1. Provide a physical interpretation and list the assumptions that must be satisfied for the different forms of Bernoulli’s equation to be valid. (10 %)

2. A fluid whose density distribution is given by \( \rho(Z) = \rho_H - (\rho_s - \rho_H) \left( \frac{Z}{H} \right)^2 - 1 \)

is at rest in Earth’s gravity field, where \( \rho_H, \rho_s \) are constant. Find the pressure gradient acting in the fluid at a depth of \( 2H/3 \). (10 %)

3. Provide a physical interpretation of Reynolds transport theorem as applied to a system and a control volume. (10 %)

4. The velocity field for a flow is given by \( \vec{u} = \frac{-C \cdot y}{\sqrt{x^2 + y^2}} \hat{i} + \frac{C \cdot x}{\sqrt{x^2 + y^2}} \hat{j} \)

where \( C \) is a constant. Determine the equations for the streamlines and make a sketch. (10 %)

5. Given the velocity field \( \vec{v} = (x^2 - y^2) \hat{i} - 2xy \hat{j} \)

(1) determine the velocity gradient (5 %)
(2) determine the vorticity field (5 %)
(3) determine whether the flow is an incompressible flow (5 %)

6. (1) Using scale analysis to derive the two dimensional Prandtl boundary layer equations. (10 %)
(2) Show that the thickness of the boundary layer \( \delta \) is proportional to \( \sqrt{x} \)

where \( x \) is distance from the leading edge of the plate. (5 %)

7. Explain the following terms (definition and physical interpretation): (20 %)
(1) potential flow and irrotational flow
(2) Kelvin’s circulation theorem
(3) barotropic flow and baroclinic flow
(4) circulation and vorticity
(5) gradient and divergence

8. The temperature at a point 50 km north of a station is 3 °C cooler than at the station. If the wind is blowing from the northeast at 20 m/s^-1 and the air is being heated by radiation at the rate of 1 °C/hour^-1. What is the local temperature change at the station? (10 %)