ASL410 **Major** **Marks 100** **Time 2 hours**

1. Derive the **continuity equation** in the log-pressure system ($z^* = -H \ln \frac{p}{p_0}$), where H is the scale height. *(5)*
2. Show that the **geostrophic perturbations** with equatorial synoptic scale disturbances will be an order of magnitude smaller than those for midlatitude systems for the same scale. *(3)*
3. Linearize the **potential temperature** equation $\theta = \theta(\rho, p)$. *(5)*
4. Linearize the vertical momentum equation with a given non-zero basic zonal state. *(6)*
5. If a system has a very strong **tangential wind speed** in the range of 60-100 ms^{-1} with a length scale is about 100 km, what is the balance of forces in the tropics and why? *(3)*
6. If the **internal energy** of an atmospheric column, which extends from the surface to the top of the atmosphere, of unit horizontal cross section is E unit, obtain the **total potential energy** for the entire column. *(6)*
7. What is **inertial stability**? Find the inertial stability condition in the Northern Hemisphere. *(6)*
8. The **balance equation** may be written as $\nabla^2[\Phi + \frac{1}{2}(\overline{\nabla}\psi)^2] = \overline{\nabla}.[(f + \nabla^2\psi)\overline{\nabla}\psi]$. Derive the linear balance equation from this. *(3)*
9. Non-dimensionalize the **nonlinear shallow water equation** with appropriate set of characteristic values of the variables, length, depth and time scales. Explain the various non-dimensional parameters thus introduced. *(6)*
10. What about the sound waves in the vertical in synoptic scale mid-latitude atmosphere if an air parcel rises with a uniform vertical velocity? *(5)*

Explain the following equations or relations:

11. $C = \overline{U} - 2\Omega\cos\phi\frac{L^2}{4\pi^2}/(radius$ of the earth), $\overline{U}$ is the mean zonal velocity at a latitude ϕ. *(5)*

12. $\Omega R^2 = (\Omega + \frac{\delta u}{R+\delta R})(R+\delta R)^2$, R is the distance from the axis of rotation of the earth, δu is the change in the zonal velocity. *(5)*

13. Explain the followings with diagrams:
(i) geostrophic wind (ii) thermal wind (iii) gradient wind (iv) gravity wave (v) Rossby wave (vi) acoustic wave (vii) divergence (viii) deformation (ix) stable and (x) unstable atmosphere. *(10)*

14. Expand $-2\overline{\Omega}\times\overline{V}$, where Ω is angular velocity of the earth and $\overline{V} = \hat{i}u + \hat{j}v + \hat{k}w$. *(5)*

15. Why thermal wind is proportional to layer thickness? *(5)*

16. Show that the geostrophic wind is perpendicular to pressure gradient. *(5)*

17. If an air parcel moves in a constant potential surface, explain why solenoidal term in the eirculation theorem will be zero? *(6)*

18. At a given time, temperature of an air parcel in a channel is decreasing from south to north. Will the local rate of change of temperature decrease or increase in the middle of the channel? Explain. *(5)*

19. If in a stably stratificd system the density is a constant in a layer and if the fluid is hydrostatic show that horizontal pressure gradient is independent of height in each layer. *(3)*

20. Write the continuity equation in isentropic coordinate systems. *(3)*