Show all your work. Partial credit is always possible if I can follow your reasoning.

1. Assume that air flows over a broad building 10 m high. The flow is in steady state and the density is constant ($\rho = 1.3 \text{ kg m}^{-3}$) through this depth of the atmosphere. The observed speed at ground level is 5 m s$^{-1}$ while on the rooftop it is 9 m s$^{-1}$.

   a) What is the pressure difference, in mb, between the ground and roof level?

   b) How much of this pressure difference is purely hydrostatic?

   c) What is the magnitude and direction of the non-hydrostatic pressure gradient force vector generated by these circumstances?

   In all of the above, you may neglect the vertical variation in temperature.

2. Holton 2.11

3. On a certain day at Sarmiento, Argentina ($41^\circ S$) the surface wind has a speed of 10 m s$^{-1}$ and is directed across the isobars from high toward low pressure at an angle $\psi = 20^\circ$.

   (a) Calculate the magnitude of the frictional drag force and the horizontal pressure gradient force (per unit mass).

   (b) What is the rate of kinetic energy generation that results from this cross-isobar flow?

   (c) If the horizontal pressure gradient force vector is observed to be constant (in both magnitude and direction) through the first 2 km of the atmosphere, verify that the wind **backs** (direction turns counterclockwise) with height through the lowest 2 km.

   (d) Demonstrate that the vertical shear of the wind (i.e. the vector difference between the upper wind and the surface wind) in this 2 km layer is exactly parallel to the Coriolis force associated with the surface wind.