Atmospheric Physics I

PHYS 621, Fall 2015

Dates and Location: Tuesday & Thursday, 2:30PM- 3:45AM

INSTRUCTOR: Dr. Pengwang Zhai
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OFFICE HOURS: Anytime Through Email appointment

TEXTS:

REFERENCE TEXTS (Highly recommend):

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

GRADING:
Homework (25%), Two Midterms (20% each), Final (30%), Participation/Discussion(5%)
COURSE OUTLINE:

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. Atmospheric Radiation
   Maxwell’s Equation & EM wave
   Blackbody radiation: Planck’s Law and Stefan-Boltzmann’s law
   Spectral characteristics of Solar and Thermal infrared radiation
   Atmospheric absorption & Greenhouse effect
   Atmospheric scattering, clouds and aerosols
   Radiative forcing and climate
   Spatial and Temporal distribution of solar 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

Atmospheric thermodynamics

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

**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

**The planetary boundary layer (if time permits)**

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
**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.]