

Name \_\_\_\_\_

Dynamics of the Atmosphere 11:670:324  
Spring 2012  
Hourly Exam #2  
April 10, 2012

Unless otherwise noted, please answer each of the following questions in the blue book. **Read each question very carefully before formulating your answer.** Show intermediate steps in any calculations or mathematical manipulations.

1. Sketch a diagram illustrating the balance of forces for each of the two physically realistic types of cyclostrophic flow. Please be sure to label correctly the types of forces shown in both cases. Also show the direction in which the air parcel is moving.

**(6 points)**

2. Assume that the radius of curvature,  $R$ , in a natural coordinate system is negative and finite. Would the path of a parcel of air turn toward the left, turn toward the right, or follow a straight line?

**(2 points)**

3. For each of the following characteristics, please indicate if it applies to a barotropic or baroclinic atmosphere:

- a. no tilt of pressure systems with height
- b. density is a function of pressure only
- c. vertical wind shear is present

**(6 points)**

4. If the geostrophic wind at a particular weather station is from the south at 85 kPa and from the west at 70 kPa, please diagram the direction of the thermal wind for the 85-70 kPa layer. Assume that the geostrophic wind speeds at the two levels are equal. Also draw two thickness contours labeled  $\Delta Z_1$  and  $\Delta Z_2$  ( $\Delta Z_2 > \Delta Z_1$ ) for the same layer near the station. What type of thermal advection is taking place at this station? Please explain how you arrived at your conclusion, including any assumptions that you made.

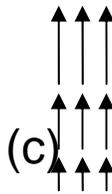
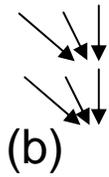
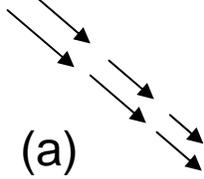
**(6 points)**

5. Gradient flow involves a balance among three forces. What are these three forces?

**(6 points)**

6. In the following diagrams of atmospheric flow patterns, the horizontal wind velocity is depicted as a vector. In each case, indicate whether there is divergence, convergence, or neither.

(3 points)



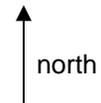
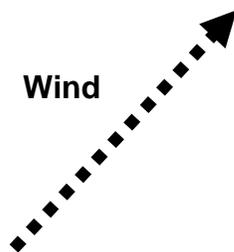
7. Write mathematical expressions for the following, defining each of the symbols used to represent atmospheric variables.

- a. geostrophic balance in natural coordinates
- b. thermal wind equation

(4 points)

8. In the following diagram, the thick, dashed arrow indicates the direction of the wind. Please indicate the orientation of the *horizontal* unit vectors for (a) a natural coordinate system and (b) a Cartesian coordinate system. In each case, label the unit vectors with their standard symbols. North is indicated by the thin arrow in the upper right corner of the diagram. Note: Please answer this question on the exam sheet.

(4 points)



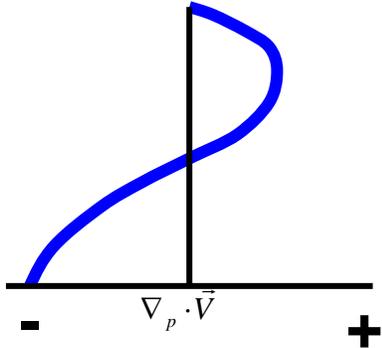
9. When horizontal divergence is expressed in natural coordinates, it is written as the sum of two terms. What type of divergence/convergence does each of these terms represent?

(4 points)

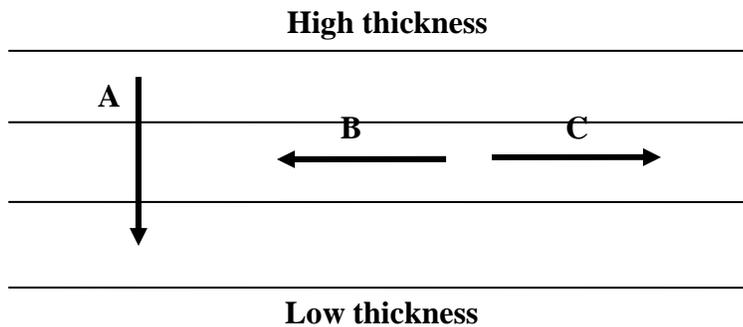
10. Please explain the difference between streamlines and trajectories.

(4 points)

11. The diagram below illustrates the vertical profile of horizontal divergence in the troposphere. In your blue book, please draw the vertical profile of  $\omega = dp/dt$  that would accompany this divergence profile. Is the air moving upward or downward?  
**(4 points)**



12. Which of the following arrows illustrates the proper orientation of the thermal wind vector? The thin solid lines represent thickness contours, with low thickness values at the top and high thickness values at the bottom.  
**(2 points)**



13. In your own words, what does the term “chaos” mean when it is used in applied mathematics? How does chaos affect our ability to make weather forecasts?  
**(4 points)**