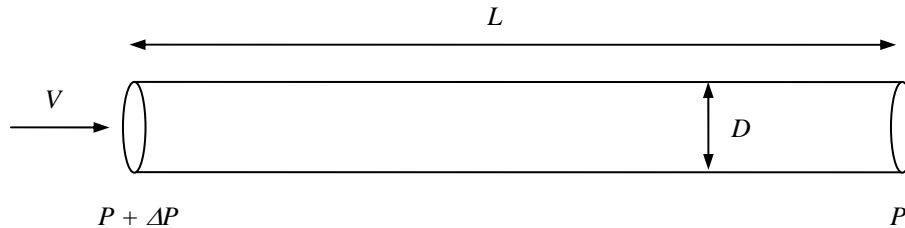


**Supplementary Homework Problem (HW Set 21)****Due at the beginning of Lecture 23**Dimensional analysis of pipe friction

Consider a fluid flows through a horizontal circular pipe:



The pressure drop, from the inlet to the outlet, due to friction in the pipe,  $\Delta P$ , depends on the following fluid properties and geometry parameters:

- fluid density,  $\rho$
- flow velocity,  $V$
- pipe diameter,  $D$
- fluid viscosity,  $\mu$
- pipe surface roughness,  $\varepsilon$
- pipe length,  $L$

In dimensional form, the dependency can be expressed as

$$\Delta P = f(\rho, V, D, \mu, \varepsilon, L).$$

Perform a dimensional analysis on the above functional dependency by choosing the fluid density, the flow velocity and the pipe diameter as the repeating variables, *i.e.*

$$\Pi_1 = g(\Pi_2, \Pi_3, \dots).$$

What are  $\Pi_1, \Pi_2, \Pi_3, \dots$  ?