Knowledge Expectations for METR 2013
Introduction to Meteorology I

Purpose: This document describes the principal concepts, technical skills, and fundamental understanding that all students are expected to possess upon completing METR 2013, Introduction to Meteorology I. Individual instructors may deviate somewhat from the specific topics and order listed here.

Pre-requisites: Grade of C or better in MATH 1823
Co-requisites: MATH 2423, PHYS 2514, METR 2011, CS 1313 (or CS 1323)

Goal of the Course: The Introduction of Meteorology sequence introduces students to important phenomena and physical processes that occur in the Earth's atmosphere. Students will learn the basic concepts and instruments used to study atmospheric problems. Part I of the Introduction to Meteorology sequence focuses on atmospheric radiation, thermodynamics, moisture, stability, clouds, and precipitation.

Topical Knowledge Expectations

I.   **Basics**
- <u>History</u>. Place the science of meteorology in historical context with other physical sciences such as chemistry and physics. Understand the scientific advances that make meteorology viable (computers, communications, and instrumentation, especially remote sensing).
- <u>Dimensions and units</u>. Understand various systems of units in physical sciences and the need for units. Know the basic dimensions in science, from which all other dimensions are derived. Understand the importance of including units with calculations and that units must be accounted for with the same care as other mathematical treatments. Demonstrate the ability to convert among systems of units.
- <u>Coordinate systems and meteorological conventions, including Eulerian and Lagrangian reference frames</u>. Understand that it is necessary to create a reference system in which one can locate and describe the movement of atmospheric parcels. These may be points in space (Eulerian reference) or parcels of a moving fluid (Lagrangian reference).
- <u>Basic physics (first principles, energy, equation of state, kinetic theory)</u>. Understand that atmospheric parcels obey Newton's laws and the laws of thermodynamics. Be familiar with the ideal gas law, the bulk properties and movements of fluids, and conservation of various properties.
- <u>Meteorological measurements</u>. Know the atmospheric properties that are measured at a surface weather station. Understand basic procedures involved in weather data analysis and presentation.

II. Earth and its Atmosphere
- Be able to discuss the origin, evolution, and current composition of the atmosphere.
- Understand the relationship of the volume and density of air to pressure and temperature.
- Discuss the formation and destruction of stratospheric ozone.
- Know the general compositions and characteristics of the atmospheres of other planets in our solar system.

III. Radiation
- Understand the definitions and units used for energy and radiation.
- Understand why we have seasons (solar angle, length of day).
- Know how to calculate zenith angle.
- Understand the daily temperature cycle and how that relates to radiation.
- Be able to name the various components of the electromagnetic spectrum that impact Earth (from gamma through microwave). Know the difference between solar radiation and Earth radiation and be aware of various measurement techniques.
- Understand absorption and emission of radiation by molecules.
- Understand the difference between diffuse and parallel plane radiation.
- Blackbody radiation: Understand the applications of Planck's Law, Wien's Law and the Stefan-Boltzmann Law and the relationships between them.
- Understand albedo.
- Know why greybodies are important. Understand what equilibrium implies. Work with these concepts and some geometry to be able to calculate the radiative equilibrium temperature.
- Understand the concepts of transmissivity and extinction and be introduced to Beer's Law and how it relates to atmospheric absorption.
- Understand the Greenhouse effect and the various gases that contribute to it.
- Understand the general concept of scattering of short wave radiation in the atmosphere.
- Understand how radiative transfer relates to the global energy balance.

IV. Thermodynamics
- Understand the gas laws and how pressure, volume and temperature can be related to the equation of state.
- Know Dalton's Law and the definitions of partial pressure, partial volume, mass mixing ratio and volume mixing ratio.
- Be able to formulate the hydrostatic balance for an air column and know the hydrostatic equation.
- Understand the differences between sensible and latent heat.
- Understand the First Law of Thermodynamics, and be able to derive and apply it.
- Know the definition of an adiabatic process and be able to calculate the dry and moist adiabatic lapse rates.
- Understand the concepts of potential and virtual potential temperature and be able to calculate the potential and virtual potential temperatures.

- Understand the concept of a parcel and when to use the concept. Be able to contrast that with atmospheric sounding data.
- Understand why we use geopotential height, virtual temperature, and the equation of state to derive the hypsometric equation. Also, understand the physical meaning of scale height and how it is used to obtain sea level pressure.
- Understand a reversible process and be able to contrast with an irreversible one. Be introduced to the ideas of the Carnot cycle, entropy and the Second Law of Thermodynamics.

V.   Moisture
- Know the different phases of water that are present in the atmosphere and understand the hydrological cycle.
- Understand the concept of vapor pressure and saturation. Be able to effectively use the Clausius-Clapeyron equation.
- Understand the physical meaning of different moisture variables, be aware of how they are measured, know their units and be able to relate the different variables to each other.

VI.   Stability and Instability
- Understand the parcel concept and be able to determine the atmospheric stability given the environmental lapse rate or temperature profile.
- Know the basic features of a stable, neutral, conditionally unstable and unstable atmosphere and the environmental conditions that can result in the different stabilities.
- Understand the four primary ways of cloud formation.
- Be able to determine the cloud condensation level.
- Be able to use a form of the thermodynamic diagram (e.g., Skew-T, Stuve) to study atmospheric processes.

VII. Clouds
- Understand the importance of cloud condensation nuclei in the formation of clouds.
- Know the four major cloud groups (high, middle, low, vertical development).
- Know the ten types of clouds, and the group to which they belong.
- Know the major characteristics of each cloud type.
- Understand the formation of dew and frost.
- Know the different types of fog and understand their formation mechanisms.

VIII. Precipitation
- Understand the curvature and solute effect.
- Be able to describe the collision-coalescence process of precipitation formation.
- Be able to describe the Bergeron process of precipitation formation.
- Know the various forms of precipitation and the conditions under which each forms.
- Discuss the pros and cons of various types of rain gauges.
- Understand that radar can be used to estimate rainfall rate.
- Know how to determine the liquid water equivalent of snow.

Knowledge Expectations for METR 2011
General Meteorology Lab I

Purpose: This document describes the principal concepts, technical skills, and fundamental understanding that all students are expected to possess upon completing METR 2011, General Meteorology Lab I.

Pre-requisites: Grade of C or better in MATH 1823
Co-requisite: METR 2013 (normally taken concurrently)

Goal of the Course: General Meteorology Lab I reinforces the theoretical concepts provided in the counterpart lecture course Introduction to Meteorology I (METR 2013), which introduces students to important phenomena and physical processes that occur in the Earth's atmosphere. Through a series of laboratory exercises, students will learn the basic concepts and tools that are used to study atmospheric problems. Special emphasis will be placed on developing information technology and computational skills. The laboratory exercises target the topics covered in METR 2013 and, for more detail, please refer to the knowledge expectations for METR 2013.