Problems on Ch. 8: Planetary Boundary Layer, Ekman Spiral

Q 8.1: Estimate the fractional changes in density between the surface and a height of 1 km.

(We neglected these changes in the derivation; this question is included to give you a "handle" on the size of the error that that is likely to have been introduced)

Hint: use the gas law then the hydrostatic equation and what you know of maximum temperature lapse rates

Q 8.2: In the Ekman wind spiral theory find an expression in terms of K and f for the lowest height above the surface at which the ageostrophic wind is in exactly the opposite direction to the geostrophic wind. What is this height if $K = 7\,\mathrm{m^2\,s^{-1}}$ and the latitude is 60°N?

Q 8.3: At what height in the Ekman spiral is the magnitude of the ageostrophic wind one tenth of that of the geostrophic wind? Use the same value of K as in question Q 8.2.

Q 8.4: Is the frictional stress at the surface in exactly the opposite direction to the wind just above the surface, or in some other orientation?

Q 8.5: (Optional) Ekman originally introduced his spiral for currents near the surface of the ocean. The ocean also has geostrophic balance. Near the surface the ageostrophic current is produced by the wind drag and the geostrophic current is small compared with the ageostrophic part in the trop few meters of water. See if you can deduce the shape of the current near the surface and how it is orientated compared with the geostrophic wind.