# Meteorology 5140 MidTerm 1 Review

The first part of the course has been designed to establish the basic concepts required to observe and understand mesoscale systems. There's not much point describing complex mesoscale systems, if these critical concepts are not understood.

The format of the exam will be such that many in the class will need more than 50 minutes. To relieve time pressures, you will have a maximum of 90 minutes to complete the exam. Depending on any pre- or post- class conflicts, you may start up to 40 minutes early or continue 40 minutes late (but not both). I've indicated the subjects with high probability of showing up on the exam as HIGH with some combination of the LIKELY ones showing up too (but not all).

1. (HIGH) Be able to integrate and differentiate simple functions (e.g., $x^2$, sin(x), exp(x)) and recognize what those integrals and differentials mean physically (rates, gradients, sums, averages) in the context of meteorological problems.
2. (HIGH) Sounding evaluation. From a sounding provided to you, be able to determine T, $T_d$, $T_w$, $T_v$, w, $w_s$, RH, $\theta$, $\theta_w$, $\theta_e$, LCL, LFC, equilibrium level, lifted index, areas of positive and negative buoyancy due to parcel ascent or descent under different types of assumptions (unsaturated adiabatic, saturated adiabatic, partial or complete precipitation removal from parcel), contrast CAPE and CIN values based on areas of positive and negative buoyancy, layers of backing and veering winds, and layers of warm, cold, and small temperature advection, if the winds are assumed to be in geostrophic balance.
3. (LIKELY) Know what is conserved during isobaric changes, and unsaturated and saturated adiabatic expansion and compression.
4. (LIKELY) Know the forces acting on a parcel in the vertical including the parcel pressure perturbation term; how the buoyancy can be expressed in terms of density, temperature, potential temperature and virtual temperature; and what the impacts on buoyancy and CAPE/CIN are of water vapor, precipitation loading, and entrainment.
5. (HIGH) Radar characteristics. Be able to apply the relationship between speed of light and frequency and wavelength to infer PRF and pulse duration. Be able to interpret gain both conventionally and in dB. Be able to infer the speed through a medium as a function of the refractive index. Know what the vertical gradient in refractivity is for normal, subrefractive, and superrefractive situations. Be able to explain why a traditional RHI scan may bias interpretation of where the actual beam is, but you don't need to provide all the geometric details.
6. (HIGH) Radar equation. Know the conceptual differences between large target, Mie, and Rayleigh scattering. Know how the effective radar reflectivity factor is related to droplet diameter. Be able to relate and manipulate how the radar power is related to reflectivity, attenuation, and target range. Be able to convert from effective radar reflectivity factor to logarithmic reflectivity.
7. (LIKELY) Applications of the radar equation. Given a known drop size distribution and distance from radar, be able to estimate what the reflectivity is and what the rainfall rate might be (given as well the terminal velocity).
8. (LIKELY) Be able to explain what the empirical Z-R and Z-S relationships mean. Be able to explain what causes a bright band and under what conditions bright bands are most likely to take place.
9. (LOWER) Given a radar reflectivity image, be able to identify AP, ground clutter, and beam blockage effects.
10. (HIGH) Given a hodograph, be able to define: the vector difference in wind between 2 or more levels; the vector mean wind between two levels; whether warm or cold air advection is likely (if the winds are assumed to be in geostrophic balance); winds associated with barotropic, equivalent barotropic, or baroclinic environments. Given a storm velocity, be able to define the storm relative motion.

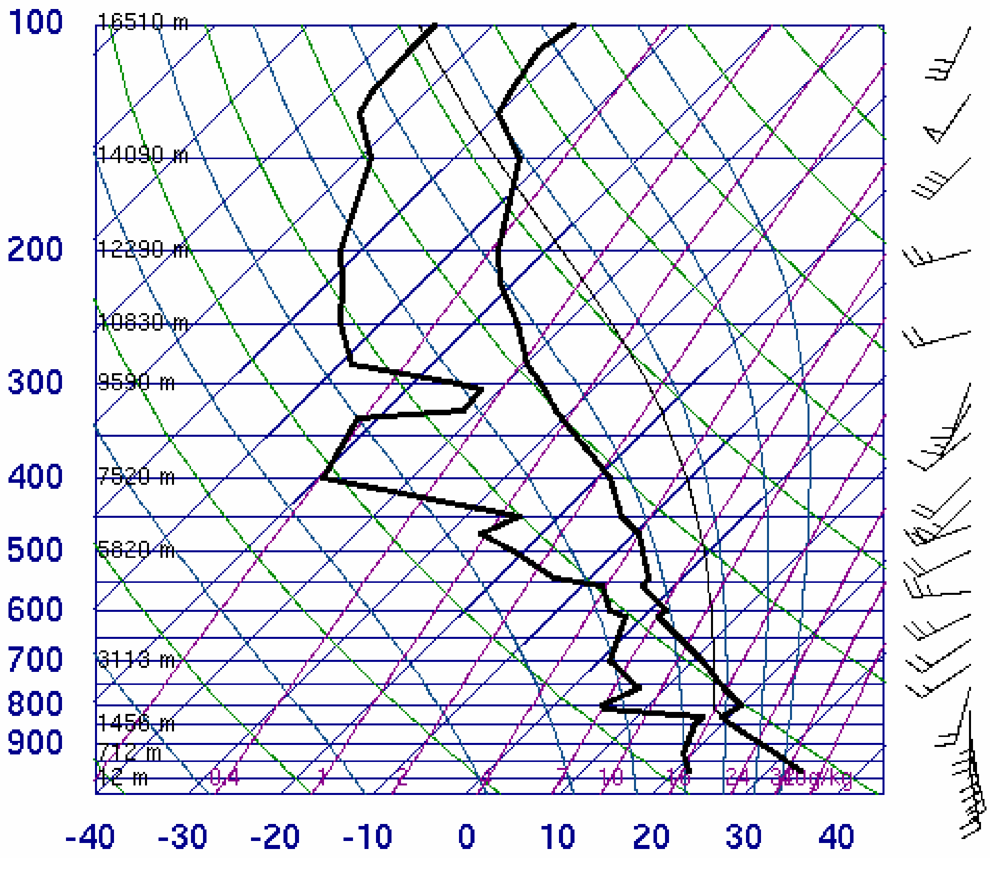
Sample problems.

1. The buoyancy of an unsaturated air parcel decreases linearly from sea level to 3000 m. Sketch a temperature profile on a skewT sounding that would correspond to this situation assuming that the parcel at the surface begins with a temperature 2$^o$C higher than the environment. Shade the area that corresponds to the CAPE. The value of buoyancy at the surface is .1 m/s$^2$ and the value at 3000 m is .05 m/s$^2$. How much CAPE (in J/kg) is present in this situation in the lowest 3 km? Answer: 225 J/kg

2. A low level southerly jet is observed with a vertical wind profile V(z) given by $V = V_0 e^{\frac{-(z-z_j)^2}{H^2}}$ where $V_0$ = 10 m/s, $z_j$= 2km, H = 1 km. Sketch this vertical profile of wind as a function of height from the ground to 4 km. Show the orientation of the axis of horizontal vorticity in this situation (Answer: axis oriented west-east). What is the magnitude of the vertical wind shear at a height of 1 km?. Answer: .007/sec.

3. Z = 200 R$^{1.6}$ describes a relationship between reflectivity and rainfall rate. What assumptions are made in deriving this relationship? Suppose that reflectivity of 40 dBZ was associated with a rainfall rate of about 20 mm/hour. Suppose that on a different day and location you find that for the same rainfall rate, the reflectivity was actually 30 dBZ, and on another occasion it was actually 50 dBZ. How could this happen?

4. Consider the following sounding. What is $\theta_w$ for the surface (297K)? What is the virtual temperature at the surface (36C)? What is the LCL for a parcel lifted adiabatically from the surface from the surface virtual temperature (775 mb)? What is the LFC (760 mb)? What is the lifted index (-7)? What is the equilibrium level (155 mb)? Sketch areas of CIN and CAPE. What is the mixing ratio for your parcel at the LCL (16 g/kg)? After the parcel reaches 500 mb, how much water remains as vapor (7 g/kg) and how much is now condensate (9 g/kg)? Assume that as the convection begins, that 4 g/kg of condensate remains in the parcel below the original LCL cloud base. What is the new cloud base, i.e., at what level will all the condensate be evaporated (900 mb)? How much colder is the air in this downdraft relative to the environment's virtual temperature (5-6C). Would you expect the evaporatively cooled air to be accelerating downward, traveling at a constant rate, or decelerating? Why?



5. Consider the following hodograph from the surface to 5 km (in m/s). Assume first that the winds are nearly geostrophic. What is the geostrophic temperature advection between the surface and 3 km? Is the vertical structure barotropic, equivalent barotropic, or baroclinic between the surface and 3 km? What is the geostrophic temperature advection from 3-5 km? Is the vertical structure barotropic, equivalent barotropic, or baroclinic between 3 and 5 km? Estimate the magnitude and direction of the mean wind between the surface and 2 km (10-11 m/s from 165). What is the magnitude and direction of the mean wind between 3 and 5 km (13-14 m/s from SW). What is the direction of the surface wind relative to the sfc-3 km mean wind (2-4 m/s from SE)? What is the direction of the 3 km wind relative to the 3-5 km mean wind (5 m/s from NE)? Why are convective storms more likely to form in environments with low level clockwise vertical wind shear than counter clockwise shear?