Circulation and vorticity. (Holton, Ch. 4)
(*Homework project #5 for ATM SCI 351:* DUE 12/17)

Problem #1 (Holton 4.1) What is the circulation about a square of 1000 km on a side for an easterly (that is, westward-flowing) wind that decreases in magnitude toward the north at a rate of 10 m s^{-1} per 500 km? What is the mean relative vorticity in the square?

Problem #2 (Holton 4.2) A cylindrical column of air at 30^0N with radius 100 km expands to twice its original radius. If the air is initially at rest, what is the mean tangential velocity at the perimeter after expansion?

Problem #3 (Holton 4.4) An air column at 60^0N with ζ=0 initially stretches from the surface to a fixed tropopause at 10 km height. If the air column moves until it is over a mountain barrier 2.5 km high at 45^0N, what are its absolute vorticity and relative vorticity as it passes the mountaintop, assuming that the flow satisfies the barotropic potential vorticity equation?

Problem #4 (Holton 4.10) By how much does the relative vorticity change for a column of fluid in a rotating cylinder if the column is moved from the center of the tank to a distance 50 cm from the center? The tank is rotating at the rate of 20 revolutions per minute, the depth of the fluid at the center is 10 cm, and the fluid is initially in a solid-body rotation.

Problem #5 (Holton 4.12) A westerly zonal flow at 45^0N is forced to rise adiabatically over a north–south-oriented mountain barrier. Before striking the mountain the westerly wind increases linearly toward the south at a rate of 10 m s^{-1} per 1000 km. The crest of the mountain range is at the 80-kPa (800-mb) level and the tropopause is located at 30 kPa (300 mb). What is the initial relative vorticity of the air? What is its relative vorticity when it reaches the crest if it is deflected 5^0 to the south during the forced ascent? If the current assumes a uniform speed of 20 m s^{-1} during its ascent to the crest, what is the radius of curvature of the streamlines at the crest?