所別：大氣物理研究所碩士班 一般生 科目：大氣動力學

1. Based on the definition of potential temperature θ, derive that $\frac{T}{\theta}\frac{\partial\theta}{\partial z}=\frac{\partial T}{\partial z}+\frac{g}{c_p}$ where $g/c_p=\Gamma_d$ is the dry adiabatic lapse rate and explain according to stability criteria why the inversion layer is very stable for a parcel displacement. (10%)

2. From the thermal-wind equation given by $\frac{\partial \mathbf{V}_g}{\partial \ln p}=-\frac{R}{f}\mathbf{k}\times\nabla_p T$, please show that from this equation it cannot have a warm (cold) air advection if geostrophic wind in the Northern Hemisphere in turns counterclockwise (clockwise) with height. (10%)

3. Discuss gradient wind (with balanced forcings) in a low pressure system in the Northern Hemisphere ($f>0$) and explain why the wind will be stronger in an anomalous low than in a regular low. (10%)

4. Starting from the horizontal momentum equations, please derive the vertical-vorticity equation and discuss the physical meaning of each term in the equation. (15%)

5. Starting from the steady-state horizontal momentum equations with vertical turbulent mixing in the well-mixed planetary boundary layer of depth h and assuming bulk aerodynamic formula for the surface momentum flux, please solve the boundary-layer flow and explain why this flow must across the pressure contour toward the lower pressure according to forcing balance. (15%)

6. What is the quasi-geostrophic approximation? What is the role of a secondary circulation in a quasi-geostrophic system? (15%)

7. What is phase speed and what is group velocity? State the mechanisms of sound waves, internal gravity waves, and Rossby waves. (10%)

8. State the conditions for static instability, inertial instability, and baroclinic instability. What is available potential energy? State the energetic of baroclinic waves. (15%)