

ATMO 352
Severe Weather and Mesoscale Forecasting
Spring 2007
STUDY GUIDE – Exam #1

- Date:** Monday, 2/26/07
- Time:** Class period: 50 minutes, 12:40 – 1:30 PM. Please arrive a few minutes early to allow time to hand out exam.
- Location:** O&M, Room 103
- Type:** Closed book and notes. *You must work independently!*
- Form of Exam:** Approximately three major questions with sub-parts. Midterm exams can be a mixture of objective (e.g., multiple choice, true/false) and/or subjective (e.g., short answer/definition, problem solving, derivation) questions. A typical midterm might include 1) multiple choice/true-false questions (10 minutes, 20%), 2) short answer questions (20 minutes, 40%), and 3) a problem solving/derivation question with sub-parts (20 minutes, 40%).
- Material Covered:** - Lecture notes and web-page lecture materials from 1/22/07 to 2/14/07, inclusive (Chapters 1 and 2)
- Lab notes and web-page lab materials accompanying lab exercises 1-4.
- Required reading assignments numbers 1 – 4 as specified on the class web page (i.e., COMET MetEd modules “Principles of Convection” I and II and specified sections from “Use of The Skew-T Log-P Diagram in Analysis and Forecasting”).

Instructional/Learning Objectives

1. List three categories of severe convective weather according to the National Weather Service (NWS).
2. List and describe a classification scheme for mesoscale weather, including typical temporal and spatial scales and weather features.
3. Define hydrostatic balance and the non-hydrostatic condition mathematically and in your own words.
4. Distinguish between mesoscale (meso- β to meso- γ) convective phenomenon studied in this class from synoptic scale weather using the concept of hydrostatic balance and vertical motion.
5. Describe convection from the perspective of a meteorologist.
6. Describe buoyancy in your own words. Explain the relationship between buoyancy and convective updrafts and downdrafts.
7. List two factors that increase and two factors that decrease buoyancy.
8. Identify and describe the four stages of the buoyancy process governing the evolution of convection.
9. Explain what is meant by positive and negative buoyancy.

10. Given an atmospheric sounding on a skew-T log-P diagram, assess whether a parcel is positively or negatively buoyant at a given pressure level.
11. Given the vertical equation of motion for an isolated parcel and appropriate assumptions for a convective cloud (i.e., parcel theory), derive an expression relating the updraft to the Convective Available Potential Energy (CAPE) in terms of the virtual temperatures of the environment and ascending parcel.
12. Using the mathematical definition of CAPE, derive the units of CAPE. Show that the units can also be described by energy per unit mass of the air parcel.
13. List the definition of the lifting condensation level (LCL), level of free convection (LFC), equilibrium level (EL), and convection condensation level (CCL).
14. Given a vertical profile of environmental temperature and dewpoint, identify the potential parcel path on a skew-T log-P diagram by determining the LCL, LFC and EL and following the appropriate adiabat between each level.
15. Given a vertical profile of environmental temperature, estimate the environmental lapse rate of temperature (Γ) in a specified layer (e.g., 850-500 mb or 700-500 mb).
16. Describe conditional instability both verbally and mathematically. Using a given or calculated value of Γ in a specified layer, evaluate the stability condition of the parcel in that layer.
17. In your own words, describe the meaning of CAPE from a “work” perspective and from a graphical perspective on a skew-T log-P thermodynamic chart.
18. Given a simplified form of the vertical equation of motion, derive a relationship between CAPE and updraft strength according to parcel theory.
19. List typical values for low, moderate, high and extreme CAPE. For each of these values, estimate the predicted maximum updraft speed from the expression derived in 2) above (i.e., parcel theory). For each range of CAPE, identify the actual range of maximum updraft speeds for ordinary/multi-cell and supercell convection.
20. Identify and describe the most commonly used forms of CAPE described in lab and calculated by NSHARP for our lab exercise. Be sure to highlight the differences between each type of CAPE.
21. Identify and explain the discrepancy between the maximum updraft predicted from parcel theory and those actual maximum updraft speeds measured in ordinary storms. Describe the conditions under which the actual maximum updraft in convection might be well predicted by parcel theory.
22. Given a value of CAPE, evaluate convective intensity by estimating the maximum updraft speed in ordinary/multi-cell and supercell convection that is 1) predicted by parcel theory and 2) more typical values.
23. List the mathematical definition of Normalized CAPE (NCAPE) and define it in your own words.
24. Identify and explain how the vertical profile of buoyancy or CAPE might affect the maximum updraft speed in real convection. Given two soundings with equal CAPE but different vertical distributions of buoyancy (or alternatively, two different values of NCAPE), identify the sounding most likely associated with the larger actual maximum updraft speed.
25. Given two idealized soundings with obvious differences in the vertical stratification of moisture and temperature, evaluate which one would likely be associated with the stronger updraft or downdraft.

26. Define radar reflectivity in “linear” ($z, \text{mm}^6 \text{m}^{-3}$) and logarithmic forms (Z, dBZ). Given values of N (i.e., concentration) and D (diameter) for a monodisperse size distribution (i.e., all hydrometeors of the same size), calculate radar reflectivity.
27. Assuming a balance level for precipitation and given a simple relationship between precipitation terminal fall speed and diameter, explain how CAPE and updraft can be approximately related to radar reflectivity. Given an assumed increase in CAPE, evaluate the associated approximate increase in radar reflectivity.
28. List a mathematical definition of the convective inhibition (CIN) and describe it in your own words from a “work” perspective and from a graphical perspective on a thermodynamic chart (e.g., SKEW-T).
29. Identify and describe the temperature profile associated with significant CIN. Describe the relationship between a “cap” or “lid” and CIN.
30. Identify and describe four common mechanisms for overcoming CIN and triggering convection. To support your verbal description, utilize idealized thermodynamic profiles of temperature and dewpoint before and after the triggering of convection for each mechanism.
31. Given the necessary thermodynamic data, define, describe and calculate the following stability indices: Lifted Index, Total-Totals Index, and K-index. Describe strengths and weaknesses of each index.
32. Describe the problem(s) associated with using a single stability index for convective and severe weather forecasting. Describe how the stability indices should be best utilized for forecasting.
33. Using any combination of stability indices, low-level lapse rates and CAPE, evaluate the convective threat using the rules of thumb regarding convective intensity and thunderstorm probability given in class.
34. Identify and explain two contributing factors to the strength of the downdraft and associated cold pool beneath mature to dissipating convection.
35. List a mathematical definition of the downdraft CAPE (DCAPE) and describe it in your own words from an energy perspective and from a graphical perspective on a thermodynamic chart (e.g., SKEW-T). Identify which contributing factor (from #29 above) to downdraft strength is measured by DCAPE.
36. Given a sounding of temperature and dewpoint on a skew-T diagram, determine the parcel path in a downdraft from a specified level.
37. Identify and describe the cold pool and gust front and explain their relationship to the convective downdraft.
38. Describe the relationship between cold pool strength, wind gusts, gust front propagation, cold pool depth, and temperature difference between the cold pool and surrounding environment.
39. Identify and describe the importance of downdraft and cold pool strength to mesoscale and severe weather forecasting.
40. Identify and describe characteristics associated with the four Miller sounding types (I-IV) of archetypical air masses associated with convective precipitation. Identify typical weather threats, if any, with each air mass type.
41. Define and evaluate potential (or convective) instability from sounding data.

42. Describe the properties and climatological origins of the two mixed layers that comprise the low-to-mid levels of the Miller Type I (“loaded gun”) sounding. Explain why the interface between these layers is potentially unstable.
43. For the Miller Type I sounding, identify and explain the role of the capping inversion on convective a) probability (i.e., will convection develop?) b) timing (i.e., when will convection trigger?), and c) subsequent intensity (assuming convection does form).
44. Given wind data from an idealized atmospheric sounding, plot a hodograph.
45. Given a hodograph, a) estimate the wind shear (i.e., both Δv and $\Delta v/\Delta z$) in a given layer, b) determine in which layer the shear is strongest, c) estimate the direction of the mean wind shear in a layer, d) estimate the total shear in a layer, and e) determine the shape of the hodograph (linear vs. curved and, if curved, the sense of the curvature), f) estimate the direction and speed of the mean wind in the 0-6 km layer (i.e., storm motion vector of ordinary convective cells or any cell in its early stages) and g) estimate the direction and speed of the storm relative wind speed at a specified level.
46. Estimate any of the wind shear properties described above and the storm motion vector of ordinary convective cells (or any cell in its early stages) from NSHARP output.