April 19, 2006

Homework IV: Due May 5th, 2006

Question 1: more geostrophy
i) What is the magnitude of the pressure gradient required at the Earth's surface at 45^oN to maintain a geostrophic wind of 30 ms^{-1}?
ii) For motion around a center of pressure 100 km away, at 30^o latitude, compute the wind speed for which the Coriolis term will be equal to the acceleration term.

Question 2: complicated geostrophy and geopotential height
An aircraft flying a heading of 60^o at air speed 200 ms^{-1} moves relative to the ground east (90^o) at 225 ms^{-1}. If the plane is flying at constant pressure, what is its rate of change of altitude (in meters per kilometer horizontal distance) assuming a steady pressure field, geostrophic winds, and $f = 10^{-4}$ s^{-1}.

Question 3: divergence
i) The following wind data were received from 50 km to the east, north, west, and south of a station respectively: 90^o, 10 ms^{-1}; 120^o, 4 ms^{-1}; 90^o, 8 ms^{-1}; 60^o, 4 ms^{-1}. Calculate the approximate horizontal divergence at the station.
ii) Suppose that the winds speeds given above are each in error by $\pm 10\%$. What would be the percent error in the calculated horizontal divergence in the worst case?

Question 4: fronts
The figure is a cross-section of part of a front. At a certain level, the air possesses temperatures T_2 and T_1 respectively ($T_2 > T_1$) on two sides of the front which has a slope of α relative to the horizontal. Apply the hydrostatic equation and the geostrophic wind equation to the region AB, together with the condition that the pressure must be continuous across the frontal surface (n.b. why?). Show that in equilibrium the components of the velocity v_2 and v_1 in the y-direction on the two sides satisfy the relation

$$(T_1 - T_2)g \tan\alpha = (v_2 T_1 - v_1 T_2)f \tag{1}$$

If $T_2 - T_1 = 3$K, $v_1 - v_2 = 10$ ms^{-1}, find α. As a hint, remember that T is measured in Kelvin, and so $T_1 \sim T_2$.

The slopes of typical fronts vary from around $\frac{1}{50}$ to $\frac{1}{300}$. Note that if $f = 0$, i.e., the Earth were not rotating, the sloping surface could not be in equilibrium.

From the sense of the velocity change, show that the kink in the isobars is always cyclonic (*viz.* the

2nd figure).

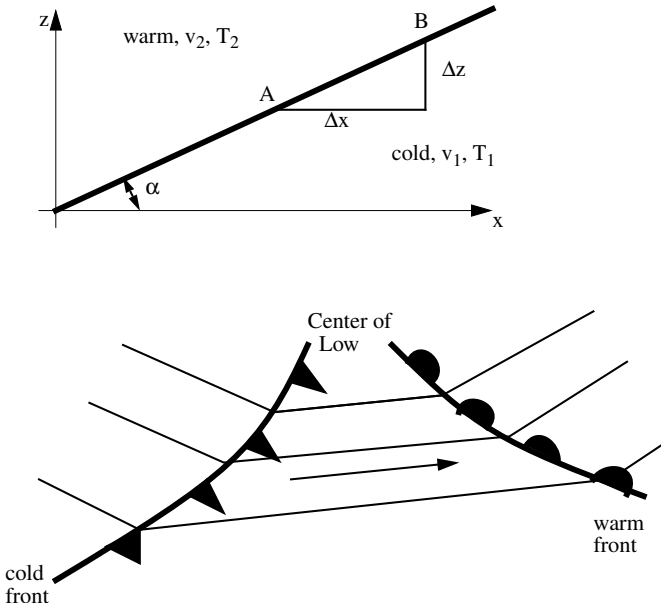

Figure 1: Schematic of fronts in a cyclone.

Question 5: random physics question - center of gravity Two identical test tubes are dropped simultaneously from the same height. Each test tube has an identical cork sealing it. In each test tube is a fly. The flies are identical in all respects except that one is dead, and the other is alive and trying to get out. Which test tube hits the floor first?