Equations and Conversion Factors

Note: the curvy volume symbol in the book is not in a standard font; below, V = velocity and V = volume.

$$W = m g$$

$$A_{circle} = \frac{\pi}{4} d^2$$

$$\mathsf{V}_{\text{sphere}} = \frac{\pi d^3}{6}$$

$$\tau = \frac{F}{A}$$

$$F_{film} = \frac{\mu A V}{l}$$

$$\Delta P_{droplet} = \frac{2\sigma_s}{R}$$

$$\Delta P_{soap\,bubble} = \frac{4\sigma_s}{R}$$

$$h = \frac{2\sigma_s}{\rho g R}\cos\phi$$

$$F_R = P_{avg} A$$

$$P = \rho g h$$

$$F_B = \rho_{fluid}\, g\, \mathsf{V}$$

$$y_P = y_C + \frac{I_{xx,c}}{\left(y_C + \frac{P_0}{\rho g \sin\theta}\right) A}$$

Ignoring P_0:

$$y_P = y_C + \frac{I_{xx,c}}{y_C A}$$

Rectangle:

$$I_{xx,c} = \frac{b h^3}{12}$$

$$\text{Pa} = \frac{\text{N}}{\text{m}^2}$$

$$\text{N} = \frac{\text{kg m}}{\text{s}^2}$$

$$\text{W} = \frac{\text{N m}}{\text{s}}$$

$$\text{J} = \text{N m}$$

$$^\circ\text{C} + 273 = \text{K}$$

$$\rho_{water} = 1000\,\frac{\text{kg}}{\text{m}^3}$$

$$g = 9.81\,\frac{\text{m}}{\text{s}^2}$$

$$P_0 = 1\,\text{atm} = 101\,\text{kPa}$$

$$\frac{P_1}{\rho g} + \alpha_1 \frac{V_1^2}{2g} + z_1 + h_{pump,u} = \frac{P_2}{\rho g} + \alpha_2 \frac{V_2^2}{2g} + h_{turbine,e} + h_L$$

$$P_1 + \alpha_1 \frac{\rho V_1^2}{2} + \rho g z_1 + \rho g h_{pump,u} = P_2 + \alpha_2 \frac{\rho V_2^2}{2} + \rho g h_{turbine,e} + \rho g h_L$$

$$h_{pump,u} = \frac{w_{pump,u}}{g} = \frac{\dot{W}_{pump,u}}{\dot{m} g} = \frac{\eta_{pump} \dot{W}_{pump}}{\dot{m} g}$$

$$h_{turbine,e} = \frac{w_{turbine,e}}{g} = \frac{\dot{W}_{turbine,e}}{\dot{m} g} = \frac{\dot{W}_{turbine}}{\eta_{turbine} \dot{m} g}$$

$$h_L = \frac{e_{mech\,loss,\,piping}}{g} = \frac{E_{mech\,loss,\,piping}}{\dot{m} g}$$

$$\vec{F}_{thrust} = m\vec{a} = \sum_{\text{in}} \beta \dot{m} \vec{V} - \sum_{\text{out}} \beta \dot{m} \vec{V}$$

$$\dot{m} = \rho V_{avg} A_c$$

$$\dot{\mathsf{V}} = V_{avg} A_c$$

$$\text{Re} = \frac{V_{avg} D}{\nu} = \frac{\rho V_{avg} D}{\mu}$$

$$D_h = \frac{4 A_c}{p}$$

Laminar: $f = \frac{64}{\text{Re}}$

$$h_{L\,pipe} = f \frac{L}{D} \frac{V_{avg}^2}{2g}$$

$$h_{L\,fitting} = K_L \frac{V_{avg}^2}{2g}$$

$$F_D = C_D A \frac{\rho V^2}{2}$$

$$F_L = C_L A \frac{\rho V^2}{2}$$

$$\text{Re}_x = \frac{V_{avg} x}{\nu} = \frac{\rho V_{avg} x}{\mu}$$

Inside a round pipe: laminar if $\mathrm{Re} < 2300$, transition if $2300 < \mathrm{Re} < 4000$, turbulent if $4000 < \mathrm{Re}$

Over a sphere or cylinder: laminar if $\mathrm{Re} < 2\times10^5$, transition if $2\times10^5 < \mathrm{Re} < 2\times10^6$, turbulent if $2\times10^6 < \mathrm{Re}$

Over a flat plate: laminar if $\mathrm{Re} < 5\times10^5$, then average $C_f = \dfrac{1.33}{\mathrm{Re}_L^{1/2}}$

Over a flat plate: turbulent if $5\times10^5 < \mathrm{Re}$, then average $C_f = \dfrac{0.074}{\mathrm{Re}_L^{1/5}}$

Flat plate with both laminar & turbulent boundary layers: $C_f = \dfrac{0.074}{\mathrm{Re}_L^{1/5}} - \dfrac{1742}{\mathrm{Re}_L}$

Aircraft $V_{min} = \sqrt{\dfrac{2W}{\rho C_{L,max} A}}$

Metric prefixes

n	=	nano-	=	10^{-9}	k	=	kilo-	=	10^{3}
μ	=	micro-	=	10^{-6}	M	=	mega-	=	10^{6}
m	=	milli-	=	10^{-3}	G	=	giga-	=	10^{9}
c	=	centi-	=	10^{-2}	T	=	tera-	=	10^{12}