Course Syllabus

Atmospheric Sciences 5950: Atmospheric Thermodynamics
Class Meetings: MWF 1:50-2:45 p.m.
Classroom: Derby Hall 0140

Instructor: Jay Hobgood
Office: Room 1100 Derby Hall
Office phone: 292-3999
Office hours: MWF 12:40-1:40
Email: hobgood.1@osu.edu

Course Prerequisites: Math 1152.

Not open to students with credit for Atmospheric Sciences 631.

Course Objectives: The basic objective of this course is to provide students with knowledge of the fundamentals of atmospheric thermodynamics. Thermodynamics deals with the processes that transfer energy and thermodynamic processes help to create and change atmospheric systems. Knowledge of the basic principles of thermodynamics and their interactions will facilitate students' comprehension of meteorological processes that determine the weather and climate of the Earth. Understanding thermodynamic processes is critical to accurate assessment of the current state of the atmosphere and to accurate evaluation of the output from numerical models of weather and climate. The four specific objectives of this course are: (1) to understand the basic principles of thermodynamics as they apply to dry air (i.e. air with no water vapor); (2) to understand the effects of the different phases of water on thermodynamic processes; (3) to determine how thermodynamic processes generate the observed structure of the atmosphere; (4) to examine how thermodynamic processes affect the stability of portions of the atmosphere.

Course Structure: The class will meet three days per week for 55 minutes each day. Lectures during the classes will present material on thermodynamic processes and their application to atmospheric situations. Important equations will be derived and the implications of assumptions will be discussed. Examples of meteorological problems will be discussed. Homework problems that involve the application of material introduced in class will also be assigned and discussed in class. Homework problems and examination are designed to test students' comprehension and ability to apply the principles of thermodynamics to "real world" atmospheric situations.

Textbook: There is no appropriate thermodynamic textbook that covers and supplements all of the topics that are discussed during this course. The following books have sections on thermodynamics that relate to the topics presented in this course and you may choose to use them to supplement the lectures.

Tsonis, A.A., 2007: *An Introduction to Atmospheric Thermodynamics*, 2nd edition, Cambridge.

Petty, G.W., 2008: *A First Course in Atmospheric Thermodynamics,* Sundog Publishing.

Bohren, C.F. and B.A. Albrecht, 1998: *Atmospheric Thermodynamics*, Oxford.

Wallace, J.M. and P.V. Hobbs, 1977: *Atmospheric Science: An Introductory Survey*, Academic Press.

Curry, J.A. and P.J. Webster, 1999: *Thermodynamics of Atmospheres &Oceans*, Academic Press.

Course requirements:

1. The **first examination** will occur on **September 25, 2019** and will comprise 25% of the course grade.

2. The **second examination** will occur on **October 30, 2019** and will comprise 25% of the course grade.

3. The **final examination** will occur at 2:00-3:45 on **Wednesday, December 11, 2019** and will comprise 30% of the course grade.

4. Sets of problems will be assigned in class and will comprise 20% of the final grade.

Examination format: Each examination will begin with a series of terms to define in one or two sentences. You will have a choice of which terms you choose to define. The remainder of the examination will consist of short essay questions that you can answer with a few sentences and problems like the problems that will be assigned as homework. The examinations are designed to test your comprehension and understanding of the material, as well as your ability to recall basic thermodynamic principles.

Homework assignments: The homework assignments are designed to accomplish several goals. The first goal is to give students some experience solving basic thermodynamic problems using concepts introduced in class. A second goal is to make students think about the thermodynamic processes that occur in certain atmospheric phenomena. More challenging problems may require students to combine thermodynamic principles in order to arrive at the solution to the problem. Some problems will be similar to the tasks require of operational meteorologists. Other problems will deal with fundamental principles and calculations that are used to develop meteorological models and software. Homework assignments are expected to be the work of the student whose name appears on them. Copying another student's work is *plagiarism* and is considered to be *academic misconduct.*

Units: Numerical answers are incomplete unless they are accompanied by the correct units. Students will lose points on examinations and homework assignments if the units are incorrect or missing.

Academic Misconduct: It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Informal discussions about homework problems are acceptable behavior but you are expected to do all of your own work on assignments and exams. Instructors shall report all instances of alleged academic misconduct to the Committee (Faculty Rule 3335-5-847). For additional information, see the Code of Student Conduct (http://studentaffairs.osu.edu/info_for_students/csc.asp).

Disability Services: Students with disabilities that have been certified by the Office of Student Life Disability Services will be appropriately accommodated, and should register with that office as soon as possible. The Office for Student Life Disability Services is located in 098 Baker Hall, 113 W. 12th Avenue; telephone 614-292-3307, VRS 614-429-1334; http://www.ods.ohio-state.edu/.

Outline of Topics

Part I: Review of basic concepts and systems (1.0 week)
- a. Systems
- b. State variables and functions
- c. Atmospheric composition

Part II: The first law of thermodynamics (3.0 weeks)
- a. Internal energy and work
- b. The first law of thermodynamics
- c. Dry adiabatic processes

Part III: The second law of thermodynamics (1.0 week)
- a. Entropy
- b. Statements of the second law of thermodynamics
- c. Implications of the second law of thermodynamics

Part IV: Thermodynamics of moist air (3.5 weeks)
- a. Saturation
- b. Phase changes of water
- c. Clausius-Clapeyron equation
- d. Humidity variables
- e. Saturated adiabatic processes

Part V: Thermodynamic diagrams (1.5 weeks)

a. Properties of an ideal thermodynamic diagram
b. Simple thermodynamic diagrams
c. Tephigram
d. Skew T-Log P diagram

Part VI: Atmospheric statics (1.5 weeks)

a. Geopotential
b. The hydrostatic approximation
c. Integration of the hydrostatic equation
d. Reduction of pressure to sea level

Part VII: Mixing in the atmosphere (1.0 week)

a. Horizontal mixing
b. Vertical mixing
c. The Mixing Condensation Level

Part VIII: Atmospheric Stability (1.5 weeks)

a. The parcel method
b. Stability indices
c. Entrainment
d. Lifting layers of air
e. Conditional Instability