ATM SCI 351 Dynamic Meteorology I FALL 2022

Section	LEC 001
Class Number	19307
Level	U/G
Credits	3
Prereq	jr st; Atm Sci 240 (P); Math 233 (P)
Dates	9/6–12/14
Days/Hours	MW 11:30–12:45am
Format: f2f	EMS E150
Instructor	Kravtsov, Sergey
Text	Holton, J. R. "An Introduction to Dynamic Meteorology," Chapters 1–4.
Additional refs.	Gill, A., 1982 "Dynamics of Atmospheres and Oceans." Kundu, P. K., 1990 "Fluid Mechanics." Pedlosky, J., 1987 "Geophysical Fluid Dynamics."

Description

This class introduces a theoretical framework for analysis of large-scale motion within the Earth's fluid envelope. Format: Weekly lectures, readings and assignments combined with Q&A and problem-solving sessions.

Homework, Exams, Grading

The students will be given four major homework projects (each worth 25 pts), and a large-number (~10–15) of 5-pt "in-class" assignments. **Most of the assignments and all of homework are open book**. Final exam will consist of two parts. The first part (closed book) will contain qualitative/theoretical questions (common for all students), while for the second part (open book) each student will be given individual problem(s) to solve. The final exam will be worth 100 pts (theory: 70pts + problem: 30pts). The final grade will be computed as follows (in percentage of maximum possible score based on all assignments excluding extra-credit assignments): A (91%–100%), B (81%–90%), C (71%–80%), D (61%–70%), F (<60%).

Office hours

EMS W441 or online, via Skype or Microsoft Teams. Officially, MW 1:30–3pm. However, please feel free to arrange an online appointment via email for any other time, including weekends.

Syllabus Addendum

To comply with a Higher Learning Commission requirement, we provide below information on the estimated amount of time an average student needs to invest in order to achieve the learning goals for this class:

- 35 hours in the classroom
- 67 hours for weakly readings, quizzes and homework assignments
- 40 hours of study and preparation for quizzes and exams
- 2-hour final exam

Total number of hours: 144

Syllabus COVID-19 Statement

See https://uwm.edu/cetl/covid-19-syllabus-statements/

Tentative schedule

9/7 ***Lecture 1*** The scope of Dynamical Meteorology. "Geophysical" vs. "classical" fluid dynamics. Fluid parcels and field variables. Gravitational force.

Homework #1: Vector operations and introduction to field theory **(due 9/26)**.

9/12 ***Lecture 2*** Effects of density stratification and Earth's rotation. Large-scale motion. Rossby number. Newton's laws. Introduction to Coriolis force.

9/14 ***Lecture 3*** Forces in a rotating reference frame. Centripetal acceleration and centrifugal force. Gravity force. Geopotential. Geopotential height.

9/19 ***Lecture 4*** Coriolis force (derivation and example problems).

9/21 ***Lecture 5*** Structure of the static atmosphere. Pressure gradient force. Hydrostatic balance. Equations of state for dry atmosphere. Atmospheric scale height. Standard atmosphere's vertical temperature profile. Pressure as a vertical coordinate (introduction).

9/26 ***Lecture 6*** Pressure as a vertical coordinate. Seminar I (problems to *Chapter 1 of Holton*).

Homework #2: Forces in a rotating frame of reference. Hydrostatic balance (**due 11/7**).

9/28 ***Lectures 7, 8*** Mass conservation. Forms of continuity equation. Material derivative (derivative following fluid parcel). Advection. Eulerian and Lagrangian description of a fluid in motion.

10/3, 5, 10, 12, 17, 19 ***Lectures 9–14*** Momentum equations in an absolute reference frame. Momentum equations in a rotating reference frame. Momentum and continuity equations in spherical coordinates.

10/24 ***Lecture 15*** Energy budget. First law of thermodynamics. Thermodynamic energy equation. Mechanical energy equation. Internal energy equation. Entropy.

10/26 ***Lecture 16*** Potential temperature. Adiabatic (isentropic) process. Dry adiabatic lapse rate. Static stability of a dry atmosphere.

10/31 ***Lecture 17*** Summary of governing equations. Scaling analysis of a vertical momentum equation. Validity of a hydrostatic approximation.

11/2 ***Lecture 18*** Scaling analysis of horizontal momentum, continuity, and internal energy equations.

11/7 ***Lecture 19*** Seminar II (problems to *Chapter 2 of Holton*).

Homework #3: Derivative following the motion. Isentropic process. Energy considerations (**due 11/28**).

11/9 ***Lecture 20*** Approximate relations between field variables describing weather systems (in pressure coordinates).

11/14 ***Lecture 21*** Elementary applications of governing equations. Natural coordinates. Geostrophic flow. Inertial flow. Cyclostrophic flow. Gradient wind.

11/16 ***Lecture 22*** Thermal wind.

11/21 ***Lecture 23*** Barotropic and baroclinic atmospheres.Vertical motion. Surface pressure tendency.

11/23 NO CLASS: Thanksgiving break

11/28 ***Lecture 24*** Seminar III (problems to *Chapter 3 of Holton*).

Homework #4: Basic applications of approximate governing equations (**due 12/19**).

11/30 ***Lecture 25*** Similarity of dynamical equations describing the ocean and the atmosphere. (Distribute individual exam problems.)

12/5, 12/7 ***Lectures 26, 27*** Review.

12/12, 14 Q&A sessions, final homework/quiz corrections accepted.

12/19 ***Final exam*** **(qualitative/theoretical part). Exam problems are due.**