Dr. Droegemeier

METR 3133 – Mesoscale Meteorology
Fall 2016

Exam #1 Study Guide

Below are listed the principal topics, concepts, and capabilities for which you will be responsible on the first exam. The absence of a topic from this sheet does NOT imply that it will be absent from the exam!

Fundamental Concepts

1. Be able to explain the difference between kinematics and dynamics.
2. Understand the definition of a Newtonian fluid
3. Be able to explain the concept of an air parcel and how it relates to its microscopic counterpart, the air molecule
4. Understand the difference between dependent and independent variables

Units, Dimensions, and Atmospheric Variables

1. Be able to explain the difference between units and dimensions and give examples of each
2. Know the principal MKS units
3. Know and be able to explain the fundamental dependent variables in atmospheric dynamics and thermodynamics (e.g., temperature, mass, force, density)
4. Understand and be able to utilize the scales of the atmosphere to distinguish how various types of features and processes differ (e.g., the horizontal scale of a synoptic low pressure system versus a thunderstorm)
5. Know what an order of magnitude difference means
6. Understand the Orlanski system for horizontal atmospheric scales
7. Be able to explain the vertical scales and regions of the lower atmosphere
8. Know the time and space scales of various atmospheric phenomena
9. Understand the importance of phenomena in the atmosphere being linked across time and space scales
10. Understand the concept of dimensional homogeneity
11. Be able to convert from one set of units to another
12. Be able to determine the units or dimensions of a quantity given other quantities related to it
13. Know that arguments of transcendental functions (e.g., sine, logarithm) must be non-dimensional

Coordinate Systems

1. Understand the definition of a coordinate system and its components (e.g., origin, abscissa, ordinate)
2. Understand how to transform variables from one coordinate system into another that is coincident with it at the origin but rotated through a given angle. You will NOT need to memorize the formulas for the transformation.

3. Understand and be able to utilize the equation for a line in performing coordinate system manipulations.
4. Understand and be able to apply the geometric definitions of sine and cosine
5. Understand the concepts of reflection and scaling in coordinate transformations
6. Know and be able to utilize the structure of a polar coordinate system
7. Know the equation for a circle in polar coordinates
8. Know and be able to utilize the position vector in Cartesian coordinates
9. Know the definition of a unit vector
10. Understand the difficulty introduced in taking the derivative of a vector in a coordinate system that is rotating, or in which the unit vectors are otherwise functions of time
11. Understand how to convert between polar and Cartesian coordinates
12. Be able to give one or more physical examples of polar coordinates in meteorology
13. Know how to apply the chain rule in converting between polar and Cartesian coordinates
14. Understand the cylindrical coordinate system and its components
15. Understand the spherical coordinate system and its components
16. Be able to coordinate between Cartesian and cylindrical coordinates (you will not have to memorize the conversion formulas)
17. Be able to coordinate between Cartesian and spherical coordinates (you will not have to memorize the conversion formulas)
18. Be able to give meteorological examples in which cylindrical and spherical coordinates are used
19. Be able to express a vector in a rotated coordinate system
20. Understand how to find the angle between two lines in a Cartesian coordinate system (you will not have to memorize the conversion formulas)

<u>The Ekman Model</u>

1. Be able to explain physically what the Ekman model represents mathematically and understand all of the terms and variables in the equations
2. Understand the physical role of eddy viscosity in the Ekman model
3. Know the definition of the geostrophic wind and be able to express it in vector and scalar (component) form
4. Be able to explain plots of the horizontal wind [u(z),v(z)] as solutions to the Ekman model, and also the same information on a wind hodograph
5. Understand the extremes of the Ekman model solutions (z = 0 and infinity)
6. Know how to convert the Ekman wind solutions from the original coordinate system to one rotated through a specified angle. You will not have to memorize the conversion formulas but will need to know how to utilize the solutions.
7. Understand how to utilize the Ekman model to define the top of the atmospheric boundary-layer
8. Know what is meant by the Ekman spiral
9. Understand the significance of the actual winds deviating from the geostrophic winds in the Ekman model aka Ekman pumping
10. Be able to compute the angle between the geostrophic and actual wind, in the Ekman model, as a function of height (you will be given the equations), and be able to interpret it for specific altitudes if given plots

Scalars and Vectors

1. Know the formal definitions of a scalar and a vector and how they differ
2. Be able to give physical examples of scalars and vectors in the atmosphere
3. Understand how to add and subtract two vectors graphically and mathematically
4. Understand and be able to manipulate the components of vectors
5. Understand how the commutative, associative, and distributive properties apply to vector manipulations
6. Know the definition of a unit vector and how to create one given an arbitrary vector
7. Know the mathematical definition of a scalar (dot) product and how to compute it given two vectors
8. Understand the concept of projection for dot products
9. Know how to compute the magnitude of a vector
10. Be able to give physical examples of dot products in meteorology or explain them if given to you
11. Know the condition, using the dot product, for two vectors to be parallel or perpendicular
12. Know the condition for two vectors to be equal