To describe a physical object/variable

Qualitative description of one of its characteristics.

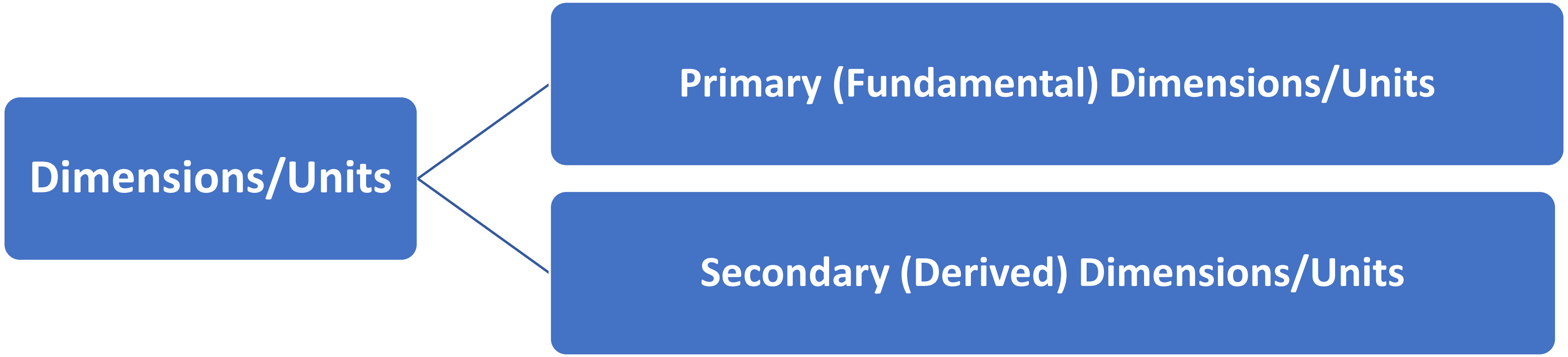
Dimension

Ex: Mass

Quantitative tool to provide a numerical magnitude to the characteristic. (as per standards)

Unit

Ex: kg



Primary Dimensions	Primary Units (SI)
Length [L]	**m**
Mass [M]	**kg**
Time [T]	**s**
Temperature [ϴ]	**K**

Secondary Dimensions	Secondary Units
Velocity $[LT^{-1}]$	m/s
Acceleration $[LT^{-2}]$	m/s^2
Force $[MLT^{-2}]$	kg m/s^2 → N
Work/Energy $[ML^2T^{-2}]$	Nm → J
Power $[ML^2T^{-3}]$	J/s → W

Standard Prefixes	
Multiple	Prefix
10^{15}	P, peta
10^{12}	T, tera
10^{9}	G, giga
10^{6}	M, mega
10^{3}	k, kilo
10^{-3}	m, milli
10^{-6}	µ, micro
10^{-9}	n, nano
10^{-12}	p, pico
10^{-15}	f, femto

Dimensional Homogeneity

Apples + Oranges ← **Absurd**

Apples + Apples ← **Makes Sense**

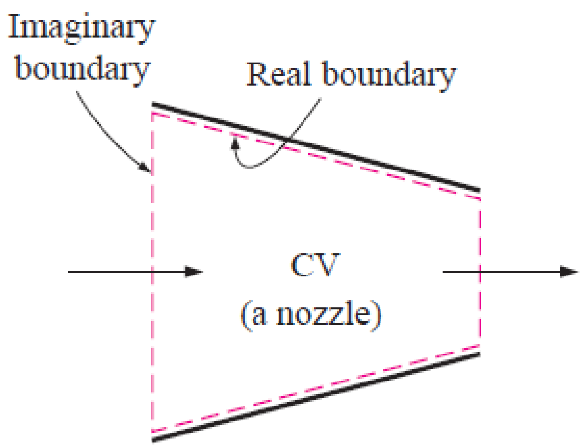
Every term in an equation must have the same dimension.

In a lab experiment there is water flowing on a flat surface and measurements are taken of the velocity of water at different heights, y, above the surface. A student analyses the measured data and reports that the velocity distribution within the range of measured y is given by,

$$u = 0.31 + 6.4y + 2.1x10^3y^3$$

With velocity in m/s and height in m. would the expression be valid in any system of units?

System & Control Volume



(*a*) A control volume (CV) with real and imaginary boundaries

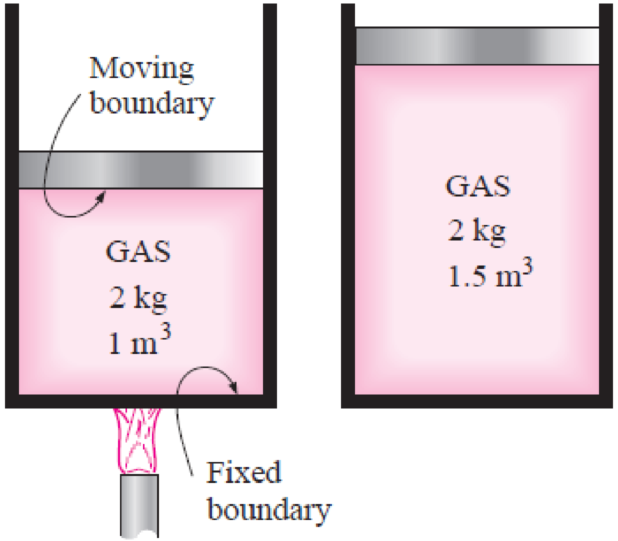
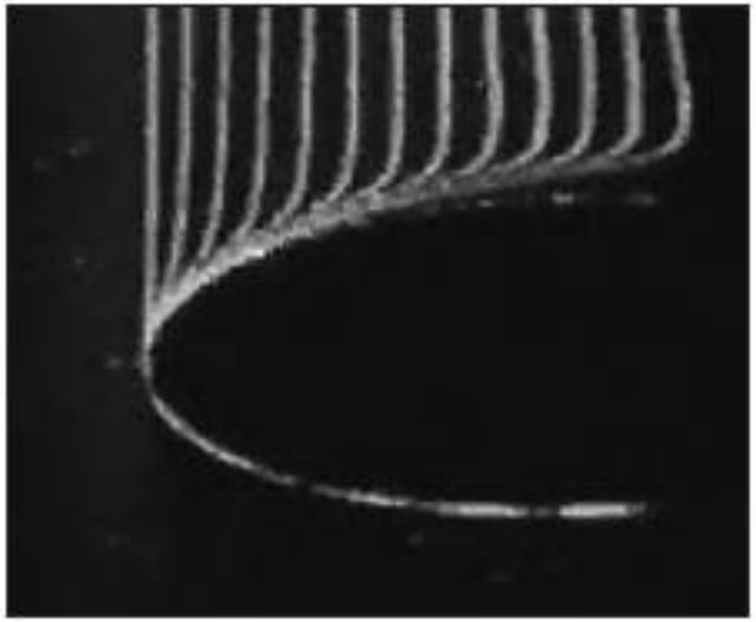
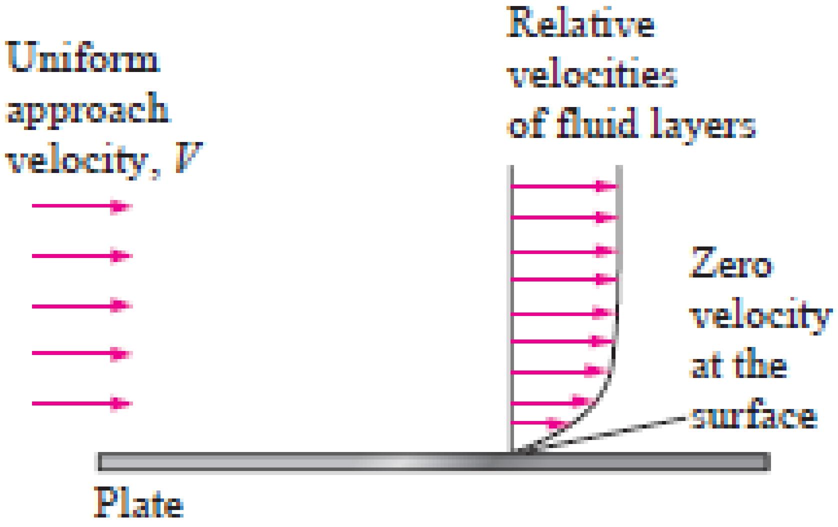


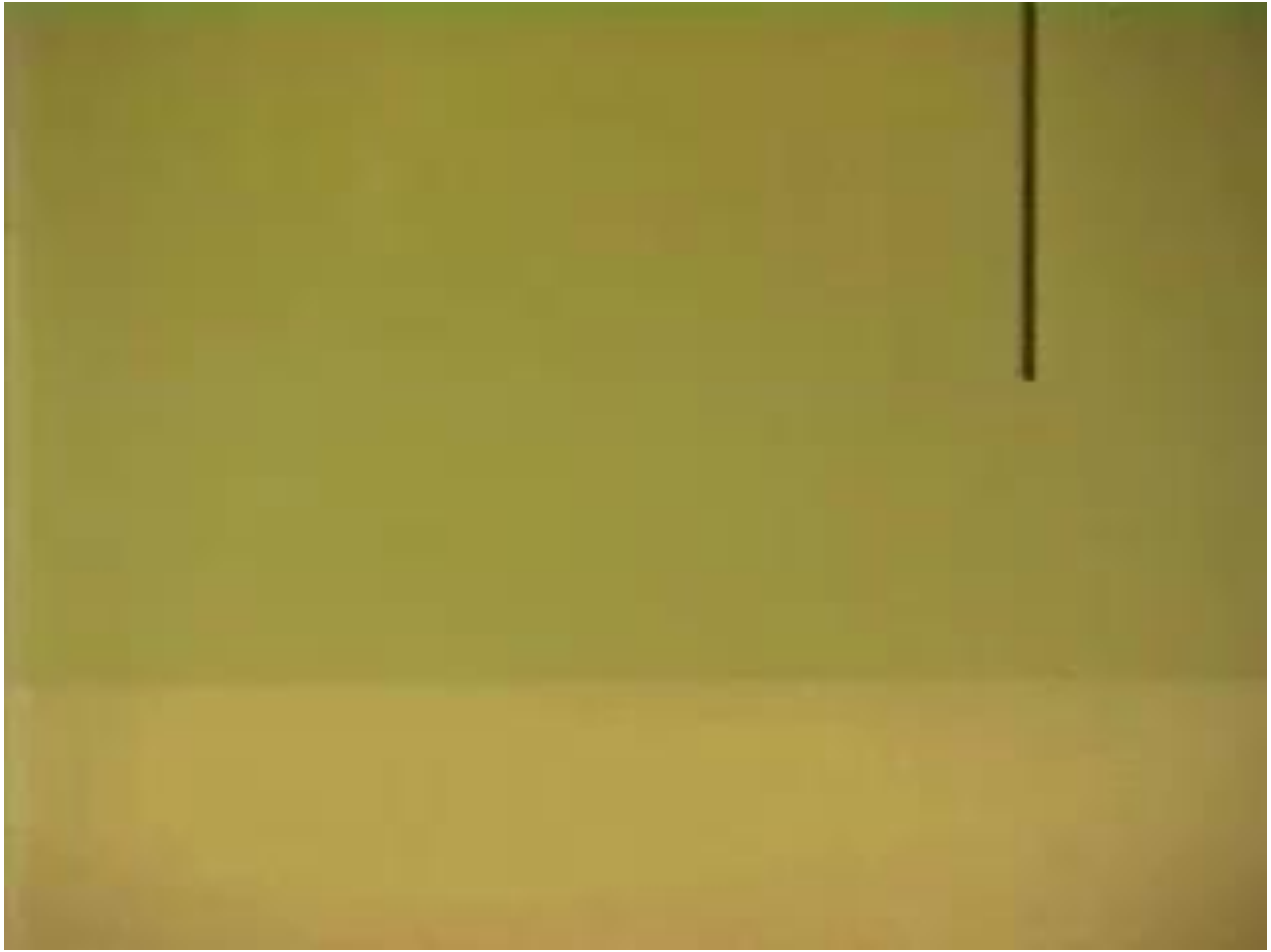
FIGURE 1–24
A closed system with a moving boundary.

The No-Slip Condition

- A flow is often confined by solid surfaces.
- Its important to know how it affects the flow.
- ***Experimentally observed fact that fluid moves with solid boundary***
  - *Zero velocity if stationary boundary.*
- Reason: **Viscosity**
- Responsible for the development of the **velocity profile**.
- Flow region adjacent to the wall where a velocity gradient exist is called the **boundary layer**.
- Causes **drag.**
- Similar condition in heat transfer: No-Temperature-Jump Condition







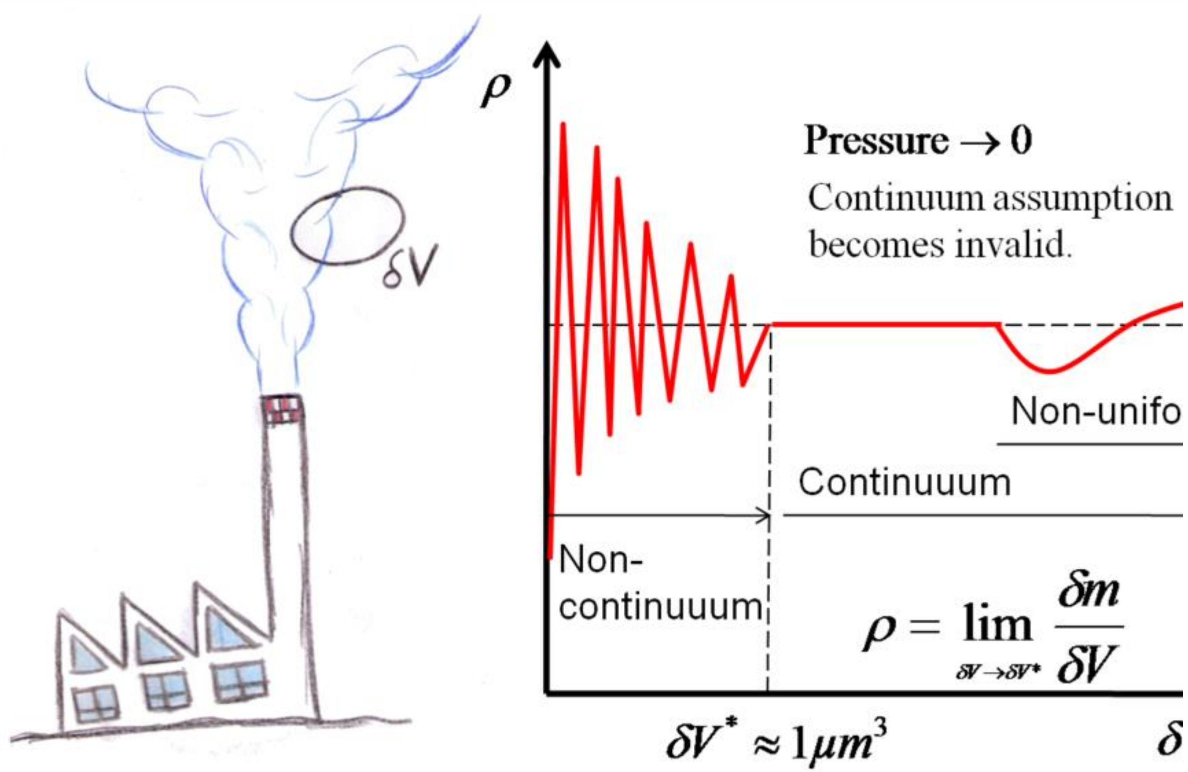
Concept of Continuum

For easy mathematical analysis,

- We assume that there is **no discontinuity** of matter, and hence of any property, in space and time.
- Gives validity to the definition of properties as a function of space and time.
- At normal conditions this assumption is valid, since due to the average effect of a large number of molecules the properties appear to vary smoothly or remain constant within a system.
  - Around 3×10^{16} molecules of a gas per mm^3 at STP

Exceptions to the continuum assumption

- When Pressure → 0, for a given volume
- Or when Volume → 0, for a given pressure
- In both the cases the number of molecules occupying the volume becomes small, which can lead to discontinuity.



Knnudsen Number ($\frac{\lambda}{L}$)

$\frac{\lambda}{L} < 0.01, Continuum\ Assumption\ is\ valid.$

$0.01 < \frac{\lambda}{L} < 0.1, Slip\ Flow.$

$0.1 < \frac{\lambda}{L} < 0.01, Transition\ Flow.$

$\frac{\lambda}{L} > 10, Free\ Molecular\ Flow.$

Where λ is the mean free path of the molecule

And L is the characteristic Dimension of the system