Session 3

1. Show that for an ideal gas the thermodynamic energy equation when expressed in terms of potential temperature has the form

$$c_p \frac{D\Theta}{Dt} = \frac{\Theta}{T}\dot{Q}$$

and that for an adiabatic parcel in hydrostatic atmosphere the dry static energy $h_d = c_p T + gz$ is conserved.

2. Consider a low pressure system centered on 43 °N, whose sea level pressure field is described by

$$p = p_0 - \Delta p e^{-r^2/R^2},$$

where r is the radial distance from the center. Determine the structure of the geostrophic wind around this system; find the maximum geostrophic wind and the radius at which it is located, if p_0 = 1000 hPa, Δp = 20 hPa and R = 500 km.

3. Show that the geostrophic balance in isobaric coordinates may be written

$$f\mathbf{U_g} = \mathbf{k} \times \nabla_p \Phi$$

4. An aircraft flying a heading of 60° (i.e., 60° east of north) at air speed 200 m/s moves relative to the ground due east (90°) at 225 m/s. If the airplane is flying at constant pressure, what is its rate of change in altitude in meters per kilometer of horizontal distance assuming a steady pressure field, geostrophic winds, and $f = 10^{-4}$ 1/s.