

### APPENDIX 7

Table for length conversion

Unit	mm	cm	m	km	in	ft	yd	mi
1 millimeter	1	0.1	0.001	$10^{-6}$	0.0397	0.00328	0.00109	$6.21 \times 10^{-7}$
1 centimeter	10	1	0.01	0.0001	0.3937	0.0328	0.0109	$6.21 \times 10^{-6}$
1 meter	1000	100	1	0.001	39.37	3.281	1.094	$6.21 \times 10^{-4}$
1 kilometer	$10^6$	$10^5$	1000	1	39,370	3281	1093.6	0.621
1 inch	25.4	2.54	0.0254	$2.54 \times 10^{-5}$	1	0.0833	0.0278	$1.58 \times 10^{-5}$
1 foot	304.8	30.48	0.3048	$3.05 \times 10^{-4}$	12	1	0.333	$1.89 \times 10^{-4}$
1 yard	914.4	91.44	0.9144	$9.14 \times 10^{-4}$	36	3	1	$5.68 \times 10^{-4}$
1 mile	$1.61 \times 10^6$	$1.01 \times 10^5$	$1.61 \times 10^3$	1.6093	63,360	5280	1760	1

### APPENDIX 8

Table for area conversion

Unit	cm <sup>2</sup>	m <sup>2</sup>	km <sup>2</sup>	ha	in <sup>2</sup>	ft <sup>2</sup>	yd <sup>2</sup>	mi <sup>2</sup>	ac
1 sq. centimeter	1	0.0001	$10^{-10}$	$10^{-8}$	0.155	$1.08 \times 10^{-3}$	$1.2 \times 10^{-4}$	$3.86 \times 10^{-11}$	$2.47 \times 10^{-8}$
1 sq. meter	$10^4$	1	$10^{-6}$	$10^{-4}$	1550	10.76	1.196	$3.86 \times 10^{-7}$	$2.47 \times 10^{-4}$
1 sq. kilometer	$10^{10}$	$10^6$	1	100	$1.55 \times 10^9$	$1.076 \times 10^7$	$1.196 \times 10^6$	0.3861	247.1
1 hectare	$10^8$	$10^4$	0.01	1	$1.55 \times 10^7$	$1.076 \times 10^5$	$1.196 \times 10^4$	$3.861 \times 10^{-3}$	2.471
1 sq. inch	6.452	$6.45 \times 10^{-4}$	$6.45 \times 10^{10}$	$6.45 \times 10^{-8}$	1	$6.94 \times 10^{-3}$	$7.7 \times 10^{-4}$	$2.49 \times 10^{-10}$	$1.574 \times 10^{-7}$
1 sq. foot	929	0.0929	$9.29 \times 10^{-8}$	$9.29 \times 10^{-6}$	144	1	0.111	$3.587 \times 10^{-8}$	$2.3 \times 10^{-5}$
1 sq. yard	8361	0.8361	$8.36 \times 10^{-7}$	$8.36 \times 10^{-5}$	1296	9	1	$3.23 \times 10^{-7}$	$2.07 \times 10^{-4}$
1 sq. mile	$2.59 \times 10^{10}$	$2.59 \times 10^6$	2.59	259	$4.01 \times 10^9$	$2.79 \times 10^7$	$3.098 \times 10^6$	1	640
1 acre	$4.04 \times 10^7$	4047	$4.047 \times 10^{-3}$	0.4047	$6.27 \times 10^6$	43,560	4840	$1.562 \times 10^{-3}$	1

### APPENDIX 9

Table for volume conversion

Unit	mL	liters	m <sup>3</sup>	in <sup>3</sup>	ft <sup>3</sup>	gal	ac-ft	million gal
1 milliliter	1	0.001	$10^{-6}$	0.06102	$3.53 \times 10^{-5}$	$2.64 \times 10^4$	$8.1 \times 10^{-10}$	$2.64 \times 10^{-10}$
1 liter	$10^3$	1	0.001	61.02	0.0353	0.264	$8.1 \times 10^{-7}$	$2.64 \times 10^{-7}$
1 cu. meter	$10^6$	1000	1	61,023	35.31	264.17	$8.1 \times 10^{-4}$	$2.64 \times 10^{-4}$
1 cu. inch	16.39	$1.64 \times 10^{-2}$	$1.64 \times 10^{-5}$	1	$5.79 \times 10^{-4}$	$4.33 \times 10^{-3}$	$1.218 \times 10^{-8}$	$4.329 \times 10^{-9}$
1 cu. foot	28,317	28.317	0.02832	1728	1	7.48	$2.296 \times 10^{-5}$	$7.48 \times 10^6$
1 U.S. gallon	3785.4	3.785	$3.78 \times 10^{-3}$	231	0.134	1	$3.069 \times 10^{-6}$	$10^6$
1 acre-foot	$1.233 \times 10^9$	$1.233 \times 10^6$	1233.5	$75.27 \times 10^6$	43,560	$3.26 \times 10^5$	1	0.3260
1 million gallons	$3.785 \times 10^9$	$3.785 \times 10^6$	3785	$2.31 \times 10^8$	$1.338 \times 10^5$	$10^6$	3.0684	1

### APPENDIX 10

Table for time conversion

Unit	sec	min	hours	days	years
1 second	1	$1.67 \times 10^{-2}$	$2.77 \times 10^{-4}$	$1.157 \times 10^{-5}$	$3.17 \times 10^{-8}$
1 minute	60	1	$1.67 \times 10^{-2}$	$6.94 \times 10^{-4}$	$1.90 \times 10^{-6}$
1 hour	360	60	1	$4.17 \times 10^{-2}$	$1.14 \times 10^{-4}$
1 day	$8.64 \times 10^4$	1440	24	1	$2.74 \times 10^{-3}$
1 year	$3.15 \times 10^7$	$5.256 \times 10^5$	8760	365	1

Appendix 9.A. Continued  
Velocity

Unit	Equivalent <sup>1,2</sup>				
	feet per day	kilometers per hour	feet per second	miles per hour	meters per second
feet per day	1	$1.27 \times 10^{-5}$	$1.157 \times 10^{-5}$	$7.891 \times 10^{-6}$	$3.528 \times 10^{-6}$
kilometers per hour	$7.874 \times 10^4$	1	0.9113	0.6214	0.2778
feet per second	$8.64 \times 10^4$	1.097	1	0.6818	0.3048
miles per hour	$1.267 \times 10^5$	1.609	1.467	1	0.447
meters per second	$2.835 \times 10^5$	3.6	3.281	2.237	1

Mass

Unit	Equivalent <sup>1,2</sup>						
	ounce	pound	kilogram	metric slug	slug	short ton	metric ton
ounce	1	$6.25 \times 10^{-2}$	$2.835 \times 10^{-2}$	$2.891 \times 10^{-3}$	$1.943 \times 10^{-3}$	$3.125 \times 10^{-3}$	$2.835 \times 10^{-3}$
pound	16	1	0.4536	$4.625 \times 10^{-2}$	$3.108 \times 10^{-2}$	$5 \times 10^{-4}$	$4.536 \times 10^{-4}$
kilogram	35.28	2.205	1	0.102	$6.852 \times 10^{-2}$	$1.102 \times 10^{-3}$	0.001
metric slug	345.9	21.62	9.807	1	0.6721	92.51	$9.807 \times 10^{-3}$
slug	514.7	32.17	14.59	1.49	1	62.17	$1.459 \times 10^{-2}$
short ton	$3.2 \times 10^4$	2,000	907.2	92.51	62.16	1	0.907
metric ton	$3.528 \times 10^4$	2,205	1,000	102	68.52	1.103	1
long ton	$3.584 \times 10^4$	2,240	1,016	103.7	69.63	1.12	1.016

Force

Unit	Equivalent <sup>1,2</sup>			
	dyne	newton	pound <sub>force</sub>	kilogram <sub>force</sub>
dynes	1	$1 \times 10^{-5}$	$2.248 \times 10^{-6}$	$1.02 \times 10^{-6}$
newtons	$1 \times 10^5$	1	0.2248	0.102
pound <sub>force</sub>	$4.448 \times 10^5$	4.448	1	0.4536
kilogram <sub>force</sub>	$9.807 \times 10^5$	9.807	2.205	1

Density

Unit	Equivalent <sup>1,2</sup>				
	pounds per cubic inch	pounds per cubic foot	pounds per gallon	grams per cubic centimeter	grams per liter
pounds per cubic inch	1	1,728	231	27.68	$2.768 \times 10^4$
pounds per cubic foot	$5.787 \times 10^{-4}$	1	0.1337	$1.6 \times 10^{-2}$	16.02
pounds per gallon	$4.33 \times 10^{-3}$	7.481	1	0.1198	119.8
grams per cubic centimeter	$3.61 \times 10^{-2}$	62.43	8.345	1	1,000
grams per liter	$3.61 \times 10^{-3}$	$6.24 \times 10^{-2}$	$8.35 \times 10^{-3}$	0.001	1

APPENDIX 9.A.  
Conversion Tables

Length

Unit	Equivalent <sup>1,2</sup>					
	millimeters	inches	feet	meters	kilometers	miles
millimeters	1	$3.937 \times 10^{-2}$	$3.281 \times 10^{-3}$	$1 \times 10^{-3}$	$1 \times 10^{-6}$	$6.214 \times 10^{-7}$
inches	25.4	1	$8.33 \times 10^{-2}$	$2.54 \times 10^{-2}$	$2.54 \times 10^{-5}$	$1.578 \times 10^{-5}$
feet	304.8	12	1	0.3048	$3.048 \times 10^{-4}$	$1.894 \times 10^{-4}$
meters	1,000	39.37	3.281	1	$1 \times 10^{-3}$	$6.214 \times 10^{-4}$
kilometers	$1 \times 10^6$	$3.937 \times 10^4$	3,281	1,000	1	0.6214
miles	$1.609 \times 10^6$	$6.336 \times 10^4$	5,280	1,609	1.609	1

Area

Unit	Equivalent <sup>1,2</sup>						
	square inches	square feet	square meters	acres	hectares	square kilometers	square miles
square inches	1	$6.944 \times 10^{-3}$	$6.452 \times 10^{-4}$	$1.994 \times 10^{-8}$	$6.452 \times 10^{-8}$	$6.452 \times 10^{-10}$	$2.491 \times 10^{-10}$
square feet	144	1	$9.29 \times 10^{-2}$	$2.296 \times 10^{-5}$	$9.29 \times 10^{-9}$	$9.29 \times 10^{-8}$	$3.597 \times 10^{-8}$
square meters	1,550	10.76	1	$2.471 \times 10^{-4}$	$1 \times 10^{-4}$	$1 \times 10^{-6}$	$3.861 \times 10^{-7}$
acres	$6.273 \times 10^6$	$4.356 \times 10^4$	4,047	1	0.4047	$4.047 \times 10^{-3}$	$1.563 \times 10^{-3}$
hectares	$1.55 \times 10^7$	$1.076 \times 10^5$	$1 \times 10^4$	2.471	1	0.01	$3.861 \times 10^{-3}$
square kilometers	$1.55 \times 10^9$	$1.076 \times 10^7$	$1 \times 10^6$	247.1	100	1	0.3861
square miles	$4.014 \times 10^9$	$2.789 \times 10^7$	$2.59 \times 10^6$	640	259	2.59	1

Volume

Unit	Equivalent <sup>1,2</sup>							
	cubic inches	liters	gallons	cubic feet	cubic yards	cubic meters	acre-ft	acre-ft
cubic inches	1	$1.639 \times 10^{-2}$	$4.379 \times 10^{-3}$	$5.787 \times 10^{-4}$	$2.143 \times 10^{-5}$	$1.639 \times 10^{-5}$	$1.379 \times 10^{-8}$	$1.379 \times 10^{-8}$
liters	61.02	1	0.2642	$3.531 \times 10^{-2}$	$1.308 \times 10^{-3}$	0.001	$8.108 \times 10^{-7}$	$8.108 \times 10^{-7}$
gallons	231.0	3.785	1	0.1337	$4.951 \times 10^{-3}$	$3.785 \times 10^{-3}$	$3.068 \times 10^{-6}$	$3.068 \times 10^{-6}$
cubic feet	1,728	28.32	7.481	1	$3.704 \times 10^{-2}$	$2.832 \times 10^{-3}$	$2.596 \times 10^{-5}$	$2.596 \times 10^{-5}$
cubic yards	$4.666 \times 10^4$	764.6	202.0	27	1	0.7646	$6.198 \times 10^{-4}$	$6.198 \times 10^{-4}$
cubic meters	$6.102 \times 10^4$	1,000	264.2	35.31	1.308	1	$8.108 \times 10^{-4}$	$8.108 \times 10^{-4}$
acre-ft	$7.527 \times 10^7$	$1.233 \times 10^6$	$3.259 \times 10^5$	$4.356 \times 10^4$	1,613	1,233	1	1

Discharge (flow rate, volume/time)

Unit	Equivalent <sup>1,2</sup>				
	gallons per minute	liters per second	liters per second	acre-feet per day	cubic meters per day
gallons per minute	1	$6.309 \times 10^{-2}$	$6.309 \times 10^{-2}$	$4.419 \times 10^{-3}$	$2.228 \times 10^{-3}$
liters per second	15.85	1	1	$7.005 \times 10^{-2}$	$3.531 \times 10^{-2}$
acre-feet per day	226.3	14.28	28.32	1	0.5042
cubic feet per second	448.8	28.32	1.983	1	1,234
cubic meters per day	$1.369 \times 10^6$	$8.64 \times 10^7$	$6.051 \times 10^6$	$3.051 \times 10^6$	2,447

TABLE 4.1 English and SI Units

$1 N = 1 Kg \cdot m / sec^2$

Parameter	English Unit	SI Unit	Conversion Factor	Dimensional Formula
Force	pound (lb)	newton (N)	1 lb = 4.448 N	$ML/T^2$
Mass	slug	kilogram (kg)	1 slug = 14.594 kg	$M$
Length	foot (ft)	meter (m)	1 ft = 0.3048 m	$L$
Time	second (s)	second	1 s = 1 s	$T$
Density	slug/ft <sup>3</sup>	kg/m <sup>3</sup>	1 slug/ft <sup>3</sup> = 515.4 kg/m <sup>3</sup>	$M/L^3$
Specific weight	lb/ft <sup>3</sup>	N/m <sup>3</sup>	1 lb/ft <sup>3</sup> = 157.1 N/m <sup>3</sup>	$M/L^2T^2$
Pressure	lb/ft <sup>2</sup>	N/m <sup>2</sup>	1 lb/ft <sup>2</sup> = 47.88 N/m <sup>2</sup>	$M/LT^2$
Dynamic viscosity	lb-s/ft <sup>2</sup>	N-s/m <sup>2</sup>	1 lb-s/ft <sup>2</sup> = 47.88 N-s/m <sup>2</sup>	$M/LT$
Bulk modulus	lb/ft <sup>2</sup>	N/m <sup>2</sup>	1 lb/ft <sup>2</sup> = 47.88 N/m <sup>2</sup>	$M/LT^2$

$g = \text{ACCELERATION DUE TO GRAVITY} = 9.8 \text{ m/sec}^2$

Equations for areas and volumes

- Circumference of circle =  $3.1416 \times \text{dia} = 6.2832 \times \text{radius}$
- Area of circle =  $0.7854 \times (\text{dia})^2 = 3.1416 \times (\text{radius})^2$
- Area of sphere =  $3.1416 \times (\text{dia})^2$
- Volume of sphere =  $0.5236 \times (\text{dia})^3$
- Area of triangle =  $0.5 \times \text{base} \times \text{height}$
- Area of trapezoid =  $0.5 \times \text{sum of the two parallel sides} \times \text{height}$
- Area of square, rectangle, or parallelogram =  $\text{base} \times \text{height}$
- Volume of pyramid =  $\text{area of base} \times 1/3 \text{ height}$
- Volume of cone =  $0.2618 \times (\text{dia of base})^2 \times \text{height}$
- Volume of cylinder =  $0.7854 \times \text{height} \times (\text{dia})^2$

Pressure

Unit	Equivalent <sup>1,2</sup>										
	pounds per square inch	pounds per square foot	atmospheres	kilograms per square centimeter	kilograms per square meter	inches of water (68°F)	feet of water (68°F)	inches of mercury (32°F)	millimeters of mercury (32°F)	bars	kilo Pascals
pounds per square inch	1	144	$6.805 \times 10^{-2}$	$7.031 \times 10^{-3}$	703.1	27.73	2.311	2.036	51.72	$6.895 \times 10^{-2}$	6.895
pounds per square foot	$6.945 \times 10^{-3}$	1	$4.73 \times 10^{-4}$	$4.88 \times 10^{-4}$	4.882	0.1926	$1.605 \times 10^{-2}$	$1.414 \times 10^{-2}$	0.3591	$4.79 \times 10^{-4}$	$4.79 \times 10^{-2}$
atmospheres	14.7	2,116	1	1.033	$1.033 \times 10^4$	407.5	33.96	29.92	760	1.013	101.3
kilograms per square centimeter	14.22	2,048	0.9678	1	$1 \times 10^4$	394.4	32.87	28.96	735.6	0.9807	98.07
kilograms per square meter	$1.422 \times 10^{-3}$	0.2048	$9.678 \times 10^{-5}$	0.001	1	$3.944 \times 10^{-2}$	$3.287 \times 10^{-3}$	$2.896 \times 10^{-3}$	$7.356 \times 10^{-2}$	$9.807 \times 10^{-3}$	$9.807 \times 10^{-3}$
inches of water (68°F)	$3.609 \times 10^{-2}$	5.197	$2.454 \times 10^{-3}$	$2.53 \times 10^{-3}$	25.38	1	$8.333 \times 10^{-2}$	$7.343 \times 10^{-2}$	1.865	$2.49 \times 10^{-3}$	0.249
feet of water (68°F)	0.4328	62.32	$2.945 \times 10^{-3}$	$3.043 \times 10^{-3}$	304.3	12	1	0.8812	22.38	$2.984 \times 10^{-2}$	2.984
inches of mercury (32°F)	0.4912	70.73	$3.342 \times 10^{-3}$	$3.453 \times 10^{-3}$	345.3	13.62	1.135	1	25.4	$3.386 \times 10^{-2}$	3.386
millimeters of mercury (32°F)	$1.934 \times 10^{-2}$	2.785	$1.316 \times 10^{-3}$	$1.36 \times 10^{-3}$	13.6	0.5362	$4.468 \times 10^{-2}$	$3.937 \times 10^{-2}$	1	$1.333 \times 10^{-3}$	0.1333
bars	14.5	2,089	0.9869	1.02	$1.02 \times 10^4$	402.2	33.51	29.53	750.1	1	100
kilo Pascals	0.145	20.89	$9.869 \times 10^{-3}$	$1.02 \times 10^{-2}$	102	4.022	0.3351	0.2953	7.501	0.01	1

**APPENDIX 14**  
**Absolute density and absolute viscosity of water**

Temperature (°C)	Density (kg/m <sup>3</sup> )	Density (g/cm <sup>3</sup> )	Viscosity (g/s-cm)
0	999.841	0.999841	0.017921
1	999.900	0.999900	0.017313
2	999.941	0.999941	0.016728
3	999.965	0.999965	0.016191
4	999.973	0.999973	0.015674
5	999.965	0.999965	0.015188
6	999.941	0.999941	0.014728
7	999.902	0.999902	0.014284
8	999.849	0.999849	0.013860
9	999.781	0.999781	0.013462
10	999.700	0.999700	0.013077
11	999.605	0.999605	0.012713
12	999.498	0.999498	0.012363
13	999.377	0.999377	0.012028
14	999.244	0.999244	0.011709
15	999.099	0.999099	0.011404
16	998.943	0.998943	0.011111
17	998.774	0.998774	0.010828
18	998.595	0.998595	0.010559
19	998.405	0.998405	0.010299
20	998.203	0.998203	0.010050
21	997.992	0.997992	0.009810
22	997.770	0.997770	0.009579
23	997.538	0.997538	0.009358
24	997.296	0.997296	0.009142
25	997.044	0.997044	0.008937
26	996.783	0.996783	0.008737
27	996.512	0.996512	0.008545
28	996.232	0.996232	0.008360
29	995.944	0.995944	0.008180
30	995.646	0.995646	0.008007
35	994.029	0.994029	0.007225
40	992.214	0.992214	0.006560
45	990.212	0.990212	0.005988
50	988.047	0.988047	0.005494

**NOTATION**

- |   |   |
|---|---|
| <b>a</b> Acceleration   | <b>P</b> Pressure                             |
| <b>A</b> Area   | <b>q</b> Flux                                 |
| <b>A<sub>t</sub></b> Cross-sectional area of a falling-head tube          | <b>Q</b> Discharge (rate)                     |
| <b>A<sub>c</sub></b> Cross-sectional area of a permeameter sample chamber | <b>S</b> Storativity                          |
| <b>b</b> Aquifer thickness  | <b>S<sub>s</sub></b> Specific storage         |
| <b>c</b> Shape factor   | <b>S<sub>r</sub></b> Specific retention       |
| <b>c<sub>u</sub></b> Uniformity coefficient                               | <b>S<sub>y</sub></b> Specific yield           |
| <b>d</b> Grain size   | <b>T</b> Transmissivity                       |
| <b>D</b> Distance   | <b>w</b> Weight                               |
| <b>d<sub>i</sub></b> Inside diameter of falling-head tube                 | <b>V</b> Volume                               |
| <b>d<sub>c</sub></b> Inside diameter of a permeameter sample chamber      | <b>V<sub>v</sub></b> Volume of voids          |
| <b>F</b> Force  | <b>V<sub>w</sub></b> Volume of water          |
| <b>g</b> Gravitational constant   | <b>W</b> Work                                 |
| <b>h</b> Head   | <b>α</b> Compressibility of aquifer skeleton  |
| <b>j</b> An exponent  | <b>β</b> Compressibility of water             |
| <b>K</b> Hydraulic conductivity   | <b>γ</b> Specific weight                      |
| <b>K<sub>h</sub></b> Horizontal hydraulic conductivity                    | <b>Δh</b> Decline in head                     |
| <b>K<sub>i</sub></b> Intrinsic permeability                               | <b>ρ</b> Density                              |
| <b>K<sub>v</sub></b> Vertical hydraulic conductivity                      | <b>ρ<sub>b</sub></b> Bulk density             |
| <b>L</b> Length   | <b>ρ<sub>d</sub></b> Mineral particle density |
| <b>m</b> Mass   | <b>ρ<sub>w</sub></b> Density of water         |
| <b>n</b> Porosity   |   |

Source: Handbook of Chemistry and Physics (Cleveland, Ohio: CRC Publishing Company, 1986).

/	44°		44°		44°		44°		/
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.96569	1.03555	60	.97189	1.02892	49	.97189	1.03555	20
1	.96625	1.03495	59	.97246	1.02832	48	.97246	1.03495	19
2	.96681	1.03435	58	.97302	1.02772	47	.97302	1.03435	18
3	.96738	1.03372	57	.97359	1.02713	46	.97359	1.03372	17
4	.96794	1.03312	56	.97416	1.02653	45	.97416	1.03312	16
5	.96850	1.03252	55	.97472	1.02593	44	.97472	1.03252	15
6	.96907	1.03192	54	.97529	1.02533	43	.97529	1.03192	14
7	.96963	1.03132	53	.97586	1.02474	42	.97586	1.03132	13
8	.97020	1.03072	52	.97643	1.02414	41	.97643	1.03072	12
9	.97076	1.03012	51	.97700	1.02355	40	.97700	1.03012	11
10	.97133	1.02952	50						10
11	.97189	1.02892	49						9
12	.97246	1.02832	48						8
13	.97302	1.02772	47						7
14	.97359	1.02713	46						6
15	.97416	1.02653	45						5
16	.97472	1.02593	44						4
17	.97529	1.02533	43						3
18	.97586	1.02474	42						2
19	.97643	1.02414	41						1
20	.97700	1.02355	40						0

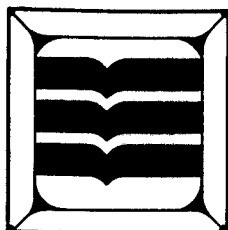
APPENDIX 8. EQUIVALENCE OF SOME UNITS OF WEIGHT AND MEASURE

Underlined figures are exact; others are rounded off. Condensed from Letter Circular 1035 (Jan., 1960) of the U.S. Department of Commerce, National Bureau of Standards, Washington 25, D.C.

- 1 in. = 0.08333 ft; 0.02778 yd; 2.54 cm.
- 1 ft = 12 in.; 0.6061 rods; 0.3048 m; 0.0001894 mi
- 1 yd = 3 ft; 0.9144 m; 0.1818 rods; 0.0005682 mi
- 1 m = 1000 mm; 100 cm; 10 decimeters 0.1 dekameters; 0.01 hectometers; 0.001 km
- 1 m = 39.37 in.; 3.2808 ft; 1.0936 yd; 0.0006214 mi
- 1 fathom = 6 ft; 1.8288 m
- 1 rod = 198 in.; 16.5 ft; 5.5 yd
- 1 chain = 100 links; 66 ft; 0.0125 mi; 20.117 m;
- 1 mi = 5280 ft; 1760 yd; 320 rods; 1609.344 m;
- 1 nautical mi = 6076.1 ft; 1852 m
- 1 sq in. = 6.4516 sq cm; 0.00684 sq ft
- 1 sq ft = 144 sq in.; 0.1111 sq yd; 0.0929 sq m
- 1 sq yd = 1296 sq in.; 9 sq ft; 0.8361 sq m
- 1 sq m = 1551 sq in.; 10.76 sq ft; 1.196 sq yd
- 1 acre = 43560 sq ft; 4840 sq yd; 0.405 hectares; 0.00156 sq mi
- 1 sq mi = 640 acres; 259 hectares
- 1 cu cm = 0.0610 cu in.; 0.000001 cu m
- 1 cu in. = 0.0005787 cu ft; 16.387 cu cm
- 1 cu ft = 1728 cu in.; 0.03704 cu yd; 0.0283 cu m; 7.480 gal (U.S.)
- 1 cu yd = 46656 cu in.; 27 cu ft; 0.7645 cu m
- 1 cu m = 35.315 cu ft; 1.3079 cu yd
- 1 gal (U.S.) = 231 cu in; 128 fl oz; 0.1337 cu ft; 3.785 liters
- 1 liter = 61.025 cu in.; 0.2642 gal (U.S.); 0.0353 cu ft
- 1 acre ft = 43560 cu ft; 325851 gal (U.S.); 1233.5 cu m
- 1 oz (avoir.) = 437.5 grains; 28.350 grams; 0.0625 lbs (avoir.)
- 1 gram = 15.432 grains; 0.03527 oz (avoir.); 0.002205 lbs (avoir.)
- 1 short (net) ton = 2000 lbs; 0.9072 metric ton; 0.8929 long (gross) ton

# For all the answers . . .

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#### Conversions of Hydraulic Conductivity, Intrinsic Permeability and Transmissivity

##### A. Hydraulic Conductivity, K [L/T], and Intrinsic Permeability, k [L<sup>2</sup>]

	K								k		
	cm/s	m/s	m/day	ft/s	ft/day	ft/yr	USgpd/ft <sup>2</sup>	UKgpd/ft <sup>2</sup>	darcy	cm <sup>2</sup>	ft <sup>2</sup>
cm/s	1	1.00E-2	8.64E2	3.28E-2	2.83E3	1.03E6	2.12E4	1.77E4	1.16E3	1.15E-5	1.24E-8
m/s	1.00E2	1	8.64E4	3.28	2.83E5	1.03E8	2.12E6	1.77E6	1.16E5	1.15E-3	1.24E-6
m/day	1.16E-3	1.16E-5	1	3.80E-5	3.28	1.20E3	2.45E1	2.04E1	1.35	1.33E-8	1.43E-11
ft/s	3.05E1	.305	2.63E4	1	8.64E4	3.15E7	6.46E5	5.38E5	3.55E4	3.50E-4	3.77E-7
ft/day	3.53E-4	3.53E-6	.305	1.16E-5	1	3.65E2	7.48	6.23	.411	4.06E-9	4.36E-12
ft/yr	9.66E-7	9.66E-9	8.35E-4	3.17E-8	2.74E-3	1	2.05E-2	1.71E-2	1.13E-3	1.11E-11	1.20E-14
USgpd/ft <sup>2</sup>	4.72E-5	4.72E-7	4.07E-2	1.55E-6	.134	4.88E1	1	.833	5.49E-2	5.42E-10	5.83E-13
UKgpd/ft <sup>2</sup>	5.66E-5	5.66E-7	4.89E-2	1.86E-6	.161	5.86E1	1.20	1	6.60E-2	6.51E-10	7.01E-13
darcy	8.58E-4	8.58E-6	7.42E-1	2.82E-5	2.43	8.88E2	1.82E1	1.52E1	1	9.87E-9	1.06E-11
cm <sup>2</sup>	8.70E4	8.70E2	7.51E7	2.85E3	2.47E8	9.00E10	1.84E9	1.54E9	1.01E8	1	1.08E-3
ft <sup>2</sup>	8.08E7	8.08E5	6.98E10	2.65E6	2.29E11	8.36E13	1.71E12	1.43E12	9.41E10	9.29E2	1

The relation between units of K and k is temperature dependent: these factors are for 60° F.

##### B. Transmissivity [L<sup>2</sup>/T]

	m <sup>2</sup> /s	m <sup>2</sup> /min	m <sup>2</sup> /day	ft <sup>2</sup> /s	ft <sup>2</sup> /day	USgpd/ft	UKgpd/ft
m <sup>2</sup> /s	1	6.00E1	8.64E4	1.08E1	9.30E5	6.96E6	5.79E6
m <sup>2</sup> /min	1.67E-2	1	1.44E3	1.79E-1	1.55E4	1.16E5	9.65E4
m <sup>2</sup> /day	1.16E-5	6.94E-4	1	1.25E-4	1.08E1	8.05E1	6.70E1
ft <sup>2</sup> /s	9.29E-2	5.57	8.03E3	1	8.64E4	6.46E5	5.38E5
ft <sup>2</sup> /day	1.08E-6	6.45E-5	9.29E-2	1.16E-5	1	7.48	6.23
USgpd/ft	1.44E-7	8.62E-6	1.24E-2	1.55E-6	1.34E-1	1	.833
UKgpd/ft	1.73E-7	1.04E-5	1.49E-2	1.86E-6	1.61E-1	1.20	1

Enter either table at the left with the given unit: move right to the column of the unit to be derived; read the conversion factor as a multiplier.  
Example: to convert 2.1 ft/day (hydraulic conductivity) to cm/s: 2.1 ft/day × 3.53E-4 = 7.4E-4 cm/s.  
Conversion factors are given in FORTRAN/BASIC notation; thus 3.53E-4 = 3.53 × 10<sup>-4</sup>.

**ENGLISH-METRIC UNIT CONVERSION TABLE**

To convert A to B, multiply A by C; To convert B to A, divide B by C

A	B	C	A	B	C
<b>Length —</b>			<b>Hydraulic conductivity —</b>		
inch	meter	2.540E-2	gal/day/ft <sup>2</sup>	cm/sec	4.716E-5
foot	meter	.3048	gal/day/ft <sup>2</sup>	ft/day	.1337
yard	meter	.9144	gal/day/ft <sup>2</sup>	meter/day	4.075E-2
mile	kilometer	1.609	gal (UK)/day/ft <sup>2</sup>	meter/day	4.893E-2
inch	centimeter	2.540	ft/yr	cm/sec	9.665E-7
<b>Area —</b>			ft/yr	meter/day	8.351E-4
sq inch	sq centimeter	6.452	darcy (atm/cm)	cm/sec	8.584E-4
sq feet	sq meter	9.290E-2	darcy	ft/day	2.433
sq yard	sq meter	.8361	darcy	meter/day	.7416
sq mile	sq kilometer	2.590	<b>Transmissivity —</b>		
acre	sq kilometer	4.047E-3	gal/day/ft	sq meter/day	1.242E-2
acre	hectare	.4047	gal (UK)/day/ft	sq meter/day	1.492E-2
<b>Volume —</b>			sq ft/sec	sq meter/day	8.027E3
cu feet	cu meter	2.832E-2	sq ft/day	sq meter/day	9.290E-2
cu yard	cu meter	.7646	<b>Force and pressure —</b>		
cu inch	cu centimeter	1.639E1	pound (f)	newton	4.448
quart	liter	.9464	poundal	newton	.1383
gallon	liter	3.785	pounds/sq in.	pascal	6.895E3
gallon (UK)	liter	4.546	lb/sq ft	pascal	4.788E1
barrel (petr.)	liter	1.590E2	poundal/sq ft	pascal	1.488
acre-feet	cu meter	1.234E3	atmosphere	pascal	1.013E5
million gal	cu meter	3.785E3	inches of Hg	pascal	3.386E3
gallon (UK)	gallon (US)	1.200	millibar	pascal	1.000E2
<b>Mass —</b>			psi	kg/cm <sup>2</sup>	7.031E-2
pound (lb)	kilogram	.4536	ft of H <sub>2</sub> O (4°C)	psi	.4335
ounce	gram	2.835E1	<b>Work, energy and heat —</b>		
ton, short	tonne (metric)	.9072	horsepower (US)	horsepower (CV)	1.014
ton, long	tonne	1.016	horsepower (US)	kW-hr	.7457
<b>Velocity and gradient —</b>			ft-lb/sec	kW	1.356E-3
feet/sec	meter/sec	.3048	BTU	kW-hr	2.930E-4
mile/hour	meter/sec	.4470	gpm/100' lift	kW	1.884E-2
feet/mile	meter/km	.1894	ft-lb	joule	1.356
<b>Flow rate —</b>			ft-poundal	joule	4.214E-2
gal/min	liter/sec	6.309E-2	BTU	joule	1.055E-3
gal/min	cu meter/day	5.300	calorie	joule	4.187
gal (UK)/min	liter/sec	7.577E-2	<b>Temperature —</b>		
10 <sup>6</sup> gal/day	liter/sec	4.381E1	Fahrenheit	Celsius	5(F-32)/9
10 <sup>6</sup> gal/day	cu meter/day	3.785E-3	Celsius	Fahrenheit	1.8(C)+32
cu ft/sec (cfs)	liter/sec	2.832E1	Kelvin	Celsius	K-273.2
acre-feet/day	liter/sec	1.458E-1			
gal/day	acre-feet/yr	1.120E-3			

Notes: (1) The "E" notation indicates exponentiation: 2.540E-2 = 2.540 · 10<sup>-2</sup>. (2) Unless otherwise noted, all gallons are U.S. gallons. (3) The darcy is a unit of permeability (L<sup>2</sup>), not of hydraulic conductivity (L/T). (4) A Newton (force) = kg · m/s<sup>2</sup>; A Pascal (pressure) = kg / m · s<sup>2</sup>; Joule (energy) = kg · m<sup>2</sup>/s<sup>2</sup>; each is a unit in SI. (5) Under "Temperature," entries are formulae, not multipliers.

## FORMULAS

### • Composition of Forces

The resultant of two forces acting at an angle upon a given point is equal to the diagonal of a parallelogram of which the two force vectors are sides. The equilibrant equals the magnitude of the resultant, but acts in the opposite direction.

### • Accelerated Motion

$v = at$ , or  $v = gt$   
 $v$  is final velocity;  $a$  is acceleration, or  $g$  is acceleration due to gravity;  $t$  is time

### • Accelerated Motion

$s = \frac{1}{2}at^2$  or  $s = \frac{1}{2}gt^2$   
 $s$  is total distance;  $a$  is acceleration, or  $g$  is acceleration due to gravity;  $t$  is time

### • Accelerated Motion

$v = \sqrt{2as}$ , or  $v = \sqrt{2gs}$   
 $v$  is final velocity;  $a$  is acceleration, or  $g$  is acceleration due to gravity;  $s$  is total distance

### • Newton's Second Law of Motion

$F = ma$   
 $F$  is force;  $m$  is mass;  $a$  is acceleration

### • Impulse and Momentum

$Ft = mv$   
 $F$  is force;  $t$  is time; the product  $Ft$  is impulse;  $m$  is mass;  $v$  is velocity; the product  $mv$  is momentum

### • Centrifugal Force

Centrifugal Force =  $\frac{mv^2}{r}$   
 $m$  is mass;  $v$  is velocity;  $r$  is radius of path

### • Work

$W = Fs$   
 $W$  is work;  $F$  is force;  $s$  is distance

### • Potential Energy

$$P.E. = mgh$$

P.E. is potential energy;  $m$  is mass;  $g$  is acceleration due to gravity;  $h$  is vertical distance

### • Kinetic Energy

$$K.E. = \frac{1}{2}mv^2$$

K.E. is kinetic energy;  $m$  is mass;  $v$  is velocity

## PHYSICAL CONSTANTS

$C = 2.9979 \times 10^8$  m/s  
 $G = 6.6720 \times 10^{-11}$  m<sup>3</sup> • s<sup>-2</sup> • kg<sup>-1</sup>  
 $e = 1.6022 \times 10^{-19}$  C  
 $e/m_e = 1.7588 \times 10^{11}$  C • kg<sup>-1</sup>  
 $F = 9.6485 \times 10^4$  C • mol<sup>-1</sup>  
 $V_m = 22.4138 \times 10^{-3}$  m<sup>3</sup> • mol<sup>-1</sup>  
 $h = 6.6262 \times 10^{-34}$  J • s  
 $R = 8.3144$  J • mol<sup>-1</sup> • K<sup>-1</sup>  
 $N_A = 6.0220 \times 10^{23}$  mol<sup>-1</sup>  
 Atomic Mass Unit  $m_u = 1.6606 \times 10^{-27}$  kg  
 $M_e = 9.1094 \times 10^{-31}$  kg  
 1 Kilogram Calorie (Nutrition Calorie) = 4.1868 Kilojoules  
 1 BTU = 1.0551 kJ

## RELATIONS BETWEEN COMMON UNITS

### LENGTH

1 in = 2.540 cm  
 1 ft = 30.48 cm  
 1 micron ( $\mu$ ) = 0.00001 m = 0.001 mm = 10<sup>-4</sup> cm  
 1 millionth micron ( $\mu\mu$ ) = 10<sup>-10</sup>  
 1 Angstrom Unit = 10<sup>-8</sup> cm

### VOLUME

1 Liter = 1000 cm<sup>3</sup> = 61.024 in<sup>3</sup> = 1.05671 qt.

### MASS

1 lb = 453.59 g  
 1 kg = 2.2046 lb

### ANGLES

1 circumference = 360° = 2 $\pi$  radians  
 1 radian = 57.2958°

### DENSITY

1 gr/cm<sup>3</sup> = 62.4 lb/ft<sup>3</sup>

### WORK OR ENERGY

1 ft-lb = 1.356 X 10<sup>7</sup> ergs  
 1 joule = 10<sup>7</sup> ergs  
 1 gr cal = 4.186 X 10<sup>7</sup> ergs  
 1 B.T.U. = 777.8 ft-lb = 252.2 g cal

### POWER

1 H.P. = 33,000 ft lb / min  
 = 550 ft lb / sec = 746 watts  
 1 watt = 1 joule/second

### ELECTRICAL UNITS

1 ampere = 10<sup>11</sup> abamps = 3 X 10<sup>9</sup> ESU  
 1 volt = 10<sup>8</sup> EMU = 1/3 X 10<sup>11</sup> ESU  
 1 coulomb = 10<sup>11</sup> EMU = 3 X 10<sup>9</sup> ESU  
 1 ohm = 10<sup>9</sup> EMU = 1/3 X 10<sup>11</sup> ESU  
 1 farad = 10<sup>9</sup> EMU = 9 X 10<sup>11</sup> ESU  
 1 henry = 10<sup>9</sup> EMU = 1/3 X 10<sup>11</sup> ESU

## CHEMISTRY

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### SYMBOLS OF SOME PARTICLES

electron	-1e <sup>-</sup>	deuteron	2H <sup>+</sup>
neutron	0n <sup>0</sup>	triton	3H <sup>+</sup>
proton	1H <sup>+</sup>	alpha particle	4He <sup>+</sup>

### OXIDATION STATE OF SOME RADICALS

CH <sub>3</sub> COO	ClO <sub>2</sub>	H <sub>2</sub> PO <sub>4</sub>	NO <sub>2</sub>
CO <sub>3</sub>	Cr <sub>2</sub> O <sub>7</sub> <sup>-</sup>	H <sub>2</sub> O <sub>2</sub>	OH
CO <sub>3</sub> <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	Hg <sub>2</sub> <sup>2+</sup>	PO <sub>4</sub>
ClO	HPO <sub>4</sub> <sup>-</sup>	MnO <sub>2</sub>	PO <sub>3</sub>
ClO <sub>2</sub>	H <sub>2</sub> SO <sub>4</sub>	NH <sub>4</sub> <sup>+</sup>	SO <sub>3</sub> <sup>-</sup>
ClO <sub>3</sub>	HSO <sub>4</sub> <sup>-</sup>	NO <sub>2</sub>	SO <sub>4</sub> <sup>-</sup>

### PERIODIC TABLE OF THE ELEMENTS

Atomic weights conform to the 1961 values of the Commission on Atomic Weights.

KEY		VIIB		VIII		IIB		IIB		IIB		IIB		IIB		IIB		IIB					
Atomic Mass (Weight)	Symbol	Atomic Number	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP	GROUP				
1.00797	H	1	IA																	4.0026	He	2	0
6.939	Li	3	IA																	18.9984	Be	4	IIA
22.9898	Na	11	IA																	20.183	Mg	12	IIA
39.102	K	19	IA																	35.453	Ca	20	IIA
85.47	Rb	37	IA																	79.909	Sr	38	IIA
132.905	Cs	55	IA																	126.9044	Ba	56	IIA
(223)	Fr	87	IA																	(210)	Ra	88	IIA
22.9898	Na	11	IA																	35.453	Ca	20	IIA
39.102	K	19	IA																	79.909	Sr	38	IIA
85.47	Rb	37	IA																	126.9044	Ba	56	IIA
132.905	Cs	55	IA																	(210)	Ra	88	IIA
(223)	Fr	87	IA																	(210)	Ra	88	IIA

## STANDARD OXIDATION POTENTIALS

Ionic Concentrations 1 molal in water at 25°C

### Half cell Reaction

Li = Li <sup>+</sup> + e <sup>-</sup>	E° (volts)	3.05
Rb = Rb <sup>+</sup> + e <sup>-</sup>	E° (volts)	2.93
K = K <sup>+</sup> + e <sup>-</sup>	E° (volts)	2.93
Cs = Cs <sup>+</sup> + e <sup>-</sup>	E° (volts)	2.92
Ba = Ba <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	2.90
Sr = Sr <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	2.89
Ca = Ca <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	2.87
Na = Na <sup>+</sup> + e <sup>-</sup>	E° (volts)	2.71
Mg = Mg <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	2.37
Be = Be <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	1.85

### Half cell Reaction

Al = Al <sup>3+</sup> + 3e <sup>-</sup>	E° (volts)	1.66
Mn = Mn <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	1.18
Zn = Zn <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.76
Cr = Cr <sup>3+</sup> + 3e <sup>-</sup>	E° (volts)	0.74
Fe = Fe <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.44
Cd = Cd <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.40
Co = Co <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.28
Ni = Ni <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.25
Sn = Sn <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.14
Pb = Pb <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	0.13

### Half cell Reaction

H <sub>2</sub> = 2H <sup>+</sup> + 2e <sup>-</sup>	E° (volts)	0.00
Sn <sup>2+</sup> = Sn <sup>4+</sup> + 2e <sup>-</sup>	E° (volts)	-0.15
Cu <sup>+</sup> = Cu <sup>2+</sup> + e <sup>-</sup>	E° (volts)	-0.15
Cu = Cu <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	-0.34
2I <sup>-</sup> = I <sub>2</sub> + 2e <sup>-</sup>	E° (volts)	-0.53
Fe <sup>2+</sup> = Fe <sup>3+</sup> + e <sup>-</sup>	E° (volts)	-0.77
2Hg = Hg <sub>2</sub> <sup>2+</sup> + 2e <sup>-</sup>	E° (volts)	-0.79
Ag = Ag <sup>+</sup> + e <sup>-</sup>	E° (volts)	-0.80
Hg <sub>2</sub> <sup>2+</sup> = 2Hg <sup>+</sup> + 2e <sup>-</sup>	E° (volts)	-0.92
2Br <sup>-</sup> = Br <sub>2</sub> (l) + 2e <sup>-</sup>	E° (volts)	-1.07

### Half cell Reaction

NO + 2H <sub>2</sub> O =	E° (volts)	
N <sub>2</sub> O + 4H <sup>+</sup> + 4e <sup>-</sup>	E° (volts)	-0.96
2H <sub>2</sub> O = O <sub>2</sub> + 4H <sup>+</sup> + 4e <sup>-</sup>	E° (volts)	-1.23
2Cr <sup>3+</sup> + 7H <sub>2</sub> O =	E° (volts)	
Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> + 14H <sup>+</sup> + 6e <sup>-</sup>	E° (volts)	-1.33
2Cl <sup>-</sup> = Cl <sub>2</sub> + 2e <sup>-</sup>	E° (volts)	-1.36
Au = Au <sup>3+</sup> + 3e <sup>-</sup>	E° (volts)	-1.50
Mn <sup>2+</sup> + 4H <sub>2</sub> O =	E° (volts)	
MnO <sub>2</sub> + 8H <sup>+</sup> + 5e <sup>-</sup>	E° (volts)	-1.51
2F <sup>-</sup> = F <sub>2</sub> + 2e <sup>-</sup>	E° (volts)	-2.87