES AND ENTHALPY**

- A. Thermodynamic Functions [Sect. 3.1]
- B. Specific Heats [Sect. 3.2, 3.6-3.7]
- C. Enthalpy [Sect. 3.2]

### **V. THE SECOND LAW**

- A. Spontaneous Change [Sect. 4.1]
- B. Cyclic Processes [Sect. 4.4]
- C. Entropy [Sect. 4.1-4.3]

### **VI. MULTIPHASE SYSTEMS**

- A. Phase Transformations [Sect. 5.1-5.2]
- B. Free Energy [Sect. 5.3, 5.6-5.8]
- C. Phase Diagrams [Sect. 5.5]

### **VII. ATMOSPHERIC APPLICATIONS**

- A. Thermodynamic Diagrams [Sect. 6.6]
- B. Processes [Sect. 3.3-3.5, 6.3-6.4, 6.9]
- C. Soundings and Stability [Sect. 3.5, 6.1-6.2, 6.5, 6.7]

[Information in the brackets to the right of each topic identifies where the subject matter can be located in Bohren & Albrecht's textbook.]