Common Dimensionless Parameters for Fluid Flow Problems

Most common physical quantities of importance in fluid flow problems are: (without heat transfer)

1	2	3	4	5	6	7	8
V,	ρ,	g,	μ,	σ,	K,	Δp,	L
velocity	density	gravity	viscosity	surface tension	compressibility	pressure change	length

WS (per unit $\forall$)

$n = 8 \qquad m = 3 \qquad \Rightarrow \qquad$ 5 dimensionless parameters

$\rho u u_x = \rho V \frac{V}{L}$

$\mu u_{xx} = \frac{\mu V}{L^2}$

1) Reynolds number $= \dfrac{\rho V L}{\mu} = \dfrac{\text{inertia forces}}{\text{viscous forces}} \qquad \dfrac{\rho V^2/L}{\mu V/L^2} \qquad$ Re

gravity $\gamma = \rho g$

R_{crit} distinguishes among flow regions: laminar or turbulent value varies depending upon flow situation

2) Froude number $= \dfrac{V}{\sqrt{gL}} = \dfrac{\text{inertia forces}}{\text{gravity force}} \qquad \dfrac{\rho V^2/L}{\gamma} \qquad$ Fr^2

important parameter in free-surface flows

$F_\sigma = \sigma L$

$\div L^3 = \sigma/L^2$

3) Weber number $= \dfrac{\rho V^2 L}{\sigma} = \dfrac{\text{inertia force}}{\text{surface tension force}} \qquad \dfrac{\rho V^2/L}{\sigma/L^2} \qquad$ We

important parameter at gas-liquid or liquid-liquid interfaces and when these surfaces are in contact with a boundary

4) Mach number $= \dfrac{V}{\sqrt{k/\rho}} = \dfrac{V}{a} = \sqrt{\dfrac{\text{inertia force}}{\text{compressibility force}}} \qquad$ Ma

(a ← speed of sound in liquid)

Paramount importance in high speed flow ($V \geq c$)

$F_{\Delta p} = \Delta p L^2$

$F_{\Delta p}/\forall = \Delta p/L$

5) Pressure Coefficient $= \dfrac{\Delta p}{\rho V^2} = \dfrac{\text{pressure force}}{\text{inertia force}} \qquad \dfrac{\Delta p/L}{\rho V^2/L} \qquad$ C_p

(Euler Number)