

## Quiz 6: Non-Dimensional Analysis

October 29, 2025

**Q1.-** For very low velocities it is known that the drag force  $F_D$  of a small sphere is a function solely of the velocity of the flow  $V$  past the sphere, the diameter  $d$  of the sphere, and the viscosity  $\mu$  of the fluid. Determine:

1. How many non-dimensional Pi groups are there involving these variables?
2. Find an expression of it.

**Q2.-** In a convective boundary layer flow, where the surface is characterized by surface thermal variations (patches), the NS equation for the vertical velocity component reduces to,

$$w \frac{\partial w}{\partial z} \equiv -g \frac{\Delta T}{T_0}. \quad (1)$$

1. Assuming that the mean horizontal velocity is controlled by the geostrophic wind  $U_G$ , and that the characteristic length scales in the horizontal and vertical directions are  $l_p$  and  $l_d$  correspondingly, use mass conservation to estimate a scaling velocity that can be used for  $w$ , to non-dimensionalize the vertical momentum equation.
2. With the newly found scaling velocity for  $w$ , non-dimensionalize the simplified vertical momentum equation above, also considering that  $\Delta T \equiv \Delta\theta$ , and  $T_0$  scales as  $T_0$ . What new non-dimensional parameter appears?