COURSE TITLE: Atmospheric Physics I PHYS 621 Fall 2018
Dates and Location: Tuesday & Thursday, 2:30pm- 3:45pm (Rm: Math/Psychology 105)

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

INSTRUCTOR:

Dr. Lynn Sparling (sparling@umbc.edu). ph:410-741-6355

OFFICE HOURS:
Sparling: 1130-1 T, TH or by appt

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

REFERENCE TEXTS:
Andrews, D., Introduction to Atmospheric Physics
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.
Petty, G.W. A First Course in Atmospheric Thermodynamics, Sundog Publishing, 2008 (www.sundogpublishing.com) [<- cheapest option]

GRADING: Homework: 10%, Quizzes: 30% Midterm : 20% Final: 25%, Projects: 15%

WEBSITES: (more will be added – see Bb):

Weather and climate research at NOAA: https://www.esrl.noaa.gov/psd/

Online tools for plotting global atmospheric fields (winds, temperatures, pressure, precipitation, etc.) for climate analyses:

https://www.esrl.noaa.gov/psd/data/20thC_Rean/

Weather events (fields every 3 hours) can be plotted using the North American Regional Reanalysis (NARR) meteorological data which can be found at

https://www.esrl.noaa.gov/psd/cgi-bin/data/narr/plothour.pl/

We will use the NOAA data for some HW assignments.

For an interesting view of the current state of the atmosphere and ocean, see

https://earth.nullschool.net/#current

Some proficiency in coding/plotting is required for the data analysis assignments. You may use the language of your choice, but Python is recommended. We may use Jupyter notebooks (Python).

COURSE OUTLINE:

I. Overview

A. Origin, composition and structure of the Earth's atmosphere
- Chemical constituents, turnover times, spatial structure
- Vertical structure of temperature and density
- Ozone layer, water and carbon cycles
- Distribution of water & land, topography

B. Global energy balance
- Geometric aspects of incoming solar radiation, dependence on orbital parameters, seasonal variability
- Balance of incoming and outgoing radiation; spectral characteristics
- Blackbody radiation
- Greenhouse effect

C. Overview of atmospheric motion and the general circulation
- Length and time scales of atmospheric phenomena; kinetic energy spectrum
- Hadley and Walker circulations, zonal mean circulation
- Polar and subtropical jet streams, global surface pressure

II. Atmospheric thermodynamics

A. Fundamental thermodynamic ideas
- Dry air as a mixture of ideal gases; ideal gas equation of state
- 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
- The atmosphere as a heat engine

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 (review)
- 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), coupling to ocean and land
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