Atmospheric Physics I

PHYS 621, Fall 2011

Dates and Location: Tuesday & Thursday, 2:30pm- 3:45pm (Room: PHYS201)

INSTRUCTOR: Dr. Zhibo Zhang
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OFFICE HOURS: PHYS417: Friday 3:30~4:30PM or Through Email

TEXTS:
Salby, M. L., Fundamentals of Atmospheric Physics, Academic Press, 1996.
Wallace, J.M. and P. V. Hobbs, *Atmospheric Science: An Introductory Survey*, 2nd ed., Elsevier, 2006

REFERENCE TEXTS:
Andrews, D., Introduction to Atmospheric Physics
Fleagel, R. G. and J. A. Businger, *An Introduction to Atmospheric Physics*, 2nd ed., Academic Press, 1980.
Hartmann, D. L. *Global Physical Climatology*, Academic Press, 1994. Emphasis is on the physics of the atmosphere as it relates to the atmosphere-ocean-land surface climate system.
Holton, J. R. *Introduction to Dynamic Meteorology*, 4th ed., Academic Press, 2004.
Houghton, J. T., *The Physics of Atmospheres*, 3rd ed., Cambridge University Press, 2001
Petty, G.W. A First Course in Atmospheric Thermodynamics, Sundog Publishing, 2008 (www.sundogpublishing.com) [<- cheapest option]

DESCRIPTION: **Composition and structure of the earth's atmosphere, atmospheric thermodynamics, fundamentals of atmospheric dynamics, overview of climatology.**

GRADING:
Homework (30%), Midterm (30%), Final (30%), Participation/Discussion(10%)

COURSE OUTLINE:

I. Overview

A. Earth's atmosphere
- System of units
- The Sun and the orbit and size of Earth
- Chemical constituents of Earth's atmosphere
- Vertical structure of temperature and density
- Wind and precipitation
- Ozone layer, hydrological and carbon cycles
- Global Energy Budget

B. Radiation Basics and Earth's Radiation Energy Budget
- Blackbody radiation: Planck's Law and Stefan-Boltzmann's law
- Earth's Radiation Energy Balance & Greenhouse effect
- Spatial and Temporal distribution of solar radiation
- Spectral characteristics of Solar and Thermal infrared radiation

C. Overview of atmospheric motion and the general circulation
- Atmospheric Forces, Coriolis effect and Coriolis force
- One-cell circulation model and three-cell circulation model
- Effects of season and land mass distribution
- Jet stream and monsoon
- General circulation and climate zones

II. Atmospheric thermodynamics

A. Fundamental thermodynamic ideas
- Ideal gas equation of state; Dry air as a mixture of ideal gases;
- First Law: work, heat, specific heat and energy conservation
- Second Law: entropy, adiabatic processes, potential temperature
- Thermodynamic potentials
- Thermodynamic cycles
- Hydrostatic equation, scale height, geopotential
- Dry adiabatic lapse rate and static stability

B. Thermodynamics of moist air
- Phase changes of water and the phase diagram, latent heat
- Humidity, vapor pressure
- Saturation vapor pressure, Clausius-Clapeyron equation
- The pseudo-adiabatic chart
- Saturated adiabatic lapse rate

C. Static stability
- Lifting condensation level (LCL), level of free convection (LFC)
- Brunt-Vaisala frequency and gravity waves
- Subsidence; heating by compression

D. Thermodynamic aspects of various weather and climate phenomena:
Cloud formation, hurricanes, rain shadow deserts, monsoons

III. Atmospheric Dynamics

A. Kinematic and mathematical fundamentals
Vector differential operators and integral theorems
Scalar, vector, and tensor fields
Vorticity and divergence
Rotating frames
Curvilinear coordinates

B. Atmospheric forces
Driving versus steering forces
Gravity, pressure gradient, Coriolis, friction, centrifugal force
Pressure gradient force on isobaric surfaces
The sea breeze
Geopotential height contours, surface and 500mb weather maps

C. Atmospheric equations of motion
Eulerian and Lagrangian frames, streamlines and trajectories
Forces and stresses
Conservation of mass: continuity equation
Conservation of energy: thermodynamic equation
Conservation of momentum: momentum equation

D. Applications of the equations of motion: balanced flow
Geostrophic, cyclostrophic and inertial flow
Gradient wind, thermal wind and temperature advection
Frictional effects

E. Applications of the equations of motion: time dependent
Scale analysis
Creation, conservation and modification of vorticity
Barotropic vorticity equation and Rossby waves
Barotropic and baroclinic stratification
Sound waves, shallow water waves and gravity waves
Potential vorticity on isentropic surfaces

IV. The planetary boundary layer

A. Overall structure and processes
Vertical transport of mass, energy and momentum
Aspects of turbulence
Modelling rapidly varying and small scale degrees of freedom
Reynolds decomposition, flux gradient, eddy fluxes
Ekman spiral, Ekman pumping
Coupling of the climate subsytems in the PBL

V. Miscellaneous topics (as time permits)

Ocean-atmosphere coupling: El Nino
Modeling the atmosphere: general circulation models (GCMs)
Unresolved scales: the parameterization problem
Atmospheric data and data assimilation; the observational network, measurement platforms: satellite, aircraft, ship, lidar, balloon
Mathematical and statistical tools in data analysis
Predictability: a simple example of chaos
Coupled systems: Feedbacks, oscillations and steady states
Periodic forcing and relaxation
Atmospheric mixing and transport
Mesoscale phenomena

Academic Honesty Policy

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. [Statement adopted by UMBC's Undergraduate Council and Provost's Office.]