APPENDIX A

Conversion Factors, Constants, and Fluid Properties

OUTLINE

A.1. CONVERSION FACTORS

Length:	$1\ \text{m} = 3.2808\ \text{ft}$
	$1\ \text{in.} = 2.540\ \text{cm}$
	$1\ \text{mile} = 1.609\ \text{km}$
	$1\ \text{nautical mile} = 1.852\ \text{km}$
Mass[1]:	$1\ \text{kg} = 0.06854\ \text{slug} = 1000\ \text{g} \leftrightarrow 2.205\ \text{lbs}$
	$1\ \text{metric ton} = 1000\ \text{kg}$
Time:	$1\ \text{day} = 86{,}400\ \text{s}$
Density[1]:	$1\ \text{kg m}^{-3} = 1.941 \times 10^{-3}\ \text{slugs ft}^{-3} \leftrightarrow 0.06244\ \text{lbs/ft}^3$
Velocity:	$1\ \text{knot} = 0.5144\ \text{m/s}$
Force:	$1\ \text{N} = 10^5\ \text{dyn} = 0.2248\ \text{lbs}$
Pressure:	$1\ \text{dyn cm}^{-2} = 0.1\ \text{N/m}^2 = 0.1\ \text{Pa}$
	$1\ \text{bar} = 10^5\ \text{Pa}$
Energy:	$1\ \text{J} = 10^7\ \text{erg} = 0.2389\ \text{cal}$
	$1\ \text{cal} = 4.186\ \text{J}$
Energy flux:	$1\ \text{W m}^{-2} = 2.39 \times 10^{-5}\ \text{cal cm}^{-2}\ \text{s}^{-1}$

[1]At the earth's surface, the weight of a 1 kg mass is 2.205 lbs.

A.2. PHYSICAL CONSTANTS

Avogadro's Number:	6.023×10^{23} gmole^{-1}
Boltzmann's Constant:	1.381×10^{-23} J K^{-1}
Gravitational Acceleration:	9.807 m s^{-2} = 32.17 ft s^{-2} (at the surface of the earth)
Graviational Constant:	6.67×10^{-11} m^3 kg^{-1} s^{-2}
Planck's Constant:	6.626×10^{-34} J s
Speed of Light in Vacuum:	2.998×10^{8} m s^{-1}
Universal Gas Constant:	8.314 J gmole^{-1} K^{-1}

A.3. PROPERTIES OF PURE WATER AT ATMOSPHERIC PRESSURE

Here, ρ = density, α = coefficient of thermal expansion, μ = shear viscosity, ν = kinematic viscosity = μ/ρ, κ = thermal diffusivity = $k/(\rho C_p)$, (k is first defined in Section 1.5) Pr = Prandtl number, and 1.0×10^{-n} is written as 1.0E − n.

T °C	ρ kg/m^3	α K^{-1}	μ kg m^{-1} s^{-1}	ν m^2/s	κ m^2/s	C_p J kg^{-1} K^{-1}	Pr ν/κ
0	1000	−0.6E − 4	1.787E − 3	1.787E − 6	1.33E − 7	4217	13.4
10	1000	+0.9E − 4	1.307E − 3	1.307E − 6	1.38E − 7	4192	9.5
20	998	2.1E − 4	1.002E − 3	1.004E − 6	1.42E − 7	4182	7.1
30	996	3.0E − 4	0.799E − 3	0.802E − 6	1.46E − 7	4178	5.5
40	992	3.8E − 4	0.653E − 3	0.658E − 6	1.52E − 7	4178	4.3
50	988	4.5E − 4	0.548E − 3	0.555E − 6	1.58E − 7	4180	3.5

Latent heat of vaporization at 100 °C = 2.257×10^6 J/kg.
Latent heat of melting of ice at 0 °C = 0.334×10^6 J/kg.
Density of ice = 920 kg/m^3.
Surface tension between water and air at 20 °C = 0.0728 N/m.
Sound speed at 20 °C = 1481 m/s.

A.4. PROPERTIES OF DRY AIR AT ATMOSPHERIC PRESSURE

T °C	ρ kg/m^3	μ kg m^{-1} s^{-1}	ν m^2/s	κ m^2/s	Pr ν/κ
0	1.293	1.71E − 5	1.33E − 5	1.84E − 5	0.72
10	1.247	1.76E − 5	1.41E − 5	1.96E − 5	0.72
20	1.200	1.81E − 5	1.50E − 5	2.08E − 5	0.72
30	1.165	1.86E − 5	1.60E − 5	2.25E − 5	0.71
40	1.127	1.87E − 5	1.66E − 5	2.38E − 5	0.71
60	1.060	1.97E − 5	1.86E − 5	2.65E − 5	0.71
80	1.000	2.07E − 5	2.07E − 5	2.99E − 5	0.70
100	0.946	2.17E − 5	2.29E − 5	3.28E − 5	0.70

At 20°C and 1 atm:	Specific heat capacity at constant pressure:	$C_p = 1004$ J kg^{-1} K^{-1}
	Specific heat capacity at constant volume:	$C_v = 717$ J kg^{-1} K^{-1}
	Ratio of specific heat capacities:	$\gamma = 1.40$
	Coefficient of thermal expansion:	$\alpha = 3.41 \times 10^{-3}$ K^{-1}
	Speed of sound:	$c = 343$ m s^{-1}
Constants for dry air:	Gas constant:	$R = 287$ J kg^{-1} K^{-1}
	Molecular mass:	28.966 g gmole^{-1} or kg kmole^{-1}

A.5. THE STANDARD ATMOSPHERE

The following average values are accepted by international agreement. Here, z is the height above sea level.

z km	T °C	p kPa	ρ kg/m^3
0	15.0	101.3	1.225
0.5	11.5	95.5	1.168
1	8.5	89.9	1.112
2	2.0	79.5	1.007
3	−4.5	70.1	0.909

(*Continued*)

z km	T °C	p kPa	ρ kg/m^3
4	−11.0	61.6	0.819
5	−17.5	54.0	0.736
6	−24.0	47.2	0.660
8	−37.0	35.6	0.525
10	−50.0	26.4	0.413
12	−56.5	19.3	0.311
14	−56.5	14.1	0.226
16	−56.5	10.3	0.165
18	−56.5	7.5	0.120
20	−56.5	5.5	0.088