Important Dimensionless Groups

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$$\mathrm{Re} = \frac{d\ V_{ave}}{\upsilon} = \frac{\text{momentum convection}}{\text{momentum diffusion}} = \frac{\text{inertial forces}}{\text{viscous forces}}$$ Reynolds number

$$\mathrm{Pr} = \frac{\upsilon}{\alpha} = \frac{\text{momentum diffusion}}{\text{thermal diffusion}}$$ Prandtl number

$$\mathrm{Sc} = \frac{\upsilon}{D_{12}} = \frac{\text{momentum diffusion}}{\text{mass diffusion}}$$ Schmidt number

$$\mathrm{Pe} = \mathrm{Re}\,\mathrm{Pr} = \frac{d\ V_{ave}}{\alpha} = \frac{\text{momentum convection}}{\text{thermal diffusion}}$$ Peclet number

$$\mathrm{E} = \frac{V_{ave}^2}{C_P \Delta T} = \frac{\text{heating by viscous dissipation}}{\text{heat transfer by applied } \Delta T}$$ Eckert number

$$\mathrm{Nu} = \frac{hd}{k_{fl}} = \text{dimensionless heat transfer coefficient}$$ Nusselt number

The Nusselt number is a dimensionless heat transfer coefficient between a fluid and a solid surface, where k_{fl} is the thermal conductivity of the fluid, d is a characteristic dimension of the fluid system such as tube diameter or hydraulic diameter, and h is the heat transfer coefficient between the solid surface and the fluid. The Nusselt number can also be considered a dimensionless temperature gradient in the fluid at the solid surface.

$$\mathrm{Bi} = \frac{hL}{k_s} = \text{dimensionless heat transfer coefficient}$$ Biot number

The Biot number is used in a boundary condition when computing heat transfer within a solid body, where k_s is the thermal conductivity of the solid, L is a characteristic dimension of the solid body, and h is the heat transfer coefficient between the solid surface and fluid flowing over the solid body's surface boundary. The Biot number can also be considered as Bi = $h/(k_s/L)$ = (heat transfer coeficient from fluid to solid surface) / (internal conductance within solid body).

$$\mathrm{Sh} = \frac{k_c d}{D_{12}} = \text{dimensionless mass transfer coefficient}$$ Sherwood number

The Sherwood number is sometimes referred to as the Nusselt number for mass transfer.

$\tau = \frac{\alpha\, t}{L^2}$ = dimensionless time for heat conduction   Fourier number

The Fourier number can also be considered as the ratio of the rate of heat conduction across length L in volume L^3 to the rate of heat storage in volume L^3. See Wong, p. 23.

$\mathrm{Gz} = \mathrm{Pr}\ \mathrm{Re}\frac{d}{z}$ = inverse dimensionless axial distance   Graetz number

The Graetz number appears in problems of thermal entrance length for fluid flow in ducts.

$\mathrm{Gr} = \frac{g\beta\left(T_s - T_\infty\right)L^3}{\upsilon^2} = \frac{\text{bouyancy forces}}{\text{viscous forces}}$ Grashof number

where d is tube diameter or other characteristic length, L is a characteristic length, g is gravitational acceleration, β is coefficient of thermal expansion. The Grashof number appears in problems of natural convection.

$\mathrm{Ra} = \mathrm{Pr}\ \mathrm{Gr} = \frac{\text{bouyancy driven convective heat transfer}}{\text{diffusive (conductive) heat transfer}}$ Rayleigh number

The Rayleigh number appears in problems of natural convection in the presence of forced convection.