Dimensional Analysis

FORCE F : MLt^{-2}	μ : $ML^{-1}t^{-1}$	ρ : ML^{-3}	DIAMETER D : L	SPEED V : Lt^{-1}
PRESSURE p : $ML^{-1}t^{-2}$	ν : L^2t^{-1}	g : Lt^{-2}	f or ω : t^{-1}	SURF TENSION σ : Mt^{-2}
TORQUE T : ML^2t^{-2}	WORK W : ML^2t^{-2}	AREA A : L^2	FLOWRATE Q : L^3t^{-1}	VOLUME $\forall$: L^3
MASS FLOWRATE: Mt^{-1}	POWER: ML^2t^{-3}	$\gamma = \rho g$: $ML^{-2}t^{-2}$	YOUNG'S MODULUS :	$E = Y$: $ML^{-1}t^{-2}$

Procedure to Apply the Buckingham Pi Theorem:

1. List the "n" parameters involved, starting with the dependent parameter.
2. Under each parameter, write the primary dimensions MLtT.
3. Find the rank "r" of the dimensional matrix. Typically $r =$ number of primary dimensions.
4. Select r *repeating parameters* from the n available. Avoid the *dependent variable* along with μ, c, Δp or σ. The repeating parameters must have independent units that yet include in total all the primary dimensions. The best choice is that of parameters similar to ρ, V, D.
5. For each of the $(n - r)$ remaining parameters (called *nonrepeating*), form a nondimensional Pi parameter Π starting with the dependent variable.
6. Express the Pi parameter containing the dependent variable as a function of the remaining Pi parameters: $\Pi_1 = F\left(\Pi_2, \Pi_3, \ldots\right)$. Identify well-known Pi parameters, especially those that are named after famous scientists.

$\dfrac{\rho V L}{\mu} = \mathrm{Re}$ Reynolds no. $\propto \dfrac{\text{Inertial Force}}{\text{Viscous Force}}$ near solid boundaries.

$\dfrac{V}{c} = \sqrt{\dfrac{\rho V^2}{p}} = \dfrac{V}{\sqrt{kRT}} = M$ Mach no. $\propto \dfrac{\text{Inertial Force}}{\text{Compressibility Force}}$ in high speed gaseous flows.

$\dfrac{\omega L}{V}$ or $\dfrac{fL}{V} = St$ Strouhal no. $\propto \dfrac{\text{Time-Dependent Inertial Force}}{\text{Time-Independent Inertial Force}}$ unsteady/oscillatory flows.

$L\sqrt{\dfrac{\omega}{\nu}} = \lambda$ Stokes/Womersley no. $\propto \dfrac{\text{Time-Dependent Inertial Force}}{\text{Viscous Force}}$ unsteady flows near walls.

$\dfrac{V}{\sqrt{gL}}$ or $\dfrac{V^2}{gL} = Fr$ Froude no. $\propto \dfrac{\text{Inertial Force}}{\text{Gravitational Force}}$ in free-surface flows.

$\dfrac{\rho V^2 L}{\sigma} = We$ Weber no. $\propto \dfrac{\text{Inertial Force}}{\text{Surface Tension Force}}$ in capillary flows, droplets, ripple waves.

$\dfrac{\mu V}{\sigma} = Ca$ Capillarity no. $\propto \dfrac{\text{Viscous Force}}{\text{Surface Tension Force}}$ in capillary flows near solid boundaries.

$\dfrac{\Delta p}{\frac{1}{2}\rho V^2} = Eu$ Euler no. $\propto \dfrac{\text{Pressure Force}}{\text{Inertial Force}}$ important when pressure gradients drive the flow.

$\dfrac{p - p_v}{\frac{1}{2}\rho V^2} = C$ Cavitation no. $\propto \dfrac{\text{Pressure Force}}{\text{Inertial Force}}$ when pressure drops below vapor pressure.

$\dfrac{F_D}{\frac{1}{2}\rho V^2 A} = C_D$ Drag coeff. $\propto \dfrac{\text{Drag Force}}{\text{Inertial Force}}$ when drag is important.

$\dfrac{\rho V^3}{\mu \omega^2 L} = S_p$ Penetration no. $\propto \dfrac{\text{Time-Dependent Inertial Force}}{\text{Viscous Force}}$ oscillating flow over porous walls.