May 2009

Physics 107 – Introduction to Meteorology (4)
Course Outline GE B3

Prerequisites for Phys 107: Passing score on ELM examination, or an ELM exemption, or credit in MATH 104

Learning Objectives and Criteria:

The student should:

1) Be able to read weather maps.
2) Be able to take basic atmospheric data and create weather maps.
3) Understand the physics of storm systems, such as hurricanes, tornadoes, and lightning storms.
4) Understand the physics of air pressure, pressure changes, Coriolis force, physics of air masses, cyclones and fronts.
5) Recognize different kinds of clouds and understand what they indicate for the weather.
6) Understand global atmospheric circulation patterns.
7) Understand wind patterns on a global scale.
8) Understand local wind patterns, such as Chinooks and Santa Anas.
9) Understand how the atmosphere and oceans are linked.
10) Understand how temperature, pressure, wind speeds, humidity, etc. vary with altitude.
11) Be able to manipulate simple equations relating to atmospheric phenomena, such as how pressure decreases exponentially with altitude.
12) Become familiar with dew points and saturation of the atmosphere, and be able to predict when precipitation will occur.

Physics 107 introduces properties of the Earth's atmosphere, such as temperature, winds, humidity, cloud and storm formation and development, atmospheric circulation, weather forecasting, pollution and climatic change.

Text and References:

Meteorology Today: An Introduction to Weather, Climate and the Environment, C. Donald Ahrens, 9th Edition, Brooks/Cole - Cengage Learning, 2007.

Content and Method:

Method: Physics 107 is a traditional lecture course (4 Lectures). There are occasional demonstrations.

Three problem sets, three mid-term examinations and a comprehensive final. A written report on a topic of interest during the quarter (e.g., Dust Bowl, Hurricane Andrew, Global Warming, Climate changes). Mid-terms count as approx. 20% each, the final exam as approx. 20%, and problem sets plus reports as approx. 20%. Written work constitutes a little more than 10% of the grade, split equally between the report and the homework sets.

Content: Physics 107 will adhere to the following topics:

- Week 1) General atmosphere properties, composition and warming, global temperature patterns. The student will be introduced to the fundamental concepts of thermal physics, including density, heat capacity, conduction, convection and radiation.

- Week 2) Atmospheric temperature. Physics of rising and sinking air columns. Focus on instruments used in meteorology. Further discussion of basic ideas in thermodynamics, especially heat transfer, and the resulting fluid motions.

- Week 3) Humidity, condensation and clouds. Discussion of specific heat and latent heat, and the importance in understanding temperature changes, and also changes of phase, from gas to liquid, liquid to solid, as needed to understand the physics of cloud formation, evolution and precipitation. Lab activities on cloud formation. Precipitation.

- Week 4) Air pressure and winds. There will be discussion of the Force laws, and principles of conservation of energy and momentum. The concepts of what exactly causes winds to form and move will be discussed. More work with weather maps.

- Week 5) Atmospheric circulation, local and global. Concepts such as the Jet Stream will be introduced, with emphasis on how the laws of rotational motion, and in particular the Coriolis force must be understood to explain the behavior of the Jet Stream. Discussion of links with ocean currents and patterns. The concept of heat transfer between the atmosphere and water will be understood.

- Week 6) Air masses, fronts and mid-latitude storms. The physics of what happens when air masses of very different temperature, pressure and composition (such as water content) collide will be discussed, and the resulting storms that ensue. Weather forecasting. Activities include reading weather maps and forecasting. Students will create a weather map.

- Week 7) More on forecasting. Storms, Tornadoes and Hurricanes. We will discuss the physics of the formation of waves, build-up of electrical charge within clouds, and wave equations. We will build a machine to simulate a tornado, and a lightning machine (including demonstration of static electricity with Van de Graaf generators.

- Week 8) More on the storm systems above.

- Week 9) Air pollution; Particulate composition of the air; sulphur dioxide and carbon dioxide; Effects on the weather, lakes, land area. This will rely heavily on fundamental concepts in thermal physics and fluid mechanics.

- Week 10) Global climate and change, El Nino effects and general sky viewing. Discussion of the causes of ice ages and how this is tied to the motion of the earth in terms of rotation and revolution around the sun. Discussion of Kepler's Laws of Planetary Motion will occur.