Name Solutions

Sci123:Meteorology	Spring 2017

Exam 2
April 4, 2017

This exam is given under conditions of the ***Luther College Honor Code***. You are expected to uphold the highest standards of academic integrity, and you are expected to demand the same from fellow students. **If you are aware of dishonest work, you are expected to contact the Honor Council.**

MULTIPLE CHOICE: Each question has a single correct response. Place an "X" through the ONE you believe is correct. Each problem is worth two points. 40 points maximum

1. The southerly, nocturnal, moisture-laden flow that plays an important role in mid-western agriculture is the
   (a) subtropical jet
   (b) Ekman flow
   (c) Ferrel cell
   (d) low-level jet
2. One reason three cells develop in the earth's planetary circulation instead of a single Hadley cell is
   (a) convection is not strong enough in the mid-latitudes
   (b) solar radiation is not evenly distributed over the earth's surface
   (c) contrary to popular theory, angular momentum is actually NOT conserved
   (d) the rotation of the earth destabilizes the single Hadley cell
3. In terms of the three-cell general circulation model, the thermally indirect cell
   (a) is the Hadley cell
   (b) is closest to the north pole
   (c) is the Ferrel cell
   (d) transports large amounts of warm air to the north
4. The coldest of all northern hemisphere air masses is
   (a) mP
   (b) cT
   (c) cF
   (d) cA
5. The polar jet stream flows
   (a) directly from west to east
   (b) directly from east to west
   (c) from the equator towards the poles
   (d) in a wavy pattern from west to east
6. If the absolute vorticity of an air parcel is conserved, parcels moving northeastward will turn _____ to compensate for the _____ in the earth's vorticity.
   (a) anticyclonically, decrease
   (b) anticyclonically, increase
   (c) cyclonically, increase
   (d) cyclonically, decrease

7. The following air masses are the most common to the upper midwest in the United States

   (a) mT and cP
   (b) cP and cT
   (c) mP and mT
   (d) mP and cT

8. On a weather map, the transition zone between two air masses with sharply contrasting properties is marked by

   (a) the letter "H"
   (b) the words "air mass weather"
   (c) a front
   (d) the letter "L"

9. At a warm front, the warm air

   (a) rises and cools
   (b) rises and warms
   (c) sinks and cools
   (d) sinks and warms

10. Which of the following is <u>not</u> a reason for mid-latitude cyclone decay

    (a) separation from the polar front
    (b) surface friction
    (c) vertical stacking of low pressure or trough centers
    (d) conversion of kinetic energy to potential energy ahead of the warm front

11. A barotropic atmosphere is one in which

    (a) surface temperature decreases at a uniform rate from the equator to the pole
    (b) atmospheric temperature decreases vertically at a rate that is equivalent to the standard atmospheric rate
    (c) height contours and temperature contours run in a parallel fashion
    (d) height contours and temperature contours do not need to be straight

12. The following is <u>not</u> a reason why cyclogenesis typically occurs along the stationary polar front.

    either

    (a) the destabilizing effects of its strong relative vorticity
    (b) the significant temperature contrast across the front provides an energy source
    (c) the mechanics of the companion polar jet is a source of mass divergence
    (d) in its stationary form, the front has a slight cyclonic rotation

13. Air masses originate

    (a) over regions of low surface pressure because surface wind speeds are generally slower
    (b) over regions of high surface pressure because radiational cooling is more intense
    (c) over regions of high surface pressure because surface winds speeds are generally slower
    (d) over warm water surfaces because of increased evaporation

14. Warm advection occurs

(a) when cold parcels are replaced by warm parcels

(b) in association with the MLC warm front

(c) where height contours cross temperature contours to the east of a low at 850 mb, for example

(d) all of the above

15. Which of the following statements is <u>not</u> correct about divergence?

(a) one form is know as "path divergence"

(b) there is always divergence associated with parcel motion due to the earth's rotation

(c) strong divergence is associated with the left exit flank of a jet streak

(d) decrease in vorticity causes an increase in divergence

16. Dew point is a better measure of atmospheric moisture than relative humidity because

(a) relative humidity is dimensionless

(b) dew point is independent of the parcel's elevation

(c) dew point is independent of the parcel's temperature

(d) relative humidity is a function of the parcel's mass

17. When the air is saturated, which of the following statements is <u>not</u> correct?

(a) the rate of evaporation is equal to the rate of condensation

(b) the relative humidity is 100%

(c) the air temperature equals the dew point temperature

(d) an increase in temperature will cause condensation to occur.

18. The total pressure of an atmospheric parcel is

(a) conserved as the parcel moves through the atmosphere

(b) the product of all the constituent partial pressures

(c) the sum of all the dry constituent partial pressures

(d) the sum of all the constituent partial pressures

19. An air parcel located at the 700 mb level has a 2% vapor content. Its mixing ratio is approximately

(a) 12.7 g/kg

(b) 14.2 g/kg

(c) 10.4 g/kg

(d) none of the above

$MR = \frac{\epsilon e}{P - e} = \frac{0.622 \cdot (0.02)700}{700 - 0.02(700)} = 0.0127 \frac{gm}{gm}$

$= 12.7 \, gm/kg$

20. A parcel of air near the surface of the earth has a temperature of 59 °F and a relative humidity of 70%. Its dew point temperature would be approximately

(a) 41°F

(b) 50°F

(c) 57°F

(d) none of the above

$59°F \rightarrow e_s = 17.2 \, mb$

$\frac{e}{e_s} = 0.70 \Rightarrow e = (.7)(17.2) = 12.04 \, mb$

$T_d \approx 50°F$

21. In the **Norwegian Cyclone Model** of a developing wave cyclone, energy for the storm is usually derived from all <u>except</u> which of the following

(a) conservation of potential vorticity

(b) the conversion of potential energy to kinetic energy

(c) latent heat of condensation

(d) the inherent energy of the polar jet stream

22. When a short wave catches up to a long wave trough one might expect to find

(a) the development of a baroclinic wave

(b) strong divergence on the left flank of the entrance to the resulting jet streak

(c) the development of negative vorticity

(d) none of the above

23. If the outflow of air around a surface high pressure area is greater than the convergence of air aloft, you would observe:

(a) in increase in pressure in the center of the high

(b) movement of the high toward the northeast

(c) a decrease in the central pressure

(d) strengthening in the high

24. A parcel at 900 mb has a mixing ratio of 8 g/kg. The vapor pressure for the parcel is approximately

(a) 102.6 mb

(b) 11.4 mb

(c) 5.57 mb

(d) none of the above

$$mR = \frac{\epsilon e}{p - e} \Rightarrow mR(p-e) = \epsilon e$$

$$mR \cdot p - mR\, e = \epsilon e$$

$$e = \frac{mR \cdot p}{mR + \epsilon} = \frac{8/1000 \cdot 900}{8/1000 + 0.622} = 11.4 \text{ mb}$$

SHORT ANSWER: Write your responses on the lined paper. Provide a sketch where useful. Circle the corresponding letters of the questions you want me to grade. 20 points

25. Answer one of the following:

(a) The solar radiation imbalance between the north pole and the equator is compensated by at least three energy transport mechanisms. Identify and describe these mechanisms. Include an indication of the latitudinal dependence of each mechanism. That is, for what northern hemisphere latitudinal interval, or intervals, is each of the mechanisms prominent.

(b) The three cell theory for the northern hemisphere has surface high or low pressure "bands" that encircle the globe at certain latitudes in perfect, unbroken circles. With the aid of a sketch, indicate where (what latitude), what type (high or low pressure), and why the pressure bands develop as projected by the theory. Observation reveals the bands are not perfectly circular and unbroken. Explain what factors account for the differences in model projections and observation.

(c) Compare and contrast the polar and the subtropical jet streams in the northern hemisphere in terms of genesis, location, structure, and speed.

26. Answer one of the following:

(a) Identify and describe atmospheric features, or mechanisms, by which a midlatitude cyclone may develop or intensify during its lifetime.

(b) Suppose a midlatitude cyclone is in the "open-wave" stage with very well-defined warm and cold fronts. Make a sketch of the low center and the relative locations of the two fronts. Next, compare and contrast characteristics such as frontal slope, frontal speed, type and nature of precipitation, etc., of the fronts.

(c) Explain how a baroclinic atmosphere, in which warm and cold advection is taking place at the level of 850 mb, may result in a "positive feed back loop" from which a mid-latitude cyclone will quickly strengthen. Provide supporting sketches.

CHART ANALYSIS: 25 points

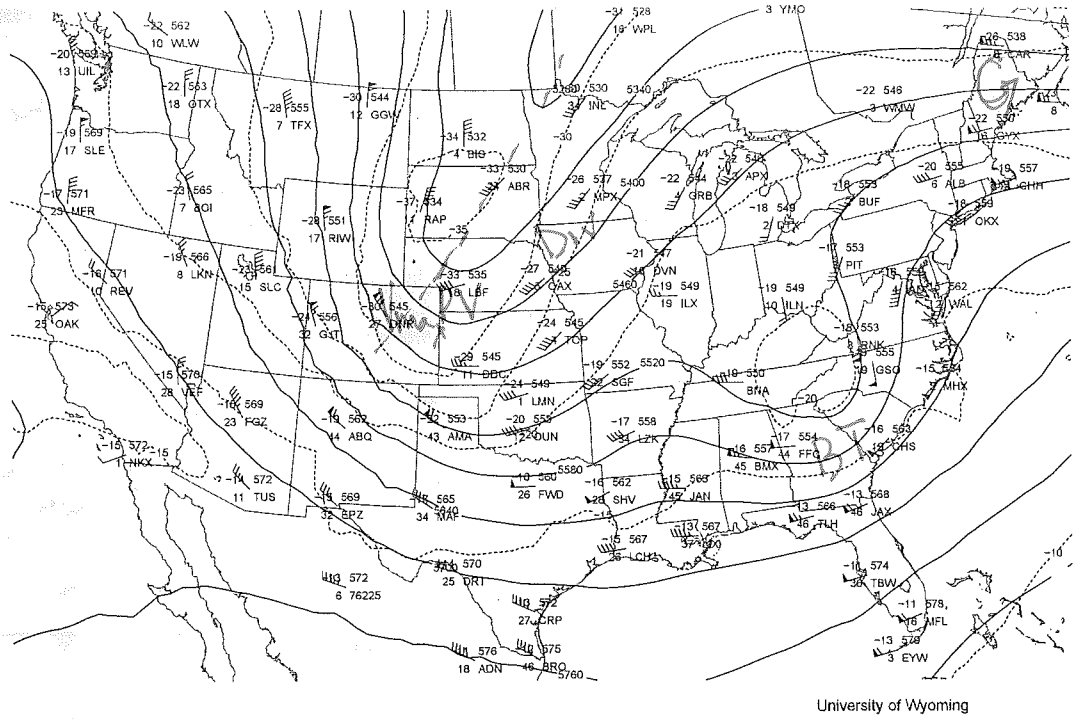


Figure 1: 500 mb chart.

27. Figure 1 shows the 500 mb surface. Indicate on the figure the features listed below. In addition, provide a short explanation of how one locates the feature on the chart.

(a) a location of positive vorticity (indicate by writing "PV")

(b) a location of a vorticity max (indicate by writing "VMax")

(c) a location of divergence (indicate by writing "Div")

(d) a barotropic region (indicate by writing "BT")

(e) a region of warm advection (indicate by writing "WA")

no area

(f) a region of geostrophic flow (indicate by writing "G")

COMPUTATION:

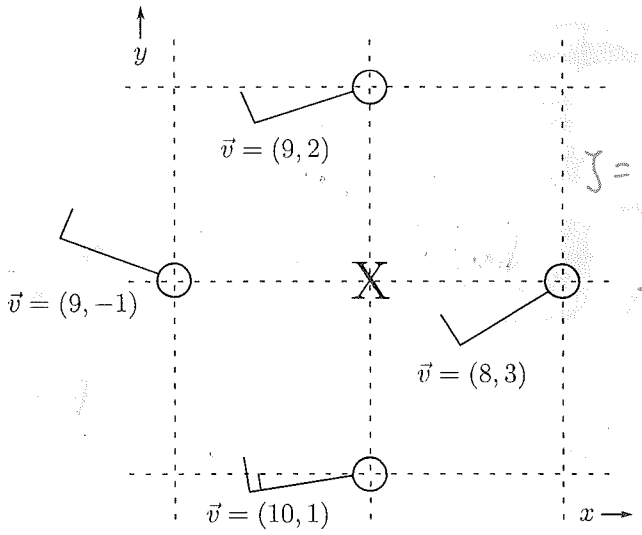
28. The velocity vectors for four adjacent weather stations are show in Figure 2. The grid spacing for the figure is 100 km. Determine the divergence and vorticity, in units of 10^{-5} sec^{-1} for the "X" spot in the grid. [10 points]

Divergence

$D = \frac{\Delta u}{\Delta x} + \frac{\Delta v}{\Delta y}$

$= \frac{8-9}{200000} + \frac{2-1}{200000}$

$= 0$



Vorticity

$\zeta = \frac{\Delta v}{\Delta x} - \frac{\Delta u}{\Delta y}$

$= \frac{3+1}{300000} - \frac{9-10}{200000}$

$= \frac{5}{2} \times 10^{-5}$

$= 2.5 \times 10^{-5}$

Figure 2: Velocity vectors for four stations.

29. The temperature contours for 65°F and 70°F are show in Figure 3. The grid spacing for the figure is 100 km. Determine the magnitude of the thermal advection in units of °F/hour at the station show where the wind is westerly with a speed of 10 meters per second. [5 points]

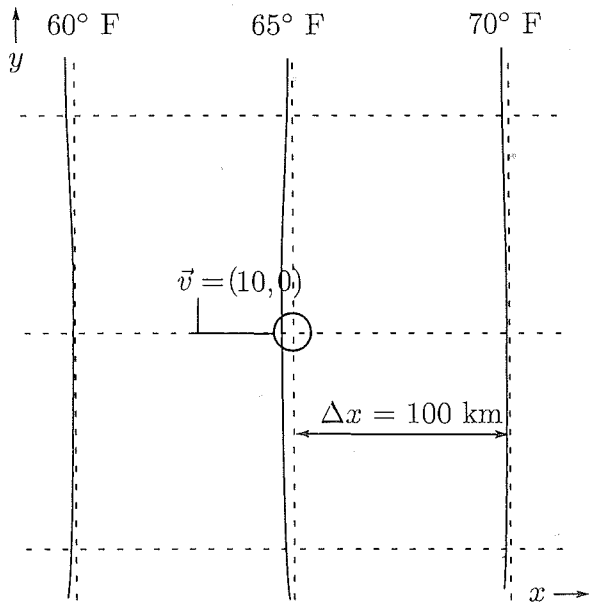


Figure 3: Temperature contours and wind speed.

Temp. Adv $= \frac{10 \text{ m}}{\text{sec}} \times \frac{-10 \text{ °F}}{200000 \text{ m}} \times 3600 \text{ sec} = \frac{-36}{20} = -1.8 \frac{\text{°F}}{\text{hr}}$