

ATMOSSC 5951 (Dynamic Meteorology I)

Fall, 2024 (Aug. 25 – Dec. 12)

Course Syllabus

Class Meetings: TuTh 12:45 - 2:05 pm

Classroom: Derby Hall 0070

Instructor: Prof. Zhengyu Liu

Office: Room 1106 Derby Hall

Office phone: 614-292-7948

Office hours: After class, or email appointment over zoom

Email: liu.7022@osu.edu

Course Prerequisites

Atmospheric Sciences: Math 2153, Phys:1250

Course Objectives

The basic objective of this course is to provide students with knowledge of the fundamentals of atmospheric dynamics. The knowledge will facilitate students' comprehension of meteorological processes that determine the weather and climate. This increased comprehension of important physical processes will improve students' ability to analyze and to forecast the state of the atmosphere.

Course Structure

The class will meet two days per week for 80 minutes each day. Lectures present material on dynamic processes and their application to atmospheric situations. Important equations are derived and the implications of assumptions discussed. Examples of meteorological problems are discussed.

Textbook

Martin, J., 2006: Mid-Latitude Atmospheric Dynamics: A First Course. John Wiley & Sons, Ltd

Course Requirements

The grade for this course will be determined using the following weighted components:

- a. Mid-term examination [30%]
- b. Final examination [30%]
- c. Homework and quiz. [39%]
- d. Attendance sign up [up to 1% bonus]

For fairness between undergraduates and graduates, the grading for mid-term and/or final exam will be graded slightly in favor of undergraduates.

Detailed Requirements

Examination format: Each examination will begin with a series of terms to define in one or two sentences. The remainder of the examination will consist of short essay questions 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 dynamic principles. You may use a scientific or graphing calculator on the exams. Cell phone calculators are not permitted during exams. Complete responses to short answer questions include explanations of relevant dynamic principles.

Homework assignments: Homework assignments will be due in class every 1-2 weeks. The homework assignments are designed to accomplish two goals. The first goal is to give students some experience solving basic dynamic problems using concepts introduced in class. A second goal is to make students think about the dynamic processes

that occur in certain atmospheric phenomena. More challenging problems may require students to combine dynamic principles in order to arrive at the solution to the problem.

Pre- and Post-tests: As part of the university's upcoming accreditation, the Department of Geography and the College of Arts and Sciences have requested that pre- and post-tests be given to assess students' understanding of relevant concepts at the beginning and end of the semester. They will constitute up to a 2% bonus (1% per test) on the final grade. If you complete both tests with evidence of effort, you get the full 2%.

Class attendance: Class attendance will be registered each class in person, which may have impact on the final grade if the attendance is extremely poor without reasons.

Other Policies

Units: Numerical answers are incomplete unless they are accompanied by the correct simplified units. Points will be deducted on examinations and homework assignments if units are incorrect, unsimplified, or missing.

Late policy: Assignments and corrections are due on the stated date. Late homework will not be accepted unless you have the permission from the instructor in advance.

Academic Misconduct: All examination and homework answers 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.

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. 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: The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me, in person, as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

List of Topics

1 Introduction and Review of Mathematical Tools (3 lectures)

1.1 Fluids and the nature of fluid dynamics (Lec 1: Vector Calculus)

1.2 Review of useful mathematical tools

1.2.1 Elements of vector calculus

1.2.2 The Taylor series expansion (Lec 2: Taylor Lagrangian Eulerian)

1.2.3 Centered difference approximations to derivatives

1.2.4 Temporal changes of a continuous variable (Lec 3: Fluid Kinematics)

1.3 Estimating with scale analysis

1.4 Basic kinematics of fluids

1.4.1 Pure vorticity

1.4.2 Pure divergence

1.4.3 Pure stretching deformation

1.4.4 Pure shearing deformation

1.5 Mensuration
HW Set 1

2 Fundamental and Apparent Forces (2+ lectures)

- 2.1 The fundamental forces (Lec 4: Fundamental Forces)
 - 2.1.1 The pressure gradient force
 - 2.1.2 The gravitational force
 - 2.1.3 The frictional force
- 2.2 Apparent forces (Lec 5: Apparent Forces)
 - 2.2.1 The centrifugal force
 - 2.2.2 The Coriolis force

HWSets 2

3 Mass, Momentum, and Energy: The Fundamental Quantities of the Physical World

- 3.1 Mass in the atmosphere
 - 3.1.1 The hypsometric equation (Lec 6: Hydrostatic Equation)
- 3.2 Conservation of momentum: the equations of motion
 - 3.2.1 The equations of motion in spherical coordinates (Lec 7: Momentum Equation)
 - 3.2.2 Conservation of mass (Lec 8: Mass Equation)
- 3.3 Conservation of energy: The energy equation (Lec 9: Energy Equation)

4 Applications of the Equations of Motion

- 4.1 Pressure as a vertical coordinate (Lec 11: Pressure Coordinate)
- 4.2 Potential temperature as a vertical coordinate (Lec 10: Lapse Rate & Stability)
- 4.3 The thermal wind balance (Lec 12: Thermal Wind)
- 4.4 Natural coordinates and balanced flows
 - 4.4.1 Geostrophic flow (Lec 13: Natural Coordinate)
 - 4.4.2 Inertial flow
 - 4.4.3 Cyclostrophic flow
 - 4.4.4 Gradient flow (Lec 14: Gradient Wind)
- 4.5 The relationship between trajectories and streamlines

5 Circulation, Vorticity, and Divergence

- 5.1 Circulation theorem and its physical interpretation (Lec 15: Circulation)
- 5.2 Vorticity and potential vorticity (Lec 16: Vorticity and Potential Vorticity)
- 5.3 The relationship between vorticity and divergence (Lec 17: Vorticity Equation)
- 5.4 The quasi-geostrophic system of equations (Lec 18: Quasi-Geostrophic System)