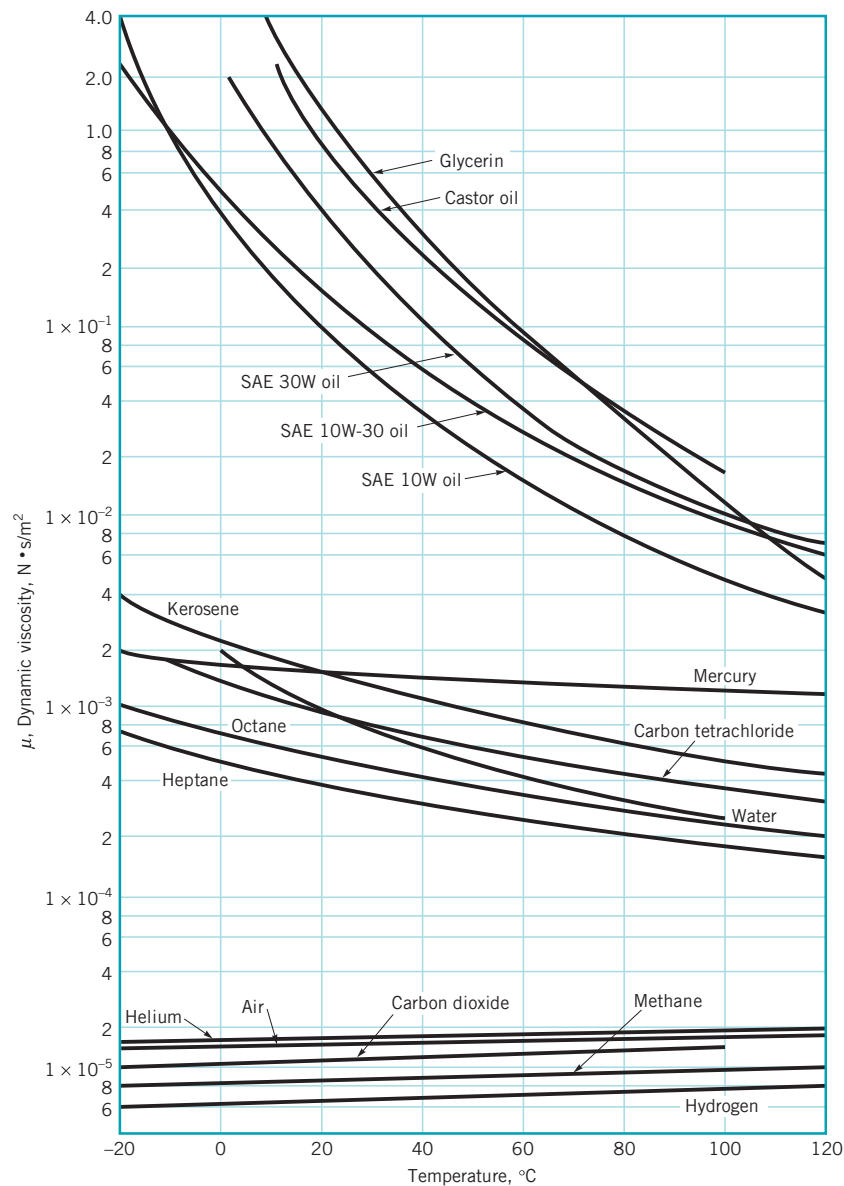
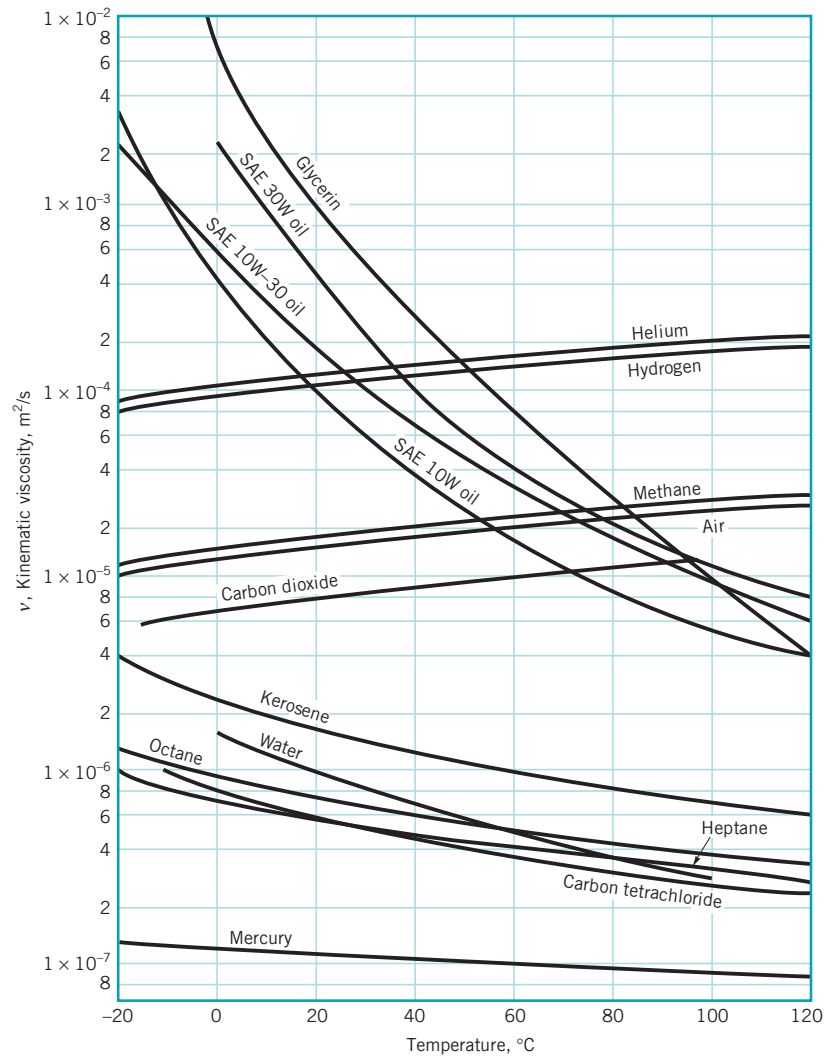


Appendix B

Physical Properties of Fluids



■ **FIGURE B.1** Dynamic (absolute) viscosity of common fluids as a function of temperature. To convert to BG units of $\text{lb} \cdot \text{s}/\text{ft}^2$ multiply $\text{N} \cdot \text{s}/\text{m}^2$ by 2.089×10^{-2} . (Curves from R. W. Fox and A. T. McDonald, *Introduction to Fluid Mechanics*, 3rd Ed., Wiley, New York, 1985. Used by permission.)



■ **FIGURE B.2** Kinematic viscosity of common fluids (at atmospheric pressure) as a function of temperature. To convert to BG units of ft^2/s multiply m^2/s by 10.76. (Curves from R. W. Fox and A. T. McDonald, *Introduction to Fluid Mechanics*, 3rd Ed., Wiley, New York, 1985. Used by permission.)

■ **TABLE B.1**
Physical Properties of Water (BG Units)^a

Temperature (°F)	Density, ρ (slugs/ft ³)	Specific Weight ^b , γ (lb/ft ³)	Dynamic Viscosity, μ (lb·s/ft ²)	Kinematic Viscosity, ν (ft ² /s)	Surface Tension ^c , σ (lb/ft)	Vapor Pressure, p_v [lb/in. ² (abs)]	Speed of Sound ^d , c (ft/s)
32	1.940	62.42	3.732 E - 5	1.924 E - 5	5.18 E - 3	8.854 E - 2	4603
40	1.940	62.43	3.228 E - 5	1.664 E - 5	5.13 E - 3	1.217 E - 1	4672
50	1.940	62.41	2.730 E - 5	1.407 E - 5	5.09 E - 3	1.781 E - 1	4748
60	1.938	62.37	2.344 E - 5	1.210 E - 5	5.03 E - 3	2.563 E - 1	4814
70	1.936	62.30	2.037 E - 5	1.052 E - 5	4.97 E - 3	3.631 E - 1	4871
80	1.934	62.22	1.791 E - 5	9.262 E - 6	4.91 E - 3	5.069 E - 1	4819
90	1.931	62.11	1.500 E - 5	8.233 E - 6	4.86 E - 3	6.979 E - 1	4960
100	1.927	62.00	1.423 E - 5	7.383 E - 6	4.79 E - 3	9.493 E - 1	4995
120	1.918	61.71	1.164 E - 5	6.067 E - 6	4.67 E - 3	1.692 E + 0	5049
140	1.908	61.38	9.743 E - 6	5.106 E - 6	4.53 E - 3	2.888 E + 0	5091
160	1.896	61.00	8.315 E - 6	4.385 E - 6	4.40 E - 3	4.736 E + 0	5101
180	1.883	60.58	7.207 E - 6	3.827 E - 6	4.26 E - 3	7.507 E + 0	5195
200	1.869	60.12	6.342 E - 6	3.393 E - 6	4.12 E - 3	1.152 E + 1	5089
212	1.860	59.83	5.886 E - 6	3.165 E - 6	4.04 E - 3	1.469 E + 1	5062

^aBased on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988. Where necessary, values obtained by interpolation.

^bDensity and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 32.174 \text{ ft/s}^2$.

^cIn contact with air.

^dFrom R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

■ **TABLE B.2**
Physical Properties of Water (SI Units)^a

Temperature (°C)	Density, ρ (kg/m ³)	Specific Weight ^b , γ (kN/m ³)	Dynamic Viscosity, μ (N·s/m ²)	Kinematic Viscosity, ν (m ² /s)	Surface Tension ^c , σ (N/m)	Vapor Pressure, p_v [N/m ² (abs)]	Speed of Sound ^d , c (m/s)
0	999.9	9.806	1.787 E - 3	1.787 E - 6	7.56 E - 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E - 3	1.519 E - 6	7.49 E - 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E - 3	1.307 E - 6	7.42 E - 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E - 3	1.004 E - 6	7.28 E - 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E - 4	8.009 E - 7	7.12 E - 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E - 4	6.580 E - 7	6.96 E - 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E - 4	5.534 E - 7	6.79 E - 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E - 4	4.745 E - 7	6.62 E - 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E - 4	4.134 E - 7	6.44 E - 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E - 4	3.650 E - 7	6.26 E - 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E - 4	3.260 E - 7	6.08 E - 2	7.010 E + 4	1550
100	958.4	9.399	2.818 E - 4	2.940 E - 7	5.89 E - 2	1.013 E + 5	1543

^aBased on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.

^bDensity and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 9.807 \text{ m/s}^2$.

^cIn contact with air.

^dFrom R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

■ TABLE B.3

Physical Properties of Air at Standard Atmospheric Pressure (BG Units)^a

Temperature (°F)	Density, ρ (slugs/ft ³)	Specific Weight ^b , γ (lb/ft ³)	Dynamic Viscosity, μ (lb·s/ft ²)	Kinematic Viscosity, ν (ft ² /s)	Specific Heat Ratio, k (—)	Speed of Sound, c (ft/s)
−40	2.939 E − 3	9.456 E − 2	3.29 E − 7	1.12 E − 4	1.401	1004
−20	2.805 E − 3	9.026 E − 2	3.34 E − 7	1.19 E − 4	1.401	1028
0	2.683 E − 3	8.633 E − 2	3.38 E − 7	1.26 E − 4	1.401	1051
10	2.626 E − 3	8.449 E − 2	3.44 E − 7	1.31 E − 4	1.401	1062
20	2.571 E − 3	8.273 E − 2	3.50 E − 7	1.36 E − 4	1.401	1074
30	2.519 E − 3	8.104 E − 2	3.58 E − 7	1.42 E − 4	1.401	1085
40	2.469 E − 3	7.942 E − 2	3.60 E − 7	1.46 E − 4	1.401	1096
50	2.420 E − 3	7.786 E − 2	3.68 E − 7	1.52 E − 4	1.401	1106
60	2.373 E − 3	7.636 E − 2	3.75 E − 7	1.58 E − 4	1.401	1117
70	2.329 E − 3	7.492 E − 2	3.82 E − 7	1.64 E − 4	1.401	1128
80	2.286 E − 3	7.353 E − 2	3.86 E − 7	1.69 E − 4	1.400	1138
90	2.244 E − 3	7.219 E − 2	3.90 E − 7	1.74 E − 4	1.400	1149
100	2.204 E − 3	7.090 E − 2	3.94 E − 7	1.79 E − 4	1.400	1159
120	2.128 E − 3	6.846 E − 2	4.02 E − 7	1.89 E − 4	1.400	1180
140	2.057 E − 3	6.617 E − 2	4.13 E − 7	2.01 E − 4	1.399	1200
160	1.990 E − 3	6.404 E − 2	4.22 E − 7	2.12 E − 4	1.399	1220
180	1.928 E − 3	6.204 E − 2	4.34 E − 7	2.25 E − 4	1.399	1239
200	1.870 E − 3	6.016 E − 2	4.49 E − 7	2.40 E − 4	1.398	1258
300	1.624 E − 3	5.224 E − 2	4.97 E − 7	3.06 E − 4	1.394	1348
400	1.435 E − 3	4.616 E − 2	5.24 E − 7	3.65 E − 4	1.389	1431
500	1.285 E − 3	4.135 E − 2	5.80 E − 7	4.51 E − 4	1.383	1509
750	1.020 E − 3	3.280 E − 2	6.81 E − 7	6.68 E − 4	1.367	1685
1000	8.445 E − 4	2.717 E − 2	7.85 E − 7	9.30 E − 4	1.351	1839
1500	6.291 E − 4	2.024 E − 2	9.50 E − 7	1.51 E − 3	1.329	2114

^aBased on data from R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.^bDensity and specific weight are related through the equation $\gamma = \rho g$. For this table $g = 32.174 \text{ ft/s}^2$.

■ TABLE B.4

Physical Properties of Air at Standard Atmospheric Pressure (SI Units)^a

Temperature (°C)	Density, ρ (kg/m ³)	Specific Weight ^b , γ (N/m ³)	Dynamic Viscosity, μ (N·s/m ²)	Kinematic Viscosity, ν (m ² /s)	Specific Heat Ratio, k (—)	Speed of Sound, c (m/s)
−40	1.514	14.85	1.57 E − 5	1.04 E − 5	1.401	306.2
−20	1.395	13.68	1.63 E − 5	1.17 E − 5	1.401	319.1
0	1.292	12.67	1.71 E − 5	1.32 E − 5	1.401	331.4
5	1.269	12.45	1.73 E − 5	1.36 E − 5	1.401	334.4
10	1.247	12.23	1.76 E − 5	1.41 E − 5	1.401	337.4
15	1.225	12.01	1.80 E − 5	1.47 E − 5	1.401	340.4
20	1.204	11.81	1.82 E − 5	1.51 E − 5	1.401	343.3
25	1.184	11.61	1.85 E − 5	1.56 E − 5	1.401	346.3
30	1.165	11.43	1.86 E − 5	1.60 E − 5	1.400	349.1
40	1.127	11.05	1.87 E − 5	1.66 E − 5	1.400	354.7
50	1.109	10.88	1.95 E − 5	1.76 E − 5	1.400	360.3
60	1.060	10.40	1.97 E − 5	1.86 E − 5	1.399	365.7
70	1.029	10.09	2.03 E − 5	1.97 E − 5	1.399	371.2
80	0.9996	9.803	2.07 E − 5	2.07 E − 5	1.399	376.6
90	0.9721	9.533	2.14 E − 5	2.20 E − 5	1.398	381.7
100	0.9461	9.278	2.17 E − 5	2.29 E − 5	1.397	386.9
200	0.7461	7.317	2.53 E − 5	3.39 E − 5	1.390	434.5
300	0.6159	6.040	2.98 E − 5	4.84 E − 5	1.379	476.3
400	0.5243	5.142	3.32 E − 5	6.34 E − 5	1.368	514.1
500	0.4565	4.477	3.64 E − 5	7.97 E − 5	1.357	548.8
1000	0.2772	2.719	5.04 E − 5	1.82 E − 4	1.321	694.8

^aBased on data from R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.^bDensity and specific weight are related through the equation $\gamma = \rho g$. For this table $g = 9.807 \text{ m/s}^2$.