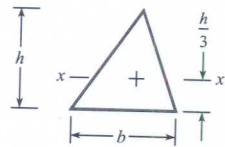


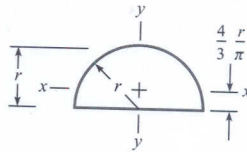
PLEASE DO NOT WRITE ON TABLES!
RETURN AFTER EXAM!

APPENDIX



$$A = \frac{bh}{2}$$

$$\bar{I}_{xx} = \frac{bh^3}{36}$$

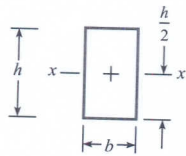


$$A = \frac{\pi r^2}{2}$$

$$\bar{I}_{xx} = 0.110r^4$$

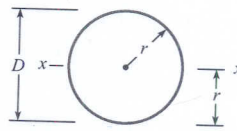
$$\bar{I}_{yy} = \frac{\pi r^4}{8}$$

FIGURE A.1
Centroids and moments of inertia of plane areas



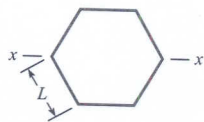
$$A = bh$$

$$\bar{I}_{xx} = \frac{bh^3}{12}$$



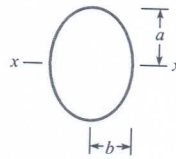
$$A = \pi r^2$$

$$\bar{I}_{xx} = \frac{\pi r^4}{4}$$



$$A = 2.5981L^2$$

$$\bar{I}_x = 0.5127L^4$$



$$A = \pi ab$$

$$\bar{I}_{xx} = \frac{\pi a^3 b}{4}$$

Volume and Area Formulas:

$$A_{\text{circle}} = \pi r^2 = \pi D^2/4$$

$$A_{\text{sphere surface}} = \pi D^2$$

$$V_{\text{sphere}} = \frac{1}{6} \pi D^3 = \frac{4}{3} \pi r^3$$

$$V_{\text{cone}} = \frac{1}{12} \pi D^2 h = \frac{1}{3} \pi r^2 h$$

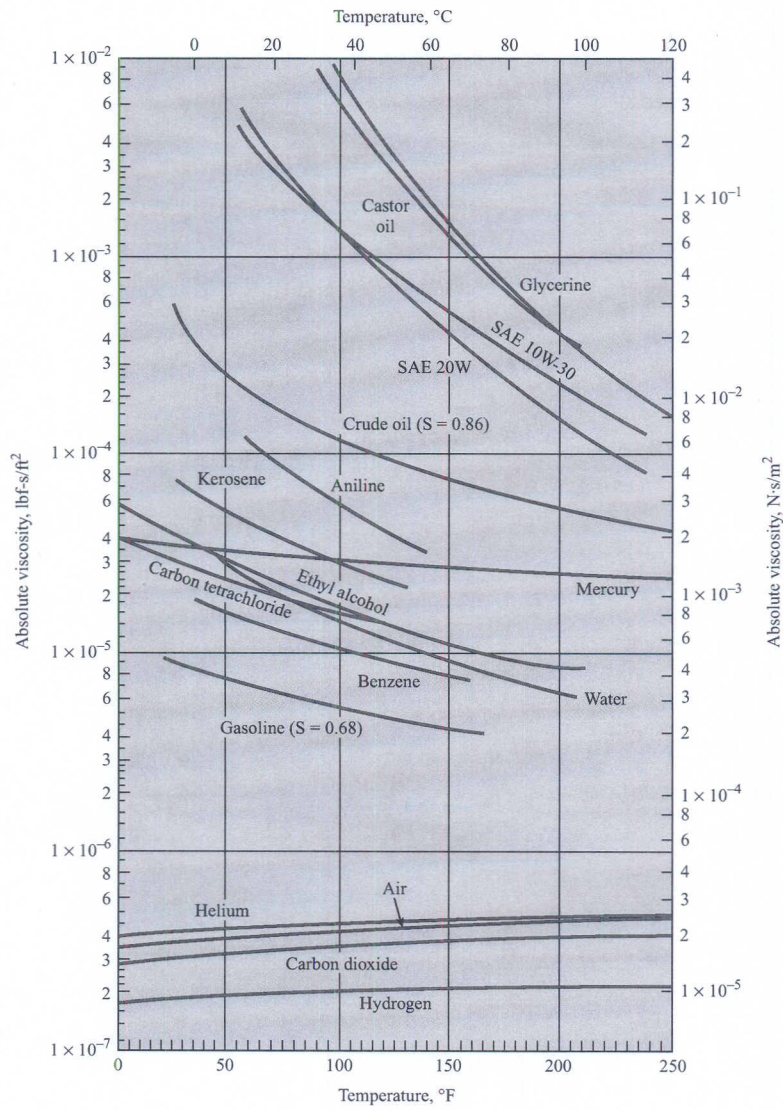


FIGURE A.2

Absolute viscosities of certain gases and liquids [Adapted from Fluid Mechanics, 5th ed., by V. L. Streeter. Copyright © 1971, McGraw-Hill Book Company, New York. Used with permission of the McGraw-Hill Book Company.]

FIGURE A.3

Kinematic viscosities of certain gases and liquids. The gases are at standard pressure. [Adapted from Fluid Mechanics, 5th ed., by V. L. Streeter. Copyright © 1971, McGraw-Hill Book Company, New York. Used with permission of the McGraw-Hill Book Company.]

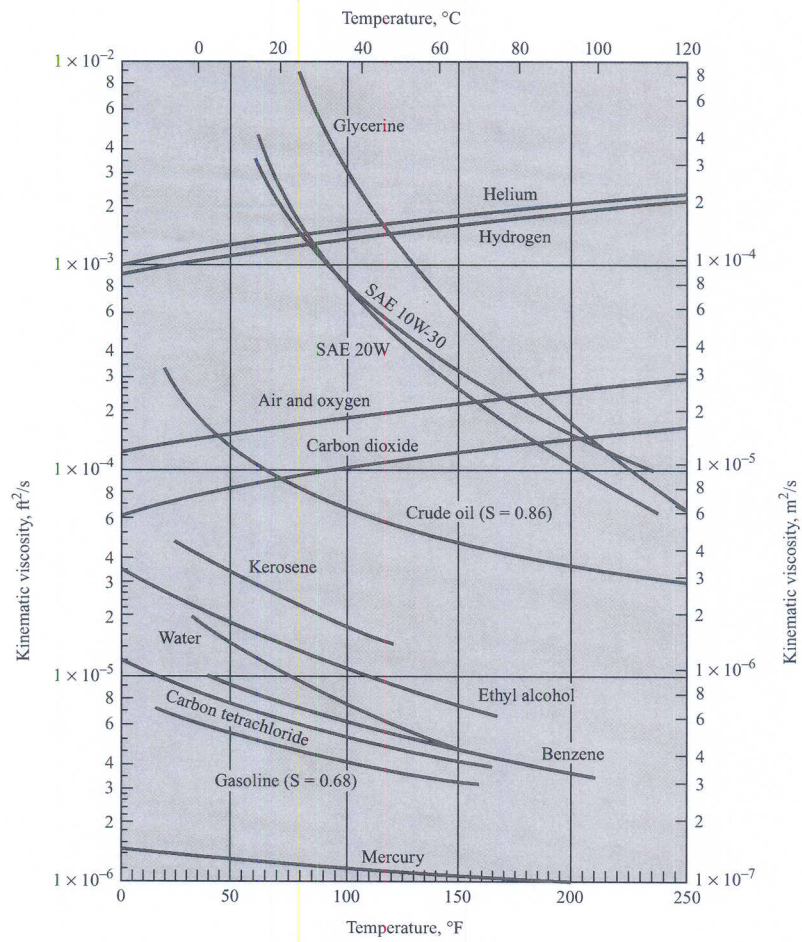


TABLE A.2 Physical Properties of Gases [$T = 15^\circ\text{C}$ (59°F), $p = 1$ atm]

Gas	Density kg/m^3 (slugs/ft ³)	Kinematic Viscosity m^2/s (ft ² /s)	R Gas Constant J/kg K (ft-lbf/slug-°R)	$\frac{c_p}{J}$ kg K ($\frac{\text{Btu}}{\text{lbm}\cdot^\circ\text{R}}$)	$k = \frac{c_p}{c_v}$	S Sutherland's Constant $\text{K}(\text{°R})$
Air	1.22 (0.00237)	1.46×10^{-5} (1.58×10^{-4})	287 (1716)	1004 (0.240)	1.40	111 (199)
Carbon dioxide	1.85 (0.0036)	7.84×10^{-6} (8.48×10^{-5})	189 (1130)	841 (0.201)	1.30	222 (400)
Helium	0.169 (0.00033)	1.14×10^{-4} (1.22×10^{-3})	2077 (12,419)	5187 (1.24)	1.66	79.4 (143)
Hydrogen	0.0851 (0.00017)	1.01×10^{-4} (1.09×10^{-3})	4127 (24,677)	14,223 (3.40)	1.41	96.7 (174)
Methane (natural gas)	0.678 (0.0013)	1.59×10^{-5} (1.72×10^{-4})	518 (3098)	2208 (0.528)	1.31	198 (356)
Nitrogen	1.18 (0.0023)	1.45×10^{-5} (1.56×10^{-4})	297 (1776)	1041 (0.249)	1.40	107 (192)
Oxygen	1.35 (0.0026)	1.50×10^{-5} (1.61×10^{-4})	260 (1555)	916 (0.219)	1.40	

Source: V. L. Streeter (ed.), *Handbook of Fluid Dynamics*, McGraw-Hill Book Company, New York, 1961; also R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc. Cleveland, 1973; and *Handbook of Chemistry and Physics*, Chemical Rubber Company, 1951.

TABLE A.3 Mechanical Properties of Air at Standard Atmospheric Pressure

Temperature	Density	Specific Weight	Dynamic Viscosity	Kinematic Viscosity
	kg/m ³	N/m ³	N · s/m ²	m ² /s
-20°C	1.40	13.70	1.61 × 10 ⁻⁵	1.16 × 10 ⁻⁵
-10°C	1.34	13.20	1.67 × 10 ⁻⁵	1.24 × 10 ⁻⁵
0°C	1.29	12.70	1.72 × 10 ⁻⁵	1.33 × 10 ⁻⁵
10°C	1.25	12.20	1.76 × 10 ⁻⁵	1.41 × 10 ⁻⁵
20°C	1.20	11.80	1.81 × 10 ⁻⁵	1.51 × 10 ⁻⁵
30°C	1.17	11.40	1.86 × 10 ⁻⁵	1.60 × 10 ⁻⁵
40°C	1.13	11.10	1.91 × 10 ⁻⁵	1.69 × 10 ⁻⁵
50°C	1.09	10.70	1.95 × 10 ⁻⁵	1.79 × 10 ⁻⁵
60°C	1.06	10.40	2.00 × 10 ⁻⁵	1.89 × 10 ⁻⁵
70°C	1.03	10.10	2.04 × 10 ⁻⁵	1.99 × 10 ⁻⁵
80°C	1.00	9.81	2.09 × 10 ⁻⁵	2.09 × 10 ⁻⁵
90°C	0.97	9.54	2.13 × 10 ⁻⁵	2.19 × 10 ⁻⁵
100°C	0.95	9.28	2.17 × 10 ⁻⁵	2.29 × 10 ⁻⁵
120°C	0.90	8.82	2.26 × 10 ⁻⁵	2.51 × 10 ⁻⁵
140°C	0.85	8.38	2.34 × 10 ⁻⁵	2.74 × 10 ⁻⁵
160°C	0.81	7.99	2.42 × 10 ⁻⁵	2.97 × 10 ⁻⁵
180°C	0.78	7.65	2.50 × 10 ⁻⁵	3.20 × 10 ⁻⁵
200°C	0.75	7.32	2.57 × 10 ⁻⁵	3.44 × 10 ⁻⁵
	slugs/ft ³	lbf/ft ³	lbf-s/ft ²	ft ² /s
0°F	0.00269	0.0866	3.39 × 10 ⁻⁷	1.26 × 10 ⁻⁴
20°F	0.00257	0.0828	3.51 × 10 ⁻⁷	1.37 × 10 ⁻⁴
40°F	0.00247	0.0794	3.63 × 10 ⁻⁷	1.47 × 10 ⁻⁴
60°F	0.00237	0.0764	3.74 × 10 ⁻⁷	1.58 × 10 ⁻⁴
80°F	0.00228	0.0735	3.85 × 10 ⁻⁷	1.69 × 10 ⁻⁴
100°F	0.00220	0.0709	3.96 × 10 ⁻⁷	1.80 × 10 ⁻⁴
120°F	0.00213	0.0685	4.07 × 10 ⁻⁷	1.91 × 10 ⁻⁴
150°F	0.00202	0.0651	4.23 × 10 ⁻⁷	2.09 × 10 ⁻⁴
200°F	0.00187	0.0601	4.48 × 10 ⁻⁷	2.40 × 10 ⁻⁴
300°F	0.00162	0.0522	4.96 × 10 ⁻⁷	3.05 × 10 ⁻⁴
400°F	0.00143	0.0462	5.40 × 10 ⁻⁷	3.77 × 10 ⁻⁴

Source: Reprinted with permission from R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc., Cleveland, 1973. Copyright © 1973 by The Chemical Rubber Co., CRC Press, Inc.

TABLE A.4 Approximate Physical Properties of Common Liquids at Atmospheric Pressure

Liquid and Temperature	Density kg/m ³ (slugs/ft ³)	Specific Gravity	Specific Weight N/m ³ (lbf/ft ³)	Dynamic Viscosity N · s/m ² (lbf-s/ft ²)	Kinematic Viscosity m ² /s (ft ² /s)	Surface Tension N/m* (lbf/ft)
Ethyl alcohol ⁽¹⁾⁽³⁾ 20°C (68°F)	799 (1.55)	0.79	7,850 (50.0)	1.2×10^{-3} (2.5×10^{-5})	1.5×10^{-6} (1.6×10^{-5})	2.2×10^{-2} (1.5×10^{-3})
Carbon tetrachloride ⁽³⁾ 20°C (68°F)	1,590 (3.09)	1.59	15,600 (99.5)	9.6×10^{-4} (2.0×10^{-5})	6.0×10^{-7} (6.5×10^{-6})	2.6×10^{-2} (1.8×10^{-3})
Glycerine ⁽³⁾ 20°C (68°F)	1,260 (2.45)	1.26	12,300 (78.5)	1.41 (2.95×10^{-2})	1.12×10^{-3} (1.22×10^{-2})	6.3×10^{-2} (4.3×10^{-3})
Kerosene ⁽¹⁾⁽²⁾ 20°C (68°F)	814 (1.58)	0.81	8,010 (51)	1.9×10^{-3} (4.0×10^{-5})	2.37×10^{-6} (2.55×10^{-5})	2.9×10^{-2} (2.0×10^{-3})
Mercury ⁽¹⁾⁽³⁾ 20°C (68°F)	13,550 (26.3)	13.55	133,000 (847)	1.5×10^{-3} (3.1×10^{-5})	1.2×10^{-7} (1.3×10^{-6})	4.8×10^{-1} (3.3×10^{-2})
Sea water 10°C at 3.3% salinity	1,026 (1.99)	1.03	10,070 (64.1)	1.4×10^{-3} (2.9×10^{-5})	1.4×10^{-6} (1.5×10^{-5})	
Oils—38°C (100°F) SAE 10W ⁽⁴⁾	870 (1.69)	0.87	8,530 (54.4)	3.6×10^{-2} (7.5×10^{-4})	4.1×10^{-5} (4.4×10^{-4})	
SAE 10W-30 ⁽⁴⁾	880 (1.71)	0.88	8,630 (55.1)	6.7×10^{-2} (1.4×10^{-3})	7.6×10^{-5} (8.2×10^{-4})	
SAE 30 ⁽⁴⁾	880 (1.71)	0.88	8,630 (55.1)	1.0×10^{-1} (2.1×10^{-3})	1.1×10^{-4} (1.2×10^{-3})	

*Liquid-air surface tension values.

Source: (1) V. L. Streeter, *Handbook of Fluid Dynamics*, McGraw-Hill, New York, 1961; (2) V. L. Streeter, *Fluid Mechanics*, 4th ed., McGraw-Hill, New York, 1966; (3) A. A. Newman, *Glycerol*, CRC Press, Cleveland, 1968; (4) R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Sciences*, CRC Press, Cleveland, 1973.

TABLE A.5 Approximate Physical Properties of Water* at Atmospheric Pressure

Temperature	Density	Specific Weight	Dynamic Viscosity	Kinematic Viscosity	Vapor Pressure
	kg/m ³	N/m ³	N · s/m ²	m ² /s	N/m ² abs
0°C	1000	9810	1.79 × 10 ⁻³	1.79 × 10 ⁻⁶	611
5°C	1000	9810	1.51 × 10 ⁻³	1.51 × 10 ⁻⁶	872
10°C	1000	9810	1.31 × 10 ⁻³	1.31 × 10 ⁻⁶	1,230
15°C	999	9800	1.14 × 10 ⁻³	1.14 × 10 ⁻⁶	1,700
20°C	998	9790	1.00 × 10 ⁻³	1.00 × 10 ⁻⁶	2,340
25°C	997	9781	8.91 × 10 ⁻⁴	8.94 × 10 ⁻⁷	3,170
30°C	996	9771	7.97 × 10 ⁻⁴	8.00 × 10 ⁻⁷	4,250
35°C	994	9751	7.20 × 10 ⁻⁴	7.24 × 10 ⁻⁷	5,630
40°C	992	9732	6.53 × 10 ⁻⁴	6.58 × 10 ⁻⁷	7,380
50°C	988	9693	5.47 × 10 ⁻⁴	5.53 × 10 ⁻⁷	12,300
60°C	983	9643	4.66 × 10 ⁻⁴	4.74 × 10 ⁻⁷	20,000
70°C	978	9594	4.04 × 10 ⁻⁴	4.13 × 10 ⁻⁷	31,200
80°C	972	9535	3.54 × 10 ⁻⁴	3.64 × 10 ⁻⁷	47,400
90°C	965	9467	3.15 × 10 ⁻⁴	3.26 × 10 ⁻⁷	70,100
100°C	958	9398	2.82 × 10 ⁻⁴	2.94 × 10 ⁻⁷	101,300
	slugs/ft ³	lbf/ft ³	lbf-s/ft ²	ft ² /s	psia
40°F	1.94	62.43	3.23 × 10 ⁻⁵	1.66 × 10 ⁻⁵	0.122
50°F	1.94	62.40	2.73 × 10 ⁻⁵	1.41 × 10 ⁻⁵	0.178
60°F	1.94	62.37	2.36 × 10 ⁻⁵	1.22 × 10 ⁻⁵	0.256
70°F	1.94	62.30	2.05 × 10 ⁻⁵	1.06 × 10 ⁻⁵	0.363
80°F	1.93	62.22	1.80 × 10 ⁻⁵	0.930 × 10 ⁻⁵	0.506
100°F	1.93	62.00	1.42 × 10 ⁻⁵	0.739 × 10 ⁻⁵	0.949
120°F	1.92	61.72	1.17 × 10 ⁻⁵	0.609 × 10 ⁻⁵	1.69
140°F	1.91	61.38	0.981 × 10 ⁻⁵	0.514 × 10 ⁻⁵	2.89
160°F	1.90	61.00	0.838 × 10 ⁻⁵	0.442 × 10 ⁻⁵	4.74
180°F	1.88	60.58	0.726 × 10 ⁻⁵	0.385 × 10 ⁻⁵	7.51
200°F	1.87	60.12	0.637 × 10 ⁻⁵	0.341 × 10 ⁻⁵	11.53
212°F	1.86	59.83	0.593 × 10 ⁻⁵	0.319 × 10 ⁻⁵	14.70

*Notes: Bulk modulus E_v of water is approximately 2.2 GPa (3.2×10^5 psi).

Source: Reprinted with permission from R. E. Bolz and G. L. Tuve, *Handbook of Tables for Applied Engineering Science*, CRC Press, Inc., Cleveland, 1973. Copyright © 1973 by The Chemical Rubber Co., CRC Press, Inc.

FIGURE 2.16

Surface tension of water for a water/air interface. Property values from White (7).

