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## Appendix C. General Tables of Units of Measurement

These tables have been prepared for the benefit of those requiring tables of units for occasional ready reference. In Section 4 of this Appendix, the tables are carried out to a large number of decimal places and exact values are indicated by underlining. In most of the other tables, only a limited number of decimal places are given, therefore, making the tables better adapted to the average user.

### 1. Tables of Metric Units of Measurement

In the International System of Units (SI), commonly known as the metric system of measurement, designations of multiples and subdivisions of any unit may be arrived at by combining the unit symbol with the prefixes deka, hecto, and kilo meaning, respectively, ten (10), one hundred (100), and one thousand (1 000), and deci, centi, and milli, meaning, respectively, one-tenth (0.1), one-hundredth (0.01), and one-thousandth (0.001). In some of the following metric tables, some such multiples and subdivisions have not been included for the reason that these have limited usage.

In certain cases, particularly in scientific usage, it becomes convenient to provide for multiples larger than one thousand (1 000) and for subdivisions smaller than one-thousandth (0.001). The following prefixes are recognized for this purpose<sup>1</sup>:

quetta, (Q),	meaning $10^{30}$	deci, (d),	meaning $10^{-1}$
ronna, (R),	meaning $10^{27}$	centi, (c),	meaning $10^{-2}$
yotta, (Y),	meaning $10^{24}$	milli, (m),	meaning $10^{-3}$
zetta, (Z),	meaning $10^{21}$	micro, ( $\mu$ ),	meaning $10^{-6}$
exa, (E),	meaning $10^{18}$	nano, (n),	meaning $10^{-9}$
peta, (P),	meaning $10^{15}$	pico, (p),	meaning $10^{-12}$
tera, (T),	meaning $10^{12}$	femto, (f),	meaning $10^{-15}$
giga, (G),	meaning $10^9$	atto, (a),	meaning $10^{-18}$
mega, (M),	meaning $10^6$	zepto, (z),	meaning $10^{-21}$
kilo, (k),	meaning $10^3$	yocto, (y),	meaning $10^{-24}$
hecto, (h),	meaning $10^2$	ronto, (r),	meaning $10^{-27}$
deka, (da),	meaning $10^1$	quecto, (q),	meaning $10^{-30}$

For example, a kilometer is 1 000 meters and a millimeter is 0.001 meter.

<sup>1</sup> By action of the 27th General Conference on Weights and Measures (2022), the number of International System of Units (SI) prefixes was expanded from 20 to 24 with the addition of ronna, ronto, quetta, and quecto. The International Bureau of Weights and Measures (BIPM) implemented the update in The International System of Units [Brochure], 9th Edition, version 2.01. For more information see <https://doi.org/10.59161/AUE>.

**Units of Length**

10 millimeters (mm)	= 1 centimeter (cm)
10 centimeters	= 1 decimeter (dm) = 100 millimeters
10 decimeters	= 1 meter (m) = 1 000 millimeters
10 meters	= 1 dekameter (dam)
10 dekameters	= 1 hectometer (hm) = 100 meters
10 hectometers	= 1 kilometer (km) = 1 000 meters

**Units of Area**

100 square millimeters (mm <sup>2</sup> )	= 1 square centimeter (cm <sup>2</sup> )
100 square centimeters	= 1 square decimeter (dm <sup>2</sup> )
100 square decimeters	= 1 square meter (m <sup>2</sup> )
100 square meters	= 1 square dekameter (dam <sup>2</sup> ) = 1 are
100 square dekameters	= 1 square hectometer (hm <sup>2</sup> ) = 1 hectare (ha)
100 square hectometers	= 1 square kilometer (km <sup>2</sup> )

**Units of Volume**

10 milliliters (mL)	= 1 centiliter (cL)
10 centiliters	= 1 deciliter (dL) = 100 milliliters
10 deciliters	= 1 liter <sup>2</sup> (L) = 1 000 milliliters
10 liters	= 1 dekaliter (daL)
10 dekaliters	= 1 hectoliter (hL) = 100 liters
10 hectoliters	= 1 kiloliter (kL) = 1 000 liters
1 000 cubic millimeters (mm <sup>3</sup> )	= 1 cubic centimeter (cm <sup>3</sup> )
1 000 cubic centimeters	= 1 cubic decimeter (dm <sup>3</sup> )
	= 1 000 000 cubic millimeters
1 000 cubic decimeters	= 1 cubic meter (m <sup>3</sup> )
	= 1 000 000 cubic centimeters
	= 1 000 000 000 cubic millimeters

**Units of Mass**

10 milligrams (mg)	= 1 centigram (cg)
10 centigrams	= 1 decigram (dg) = 100 milligrams
10 decigrams	= 1 gram (g) = 1 000 milligrams
10 grams	= 1 dekagram (dag)
10 dekagrams	= 1 hectogram (hg) = 100 grams
10 hectograms	= 1 kilogram (kg) = 1 000 grams
1 000 kilograms	= 1 megagram (Mg) or 1 metric ton (t)

<sup>2</sup> By action of the 12<sup>th</sup> General Conference on Weights and Measures (1964), the liter is a special name for the cubic decimeter (dm<sup>3</sup>).

## 2. Tables of U.S. Customary Units of Measurement<sup>3, 4</sup>

### Units of Length

12 inches (in)	= 1 foot (ft)
3 feet	= 1 yard (yd)
16½ feet	= 1 rod (rd), pole, or perch
40 rods	= 1 furlong (fur) = 660 feet
8 furlongs	= 1 mile (mi) <sup>5</sup> = 5 280 feet
1 852 meters (m)	= 6 076.115 49 feet (approximately)
	= 1 international nautical mile

### Gunter's or Surveyors Chain Units of Measurement

1 link (li)	= 0.66 foot (ft) = 0.04 rod (rd) = 0.01 chain (ch)
1 fathom	= 6 feet
1 rod, perch, or pole	= 25 links = 16.5 feet = 0.25 chain
1 chain	= 66 feet = 4 rods = 100 links
1 furlong (fur)	= 660 feet = 10 chains = 40 rods
1 cable's length	= 720 feet = 120 fathoms
1 mile (mi)	= 5 280 feet = 8 furlongs = 80 chains = 320 rods
1 league	= 15 840 feet = 3 miles

<sup>3</sup> This section lists units of measurement traditionally used in the United States. In keeping with the Metric Conversion Act of 1975 (15 U.S.C. 205a et seq.) as amended by Omnibus Trade and Competitiveness Act of 1988, the ultimate objective is to make the International System of Units (SI) the primary measurement system used in the United States.

<sup>4</sup> *Federal Register*, July 1, 1959, Vol. 24, No. 128, p. 5348. NOTICE: In collaboration, National Oceanic and Atmospheric Administration (NOAA) and NIST have taken action to provide national uniformity in the measurement of length. The final decision to retire the U.S. survey foot was published in the *Federal Register*, announcing the deprecation date of December 31, 2022. Beginning on January 1, 2023, the U.S. survey foot should be avoided, except for historic and legacy applications and will be superseded by the international foot definition (i.e., 1 foot = 0.3048 meter exactly) in all applications. Prior to this date, except for the mile and square mile, the cable's length, chain, fathom, furlong, league, link, rod, pole, perch, acre, and acre-foot were previously only defined in terms of the U.S. survey foot. With this update, relationships are available in terms of the international foot, which can simply be referred as the "foot." Either the term "foot" or "international foot" may be used, as required for clarity in technical applications. This is particularly the case for surveying and mapping applications, although over time "foot" will become more prevalent. The preferred measurement unit of length in the United States is the meter (m) and surveyors, map makers, and engineers are encouraged to adopt the SI for their work. For more information see *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698) available at <https://www.govinfo.gov/content/pkg/FR-2020-10-05/pdf/2020-21902.pdf>.

<sup>5</sup> Originally referred to as the "statute mile," when Queen Elizabeth I changed the definition of the mile from the Roman mile of 5 000 feet to the statute mile of 5 280 feet. Although the U.S. statute mile was originally based on the U.S. survey foot (1 200/393 7 meter), its definition is now based the international foot (0.304 8 meter), per *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698), which states that definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications. The mile based on the international foot is about 3 millimeters shorter than the mile based on the U.S. survey foot, although both are defined as being equal to 5 280 feet.

**Units of Area<sup>6</sup>**

1 square foot (ft <sup>2</sup> )	=144 square inches (in <sup>2</sup> )
1 square yard (yd <sup>2</sup> )	= 9 square feet = 1 296 square inches
1 square rod (rd <sup>2</sup> ), square pole, or square perch	= 272.25 square feet = 0.062 5 square chain (ch <sup>2</sup> )
1 square chain	= 4 356 square feet = 16 square rods = 0.1 acre
1 acre (ac)	= 43 560 square feet = 160 square rods = 10 square chains
1 square mile (mi <sup>2</sup> )	= 27 878 400 square feet = 640 acres
1 square mile (mi <sup>2</sup> )	= 27 878 400 square feet = 640 acres

**Units of Volume**

1 728 cubic inches (in <sup>3</sup> )	= 1 cubic foot (ft <sup>3</sup> )
27 cubic feet	= 1 cubic yard (yd <sup>3</sup> )

**Units of Liquid Volume<sup>7</sup>**

4 gills (gi)	= 1 pint (pt) = 28.875 cubic inches (in <sup>3</sup> )
2 pints	= 1 quart (qt) = 57.75 cubic inches
4 quarts	= 1 gallon (gal) = 231 cubic inches = 8 pints = 32 gills

**Apothecaries Units of Liquid Volume**

60 minims	= 1 fluid dram (fl dr or <i>f</i> 3)
	= 0.225 6 cubic inch (in <sup>3</sup> )
8 fluid drams	= 1 fluid ounce (fl oz or <i>f</i> ʒ)
	= 1.804 7 cubic inches
16 fluid ounces	= 1 pint (pt)
	= 28.875 cubic inches
	= 128 fluid drams
2 pints	= 1 quart (qt) = 57.75 cubic inches
	= 32 fluid ounces = 256 fluid drams
4 quarts	= 1 gallon (gal) = 231 cubic inches
	= 128 fluid ounces = 1 024 fluid drams

**Units of Dry Volume<sup>8</sup>**

2 pints (pt)	= 1 quart (qt) = 67.200 6 cubic inches (in <sup>3</sup> )
8 quarts	= 1 peck (pk) = 537.605 cubic inches
	= 16 pints
4 pecks	= 1 bushel (bu) = 2 150.42 cubic inches
	= 32 quarts

<sup>6</sup> Squares and cubes of U.S. customary but not of SI units are sometimes expressed by the use of abbreviations rather than symbols. For example, sq ft is an abbreviation that represents square foot, and cu ft is an abbreviation that represents cubic foot.

<sup>7</sup> When necessary to distinguish units of liquid measure such as the fluid ounce, liquid pint, or liquid quart from dry measures, the word “liquid” or “fluid,” or the abbreviations “liq” or “fl,” should be used in combination with the unit name or abbreviation.

<sup>8</sup> When necessary to distinguish dry pint or quart from the liquid pint or quart, the word “dry” should be used in combination with the name or abbreviation of the dry unit.

### Avoirdupois Units of Mass<sup>9</sup>

[The “grain” is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

1 µlb	= 0.000 001 pound (lb)
27 <sup>11</sup> / <sub>32</sub> grains (gr)	= 1 dram (dr)
16 drams	= 1 ounce (oz)
	= 437½ grains
16 ounces	= 1 pound (lb)
	= 256 drams
	= 7 000 grains
100 pounds	= 1 hundredweight (cwt) <sup>10</sup>
20 hundredweights	= 1 ton (tn) <sup>11</sup>
	= 2 000 pounds <sup>9</sup>

In “gross” or “long” measure, the following values are recognized:

112 pounds (lb)	= 1 gross (or long) hundredweight (cwt) <sup>9</sup>
20 gross (or long) hundredweights	= 1 gross (or long) ton
	= 2 240 pounds <sup>9</sup>

### Troy Units of Mass

[The “grain” is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

24 grains (gr)	= 1 pennyweight (dwt)
20 pennyweights	= 1 ounce troy (oz t) = 480 grains
12 ounces troy	= 1 pound troy (lb t)
	= 240 pennyweights = 5 760 grains

<sup>8</sup> Use the measurement system name or the abbreviation when necessary to distinguish the avoirdupois dram from the apothecaries dram, or to distinguish the avoirdupois dram or ounce from the fluid dram or ounce, or to distinguish the avoirdupois ounce or pound from the troy or apothecaries ounce or pound. When necessary, the word “avoirdupois” or the abbreviation “avdp” should be used in combination with, following the name or abbreviation of the avoirdupois unit. However, if the term “avoirdupois” or “avdp” does not specifically appear in association with a measurement expressed in drams, ounces, or pounds, the value it is understood to represent the avoirdupois unit. The word “troy” or the abbreviation “t” should be used in combination with, following the name or abbreviation of the troy unit. The word “apothecaries” or the abbreviation “ap” should be used in combination with, following the name or abbreviation of the apothecaries unit. For example, “1 pound apothecaries (lb ap),” not “1 apothecaries pound (ap lb).”

<sup>10</sup> When the terms “hundredweight” and “ton” are used unmodified, they are commonly understood to mean the 100-pound hundredweight and the 2000-pound ton, respectively; these units may be designated “net” or “short” when necessary to distinguish them from the corresponding units in gross or long measure.

<sup>11</sup> As of January 1, 2014, “tn” is the required abbreviation for “short ton.” Devices manufactured between January 1, 2008, and December 31, 2013, may use an abbreviation other than “tn” to specify “short ton.”

(Added 2013)

**Apothecaries Units of Mass**

[The “grain” is an equivalent quantity in avoirdupois, troy, and apothecaries units of mass.]

20 grains (gr)	= 1 scruple (s ap or ʒ)
3 scruples	= 1 dram apothecaries (dr ap or ʒ)
	= 60 grains
8 drams apothecaries	= 1 ounce apothecaries (oz ap or ʒ)
	= 24 scruples = 480 grains
12 ounces apothecaries	= 1 pound apothecaries (lb ap)
	= 96 drams apothecaries
	= 288 scruples = 5 760 grains

**3. Notes on British Units of Measurement**

In Great Britain, the yard, the avoirdupois pound, the troy pound, and the apothecaries pound relationships are identical with the units of the same names used in the United States. The tables of British linear measure, troy mass, and apothecaries mass are the same as the corresponding United States tables, except for the British spelling “drachm” in the table of apothecaries mass. The table of British avoirdupois mass is the same as the United States table up to 1 pound; above that point the table reads:

14 pounds	= 1 stone
2 stones	= 1 quarter = 28 pounds
4 quarters	= 1 hundredweight = 112 pounds
20 hundredweight	= 1 ton = 2 240 pounds

The present British gallon and bushel – known as the “Imperial gallon” and “Imperial bushel” – are, respectively, about 20 % and 3 % larger than the United States gallon and bushel. The Imperial gallon is defined as the volume of 10 avoirdupois pounds of water under specified conditions, and the Imperial bushel is defined as 8 Imperial gallons. Also, the subdivision of the Imperial gallon as presented in the table of British apothecaries fluid measure differs in two important respects from the corresponding United States subdivision, in that the Imperial gallon is divided into 160 fluid ounces (whereas the United States gallon is divided into 128 fluid ounces), and a “fluid scruple” is included. The full table of British measures of capacity (which are used alike for liquid and for dry commodities) is as follows:

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
2 gallons	= 1 peck
8 gallons (4 pecks)	= 1 bushel
8 bushels	= 1 quarter

The full table of British apothecaries measure is as follows:

20 minims	= 1 fluid scruple
3 fluid scruples	= 1 fluid drachm
	= 60 minims
8 fluid drachms	= 1 fluid ounce
20 fluid ounces	= 1 pint
8 pints	= 1 gallon (160 fluid ounces)



## 4. Tables of Units of Measurement

Unit conversion is a multi-step process that involves multiplication or division by a numerical factor; selection of the correct number of significant digits; and rounding. Accurate unit conversions are obtained by selecting an appropriate conversion factor (a ratio which converts one unit of measure into another without changing the quantity), which are supplied in these tables.

Some unit conversions may be exact, without increasing or decreasing the precision of the original quantity. Exact unit conversion factors are underlined in these tables. It is good practice to keep all the digits, especially if other mathematical operations or conversions will follow. Rounding should be the last step of the conversion process and should be performed only once.

To convert a value from one unit of measurement to different unit of measurement follow the steps below.

- Find the table corresponding to the general category of measurement; for example, the table titled “Units of Volume” includes conversion factors for volume measurements.
- Locate the “starting unit” of measurement in the far, left column.
- Proceed horizontally to the right on the same row until you reach the column with the heading of the appropriate “ending unit” of measurement.
- The unit conversion factor is located at the intersection of the row and column.
- Multiply the quantity value of the starting unit of measurement by the conversion factor.
- The result is the equivalent quantity value in the ending unit of measurement.

**Units of Length<sup>12</sup>**  
(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:					
	Inches	Feet	Yards	Miles	Centimeters	Meters
1 inch (in) =	<u>1</u>	0.083 333 33	0.027 777 78	0.000 015 782 83	<u>2.54</u>	<u>0.025 4</u>
1 foot (ft) =	<u>12</u>	<u>1</u>	0.333 333 3	0.000 189 393 9	<u>30.48</u>	<u>0.304 8</u>
1 yard (yd) =	<u>36</u>	<u>3</u>	<u>1</u>	0.000 568 181 8	<u>91.44</u>	<u>0.914 4</u>
1 mile (mi) =	<u>63 360</u>	<u>5 280</u>	<u>1 760</u>	<u>1</u>	<u>160 934.4</u>	<u>1 609.344</u>
1 centimeter (cm) =	0.393 700 8	0.032 808 40	0.010 936 13	0.000 006 213 712	<u>1</u>	<u>0.01</u>
1 meter (m) =	39.370 08	3.280 840	1.093 613	0.000 621 371 2	<u>100</u>	<u>1</u>
<b>NOTE:</b> Per Federal Register, July 1, 1959, Vol. 24, No. 128, p. 5348, the following are exact mathematical relationships: 1 U.S. survey foot = 1 200/393 7 meter (exactly) 1 international foot = 12 × 0.025 4 meter = 0.304 8 (exactly) 1 international foot = 0.999 998 survey foot (exactly) 1 international foot = 0.025 4 × 39.37 U.S. survey foot (exactly) 1 international mile = 0.999 998 survey mile (exactly)						

<sup>12</sup> See Footnote 3.

**Units of Length – International Foot and Survey Equivalent Measurements<sup>13</sup>**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:	
	International foot metric equivalent	U.S. survey foot metric equivalent
	Meters	Meters
1 foot =	0.304 8	0.304 800 609 601
1 cable's length =	219.456	219.456 438 913
1 chain (ch) =	20.116 8	20.116 840 234
1 fathom =	1.828 8	1.828 803 658
1 furlong (fur) =	201.168	201.168 402 337
1 league =	4 828.032	4 828.041 656 083
1 link (li) =	0.201 168	0.201 168 402
1 mile =	1 609.344	1 609.347 218 694
1 rod (rd), perch, or pole =	5.029 2	5.029 210 058

**Units of Length – Survey Measure**(All underlined figures are exact; conversions to meters based on international foot.<sup>14</sup>)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:					
	Links	Feet	Rods	Chains	Miles	Meters
1 link (li) =	1	0.66	0.04	0.01	0.000 125	0.201 168
1 foot (ft) =	1.515 151 5	1	0.060 606 06	0.015 151 5	0.000 189 393 9	0.304 8
1 rod (rd), pole, or perch =	25	16.5	1	0.25	0.003 125	5.029 2
1 chain (ch) =	100	66	4	1	0.0125	20.116 8
1 mile (mi) =	8 000	5 280	320	80	1	1 609.344
1 meter (m) =	4.970 970	3.280 840	0.198 838 8	0.049 709 70	0.000 621 371 2	1

<sup>13</sup> *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Units in this table were historically defined using the U.S. survey foot. They may now be defined using either the international definition of the foot or U.S. survey foot. Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

<sup>14</sup> See Footnote 3.

### Units of Length – Thickness Measurement

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Conversion Factor Below the Ending Unit:		
	Inches	Millimeters	Micrometers
1 mil =	0.001	0.025 4	25.4
<b>NOTE:</b> The unit “mil” is a unit traditionally used by some U.S. industry sectors for the measurement of thickness.			

### Units of Area<sup>15</sup>

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Square Inches	Square Feet	Square Yards
1 square inch (in <sup>2</sup> ) =	1	0.006 944 444	0.000 771 604 9
1 square foot (ft <sup>2</sup> ) =	144	1	0.111 111 1
1 square yard (yd <sup>2</sup> ) =	1 296	9	1
1 square mile (mi <sup>2</sup> ) =	4 014 489 600	27 878 400	3 097 600
1 square centimeter (cm <sup>2</sup> ) =	0.155 000 3	0.001 076 391	0.000 119 599 0
1 square meter (m <sup>2</sup> ) =	1 550.003	10.763 91	1.195 990

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Square Miles	Square Centimeters	Square Meters
1 square inch (in <sup>2</sup> ) =	0.000 000 000 249 097 7	<u>6.451 6</u>	<u>0.000 645 16</u>
1 square foot (ft <sup>2</sup> ) =	0.000 000 035 870 06	<u>929.030 4</u>	<u>0.092 903 04</u>
1 square yard (yd <sup>2</sup> ) =	0.000 000 322 830 6	<u>8 361.273 6</u>	<u>0.836 127 36</u>
1 square mile (mi <sup>2</sup> ) =	<u>1</u>	<u>25 899 881 103.36</u>	<u>2 589 988.110 336</u>
1 square centimeter (cm <sup>2</sup> ) =	0.000 000 000 038 610 22	<u>1</u>	<u>0.000 1</u>
1 square meter (m <sup>2</sup> ) =	0.000 000 386 102 2	<u>10 000</u>	<u>1</u>

<sup>15</sup> Area measurements are applied to both regular (e.g., regular polygons such as the square, rectangle, or equilateral triangle, or circle, ellipse, etc.) and irregular geometric shapes. For example, an acre is not necessarily a regular shape, such as a square or rectangle. If an acre is a square, then the length of one side is approximately equal to  $\sqrt{43560 \text{ ft}^2} = 208.710 \text{ ft}$ .

**Units of Area – International Foot and Survey Equivalent Measurements<sup>16</sup>**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:	
	International foot metric equivalent	U.S. survey foot metric equivalent
	Square Meters	Square Meters
1 square rod (rd <sup>2</sup> ), square pole, or square perch =	25.292 852 64	25.292 953 812
1 square chain (ch <sup>2</sup> ) =	404.685 642 24	404.687 260 987
1 acre (ac) =	4 046.856 422 4	4 046.872 609 874
1 square mile (mi <sup>2</sup> ) =	2 589 988.110 336	2 589 998.470 319 521

**Units of Area – Survey Measure<sup>16</sup>**(All underlined figures are exact; SI equivalents based on the international foot.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Square Feet	Square Rods	Square Chains	Acres
1 square foot (ft <sup>2</sup> ) =	1	0.003 673 095	0.000 229 568 4	0.000 022 956 84
1 square rod (rd <sup>2</sup> ), square pole, or square perch =	272.25	1	0.062 5	0.006 25
1 square chain (ch <sup>2</sup> ) =	4 356	16	1	0.1
1 acre (ac) =	43 560	160	10	1
1 square mile (mi <sup>2</sup> ) =	27 878 400	102 400	6 400	640
1 square meter (m <sup>2</sup> ) =	10.763 91	0.039 536 86	0.002 471 054	0.000 247 105 4
1 hectare (ha) =	107 639.1	395.368 6	24.710 54	2.471 054

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Square Miles	Square Meters	Hectares
1 square foot (ft <sup>2</sup> ) =	0.000 000 035 870 06	<u>0.092 903 04</u>	<u>0.000 009 290 304</u>
1 square rod (rd <sup>2</sup> ), square pole, square perch =	<u>0.000 009 765 625</u>	<u>25.292 852 64</u>	<u>0.002 529 285 264</u>
1 square chain (ch <sup>2</sup> ) =	<u>0.000 156 25</u>	<u>404.685 642 24</u>	<u>0.040 468 564 224</u>
1 acre (ac) =	<u>0.001 562 5</u>	<u>4 046.856 422 4</u>	<u>0.404 685 642 24</u>
1 square mile (mi <sup>2</sup> ) =	<u>1</u>	<u>2 589 988.110 336</u>	<u>258.998 811 033 6</u>
1 square meter (m <sup>2</sup> ) =	0.000 000 386 102 2	<u>1</u>	<u>0.000 1</u>
1 hectare (ha) =	0.003 861 022	<u>10 000</u>	<u>1</u>

<sup>16</sup> *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

**Units of Volume<sup>17</sup>**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Cubic Inches	Cubic Feet	Cubic Yards
1 cubic inch (in <sup>3</sup> ) =	1	0.000 578 703 7	0.000 021 433 47
1 cubic foot (ft <sup>3</sup> ) =	1 728	1	0.037 037 04
1 cubic yard (yd <sup>3</sup> ) =	46 656	27	1
1 cubic centimeter (cm <sup>3</sup> ) =	0.061 023 74	0.000 035 314 67	0.000 001 307 951
1 cubic decimeter (dm <sup>3</sup> ) =	61.023 74	0.035 314 67	0.001 307 951
1 cubic meter (m <sup>3</sup> ) =	61 023.74	35.314 67	1.307 951

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Milliliters (Cubic Centimeters)	Liters (Cubic Decimeters)	Cubic Meters
1 cubic inch (in <sup>3</sup> ) =	16.387 064	0.016 387 064	0.000 016 387 064
1 cubic foot (ft <sup>3</sup> ) =	28 316.846 592	28.316 846 592	0.028 316 846 592
1 cubic yard (yd <sup>3</sup> ) =	764 554.857 984	764.554 857 984	0.764 554 857 984
1 cubic centimeter (cm <sup>3</sup> ) =	1	0.001	0.000 001
1 cubic decimeter (dm <sup>3</sup> ) =	1 000	1	0.001
1 cubic meter (m <sup>3</sup> ) =	1 000 000	1 000	1

<sup>17</sup> Volume or capacity measurement units are applied to both regular (e.g., cube, rectangular prism, cylinder, cone, pyramid, sphere, etc.) and irregular geometric objects.

**Units of Capacity or Volume – Dry Volume Measure**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Dry Pints	Dry Quarts	Pecks	Bushels
1 dry pint (pt) =	1	0.5	0.062 5	0.015 625
1 dry quart (qt) =	2	1	0.125	0.031 25
1 peck (pk) =	16	8	1	0.25
1 bushel (bu) =	64	32	4	1
1 cubic inch (in <sup>3</sup> ) =	0.029 761 6	0.014 880 8	0.001 860 10	0.000 465 025
1 cubic foot (ft <sup>3</sup> ) =	51.428 09	25.714 05	3.214 256	0.803 563 95
1 liter (L) =	1.816 166	0.908 083 0	0.113 510 4	0.028 377 59
1 cubic meter (m <sup>3</sup> ) =	1 816.166	908.083 0	113.510 4	28.377 59

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Cubic Inches	Cubic Feet	Liters	Cubic Meters
1 dry pint (pt) =	33.600 312 5	0.019 444 63	0.550 610 5	0.000 550 610 5
1 dry quart (qt) =	67.200 625	0.038 889 25	1.101 221	0.001 101 221
1 peck (pk) =	537.605	0.311 114	8.809 768	0.008 809 768
1 bushel (bu) =	2 150.42	1.244 456	35.239 070 166 88	0.035 239 070 166 88
1 cubic inch (in <sup>3</sup> ) =	1	0.000 578 703 7	0.016 387 064	0.000 016 387 064
1 cubic foot (ft <sup>3</sup> ) =	1 728	1	28.316 846 592	0.028 316 846 592
1 liter (L) =	61.023 74	0.035 314 67	1	0.001
1 cubic meter (m <sup>3</sup> ) =	61 023.74	35.314 67	1 000	1

**Units of Capacity or Volume – Liquid Volume Measure**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Minims	Fluid Drams	Fluid Ounces	Gills
1 minim =	1	0.016 666 67	0.002 083 333	0.000 520 833 3
1 fluid dram (fl dr) =	60	1	0.125	0.031 25
1 fluid ounce (fl oz) =	480	8	1	0.25
1 gill (gi) =	1 920	32	4	1
1 liquid pint (pt) =	7 680	128	16	4
1 liquid quart (qt) =	15 360	256	32	8
1 gallon (gal) =	61 440	1 024	128	32
1 cubic inch (in <sup>3</sup> ) =	265.974 0	4.432 900	0.554 112 6	0.138 528 1
1 cubic foot (ft <sup>3</sup> ) =	459 603.1	7 660.052	957.506 5	239.376 6
1 milliliter (mL) =	16.230 73	0.270 512 2	0.033 814 02	0.008 453 506
1 liter (L) =	16 230.73	270.512 2	33.814 02	8.453 506

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Liquid Pints	Liquid Quarts	Gallons	Cubic Inches
1 minim =	0.000 130 208 3	0.000 065 104 17	0.000 016 276 04	0.003 759 766
1 fluid dram (fl dr) =	0.007 812 5	0.003 906 25	0.000 976 562 5	0.225 585 94
1 fluid ounce (fl oz) =	0.062 5	0.031 25	0.007 812 5	1.804 687 5
1 gill (gi) =	0.25	0.125	0.031 25	7.218 75
1 liquid pint (pt) =	1	0.5	0.125	28.875
1 liquid quart (qt) =	2	1	0.25	57.75
1 gallon (gal) =	8	4	1	231
1 cubic inch (in <sup>3</sup> ) =	0.034 632 03	0.017 316 02	0.004 329 004	1
1 cubic foot (ft <sup>3</sup> ) =	59.844 16	29.922 08	7.480 519	1 728
1 milliliter (mL) =	0.002 113 376	0.001 056 688	0.000 264 172 1	0.061 023 74
1 liter (L) =	2.113 376	1.056 688	0.264 172 1	61.023 74

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Cubic Feet	Milliliters	Liters
1 minim =	0.000 002 175 790	0.061 611 52	0.000 061 611 52
1 fluid dram (fl dr) =	0.000 130 547 4	3.696 691	0.003 696 691
1 fluid ounce (fl oz) =	0.001 044 379	29.573 53	0.029 573 53
1 gill (gi) =	0.004 177 517	118.294 1	0.118 294 1
1 liquid pint (pt) =	0.016 710 07	473.176 5	0.473 176 5
1 liquid quart (qt) =	0.033 420 14	946.352 9	0.946 352 9
1 gallon (gal) =	0.133 680 6	3 785.411 784	3.785 411 784
1 cubic inch (in <sup>3</sup> ) =	0.000 578 703 7	16.387 06	0.016 387 06
1 cubic foot (ft <sup>3</sup> ) =	1	28 316.85	28.316 85
1 milliliter (mL) =	0.000 035 314 67	1	0.001
1 liter (L) =	0.035 314 67	1 000	1

**Units of Volume – International Foot and Survey Equivalent Measurements<sup>18</sup>**  
 (All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:	
	International foot metric equivalent	U.S. survey foot metric equivalent
	Cubic Meters	Cubic Meters
acre-foot =	1 233.481 837 547 52	1 233.489 238 468 149

<sup>18</sup> *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Units in this table were historically defined using the U.S. survey foot. They may now be defined using either the international definition of the foot or U.S. survey foot. Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.



**Units of Mass Not Less Than Avoirdupois Ounces**(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Avoirdupois Ounces	Avoirdupois Pounds	Short Hundredweights	Short Tons
1 avoirdupois ounce (oz) =	1	0.062 5	0.000 625	0.000 031 25
1 avoirdupois pound (lb) =	16	1	0.01	0.000 5
1 short hundredweight (ctw) =	1 600	100	1	0.05
1 short ton (tn) =	32 000	2 000	20	1
1 long ton =	35 840	2 240	22.4	1.12
1 kilogram (kg) =	35.273 96	2.204 623	0.022 046 23	0.001 102 311
1 metric ton (t) =	35 273.96	2 204.623	22.046 23	1.102 311

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:		
	Long Tons	Kilograms	Metric Tons
1 avoirdupois ounce (oz) =	0.000 027 901 79	<u>0.028 349 523 125</u>	<u>0.000 028 349 523 125</u>
1 avoirdupois pound (lb) =	0.000 446 428 6	<u>0.453 592 37</u>	<u>0.000 453 592 37</u>
1 short hundredweight (ctw) =	0.044 642 86	<u>45.359 237</u>	<u>0.045 359 237</u>
1 short ton (tn) =	0.892 857 1	<u>907.184 74</u>	<u>0.907 184 74</u>
1 long ton =	<u>1</u>	<u>1 016.046 908 8</u>	<u>1.016 046 908 8</u>
1 kilogram (kg) =	0.000 984 206 5	<u>1</u>	<u>0.001</u>
1 metric ton (t) =	0.984 206 5	<u>1 000</u>	<u>1</u>

## Units of Mass Not Greater Than Pounds and Kilograms

(All underlined figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Grains	Apothecaries Scruples	Pennyweights	Avoirdupois Drams
1 grain (gr) =	1	0.05	0.041 666 67	0.036 571 43
1 apothecaries scruple (dr ap) =	20	1	0.833 333 3	0.731 428 6
1 pennyweight (dwt) =	24	1.2	1	0.877 714 3
1 avoirdupois dram (dr) =	27.343 75	1.367 187 5	1.139 323	1
1 apothecaries dram (dr ap) =	60	3	2.5	2.194 286
1 avoirdupois ounce (oz) =	437.5	21.875	18.229 17	16
1 apothecaries ounce (oz) =	480	24	20	17.554 29
1 troy ounce (oz t) =	480	24	20	17.554 29
1 apothecaries pound (lb ap) =	5 760	288	240	210.651 4
1 troy pound (lb t) =	5 760	288	240	210.651 4
1 avoirdupois pound (lb) =	7 000	350	291.666 7	256
1 milligram (mg) =	0.015 432 36	0.000 771 617 9	0.000 643 014 9	0.000 564 383 4
1 gram (g) =	15.432 36	0.771 617 9	0.643 014 9	0.564 383 4
1 kilogram (kg) =	15 432.36	771.617 9	643.014 9	564.383 4

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Apothecaries Drams	Avoirdupois Ounces	Apothecaries or Troy Ounces	Apothecaries or Troy Pounds
1 grain (gr) =	0.016 666 67	0.002 285 714	0.002 083 333	0.000 173 611 1
1 apothecaries scruple (s ap) =	0.333 333 3	0.045 714 29	0.041 666 67	0.003 472 222
1 pennyweight (dwt) =	0.4	0.054 857 14	0.05	0.004 166 667
1 avoirdupois dram (dr) =	0.455 729 2	0.062 5	0.569 661 5	0.004 747 179
1 apothecaries dram (dr ap) =	1	0.137 142 9	0.125	0.010 416 67
1 avoirdupois ounce (oz) =	7.291 667	1	0.911 458 3	0.075 954 86
1 apothecaries ounce (oz) =	8	1.097 143	1	0.083 333 333
1 troy ounce (oz t) =	8	1.097 143	1	0.083 333 333
1 apothecaries pound (lb) =	96	13.165 71	12	1
1 troy pound (lb t) =	96	13.165 71	12	1
1 avoirdupois pound (lb) =	116.666 7	16	14.583 33	1.215 278
1 milligram (mg) =	0.000 257 206 0	0.000 035 273 96	0.000 032 150 75	0.000 002 679 229
1 gram (g) =	0.257 206 0	0.035 273 96	0.032 150 75	0.002 679 229
1 kilogram (kg) =	257.206 0	35.273 96	32.150 75	2.679 229

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:			
	Avoirdupois Pounds	Milligrams	Grams	Kilograms
1 grain (gr) =	0.000 142 857 1	64.798 91	0.064 798 91	0.000 064 798 91
1 apothecaries scruple (s ap) =	0.002 857 143	1 295.978 2	1.295 978 2	0.001 295 978 2
1 pennyweight (dwt) =	0.003 428 571	1 555.173 84	1.555 173 84	0.001 555 173 84
1 avoirdupois dram (dr) =	0.003 906 25	1 771.845 195 312 5	1.771 845 195 312 5	0.001 771 845 195 312 5
1 apothecaries dram (dr ap) =	0.008 571 429	3 887.934 6	3.887 934 6	0.003 887 934 6
1 avoirdupois ounce (oz) =	0.062 5	28 349.523 125	28.349 523 125	0.028 349 523 125
1 apothecaries ounce (oz ap) =	0.068 571 43	31 103.476 8	31.103 476 8	0.031 103 476 8
1 troy ounce (oz t) =	0.068 571 43	31 103.476 8	31.103 476 8	0.031 103 476 8
1 apothecaries pound (lb ap) =	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 troy pound (lb t) =	0.822 857 1	373 241.721 6	373.241 721 6	0.373 241 721 6
1 avoirdupois pound (lb) =	1	453 592.37	453.592 37	0.453 592 37
1 milligram (mg) =	0.000 002 204 623	1	0.001	0.000 001
1 gram (g) =	0.002 204 623	1 000	1	0.001
1 kilogram (kg) =	2.204 623	1 000 000	1 000	1

**Units of Pressure**  
(All underlined> figures are exact.)

Starting Unit ↓	Multiply by the Ending Unit Conversion Factor:					
	Pascal (Pa)	Kilopascal (kPa)	Megapascal (MPa)	Pound-force per square inch (psi) (lbf/in <sup>2</sup> )	Millimeter of mercury (mm Hg [0 °C])	Inch of water (in H <sub>2</sub> O [4 °C])
1 Pa =	1	0.001	0.000 001	0.000 145 037 74	0.007 500 615	0.004 014 742 13
1 kPa =	1 000.0	1	0.001	0.145 037 744	7.500 615 05	4.014 742 133
1 MPa =	1 000 000	1 000	1	145.037 744	7 500.615 05	4 014.742 13
1 psi (lbf/in <sup>2</sup> ) =	6 894.757	6.894 757	0.006 894 757	1	51.714 918 1	27.680 671 4
1 mmHg (0 °C) =	133.322 4	0.133 322 4	0.000 133 322 4	0.019 336 78	1	0.535 255 057
1 inH <sub>2</sub> O (4 °C) =	249.082	0.249 082	0.000 249 082	0.036 126 291	1.868 268 198	1

**Conversion Equations for Units of Temperature**  
(Exact)

Units	To Degree Fahrenheit (°F)	To Degree Celsius (°C)	To Kelvin (K)
Degree Fahrenheit (°F)	°F	$\frac{(^{\circ}F - 32)}{1.8}$	$\frac{(^{\circ}F - 32)}{1.8} + 273.15$
Degree Celsius (°C)	$(^{\circ}C \times 1.8) + 32$	°C	$(^{\circ}C) + 273.15$
Kelvin (K)	$(K - 273.15) \times 1.8 + 32$	$K - 273.15$	K

**Instructions for the Conversion Equations for Temperature:**

Start at the left column of the table until you reach the row labeled with the starting unit. Then proceed horizontally to the right along that row until you reach the column of the desired unit. The unit conversion factor is located at the intersection of the row and column.

## 5. Tables of Equivalents<sup>19</sup>

In these tables, all SI equivalents that use the foot (or other U.S. Customary units derived from the foot) are based on the international foot.

When the name of a unit is enclosed in brackets (thus, [1 hand] . . .), this indicates (1) that the unit is not in general current use in the United States, or (2) that the unit is believed to be based on “custom and usage” rather than on formal authoritative definition.

Equivalents involving decimals are, in most instances, rounded off to the third decimal place except where they are exact, in which cases these exact equivalents are so designated. The equivalents of the imprecise units “tablespoon” and “teaspoon” are rounded to the nearest milliliter.

<b>Units of Length</b> (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3 048 m exactly) (All <u>underlined</u> figures are exact.)	
1 cable’s length	<u>120</u> fathoms <u>720</u> feet <u>219.456</u> meters
1 centimeter (cm)	<u>0.01</u> meter 0.393 7 inch
1 chain (ch) (Gunter’s or surveyor’s)	<u>66</u> feet <u>20.116 8</u> meters
1 decimeter (dm)	<u>0.1</u> meter (exactly) 3.937 inches
1 dekameter (dam)	<u>10</u> meters (exactly) 32.808 feet
1 fathom	<u>6 feet</u> (exactly) <u>1.828 8</u> meters (exactly)
1 foot (ft)	<u>12 inches</u> (exactly) <u>0.304 8 meter</u> (exactly)
1 furlong (fur)	<u>10 chains</u> (exactly) <u>660 feet</u> (exactly) <u>1/8</u> mile (exactly) <u>201.168</u> meters (exactly)
[1 hand]	<u>4</u> inches
1 inch (in)	<u>2.54</u> centimeters (exactly)
1 kilometer (km)	<u>1 000</u> meters (exactly) <u>0.621</u> mile
1 league (land)	<u>3</u> miles (exactly) <u>4.828 032</u> kilometers (exactly)

<sup>19</sup> *Federal Register* (October 5, 2020, 85 FR 62698, p. 62698). Use of definitions based on the U.S. survey foot should be avoided after December 31, 2022, except for historic and legacy applications.

<b>Units of Length</b> (all SI equivalents that use the foot are based on the international foot definition, 1 foot = 0.3 048 m exactly) (All <u>underlined</u> figures are exact.)	
1 link (li) (Gunter’s or surveyor’s)	<u>0.66</u> foot (exactly) <u>0.201 168</u> meter (exactly)
1 meter (m)	<u>0.001</u> kilometer (exactly) 39.37 inches 1.094 yards
1 mil	<u>0.001</u> inch (exactly) <u>0.025 4</u> millimeter (exactly) <u>25.4</u> micrometer (exactly)
1 micrometer ( $\mu\text{m}$ ) <sup>20</sup>	<u>0.001</u> millimeter (exactly) <u>0.000 001</u> meter (exactly) 0.000 039 37 inch
1 mile (mi)	<u>5 280</u> feet (exactly) <u>1.609 344</u> kilometers (exactly)
1 mile (mi) (international nautical) <sup>21</sup>	<u>1 852</u> meters (exactly) <u>1.852</u> kilometers (exactly) 1.151 miles
1 millimeter (mm)	<u>0.001</u> meter (exactly) <u>0.039 370</u> 1 inch (exactly)
1 nanometer (nm)	<u>0.000 000 001</u> meter (exactly) 0.000 000 039 37 inch
1 point	<u>0.013 837</u> inch (exactly) $\frac{1}{72}$ inch (approximately) 0.351 millimeter (“point” is historically used in typography)
1 rod (rd), pole, or perch	<u>16½</u> feet (exactly) <u>5.029 2</u> meters (exactly)
1 yard (yd)	<u>3</u> feet (exactly) <u>0.914 4</u> meter (exactly)

<sup>20</sup> The SI symbol for the prefix micro is the Greek letter mu ( $\mu$ ).

<sup>21</sup> **NIST SP 447**, *Weights and Measures Standards of the United States, A Brief History* (1975). The international nautical mile of 1 852 meters (6 076.115 49 feet) was adopted by the First International Extraordinary Hydrographic Conference, Monaco, 1929, under the name “International nautical mile.” It was later adopted for use in the United States (effective July 1, 1954) by identical directives of the U.S. Department of Commerce and Department of Defense. The value formerly used in the United States was 6 080.20 feet = 1 nautical (geographical or sea) mile.

<b>Units of Area</b> (All <u>underlined</u> figures are exact.)	
1 acre (ac)	<u>43 560</u> square feet (exactly) <u>0.404 685 642 24</u> hectare (exactly)
1 are (a)	<u>100</u> square meters (exactly) 119.599 square yards 0.025 acre
1 hectare (ha)	<u>10 000</u> square meters (exactly) <u>0.01</u> square kilometer (exactly) 2.471 acres
[1 section (of land)]	[1 mile square] (approximate)
[1 square (building)]	100 square feet
1 square centimeter (cm <sup>2</sup> )	<u>0.000 1</u> square meter (exactly) 0.155 square inch
1 square decimeter (dm <sup>2</sup> )	<u>0.01</u> square meter (exactly) 15.500 square inches
1 square foot (ft <sup>2</sup> )	<u>144</u> square inches (exactly) <u>929.030 4</u> square centimeters (exactly)
1 square inch (in <sup>2</sup> )	0.006 944 444 square feet <u>6 451 6</u> square centimeters (exactly)
1 square kilometer (km <sup>2</sup> )	<u>1 000 000</u> square meters (exactly) 247.104 acres 0.386 square mile
1 square meter (m <sup>2</sup> )	<u>0.000 001</u> square kilometer (exactly) <u>1 000 000</u> square millimeters (exactly) 1.196 square yards 10.764 square feet
1 square mile (mi <sup>2</sup> )	2.589 99 square kilometers 258.999 hectares
1 square millimeter (mm <sup>2</sup> )	<u>0.000 001</u> square meter (exactly) 0.002 square inch
1 square rod (rd <sup>2</sup> ), square pole, or square perch	<u>25.292 852 64</u> square meters (exactly)
1 square yard (yd <sup>2</sup> )	<u>0.836 127 36</u> square meter (exactly) <u>9</u> square feet (exactly) <u>1 296</u> square inches (exactly)
[1 township]	[6 miles square] (approximate) [36 sections (of land)] 36 square miles (approximate)

<b>Units of Capacity or Volume</b> (All <u>underlined</u> figures are exact.)	
1 barrel (bbl), liquid	31 to 42 gallons <sup>22</sup>
1 barrel (bbl), standard for fruits, vegetables, and other dry commodities, except cranberries	7 056 cubic inches 105 dry quarts 3.281 bushels, struck measure
1 barrel (bbl), standard, cranberry	5 826 cubic inches 86 <sup>45</sup> / <sub>64</sub> dry quarts 2.709 bushels, struck measure
1 bushel (bu) (U.S.) struck measure	<u>2 150.42</u> cubic inches (exactly) 35.238 liters
[1 bushel, heaped (U.S.)]	2 747.715 cubic inches 1.278 bushels, struck measure <sup>23</sup>
[1 bushel (bu) (British Imperial) (struck measure)]	1.032 U.S. bushels, struck measure 2 219.36 cubic inches
1 cord (cd) (firewood)	<u>128</u> cubic feet (exactly)
1 cubic centimeter (cm <sup>3</sup> )	<u>0.001</u> cubic decimeter (exactly) <u>0.001</u> liter (exactly) <u>1</u> milliliter (exactly) 0.061 cubic inch
1 cubic decimeter (dm <sup>3</sup> )	<u>1 000</u> cubic centimeters (exactly) <u>1 000</u> milliliters (exactly) <u>1</u> liter (exactly) 61.024 cubic inches
1 cubic foot (ft <sup>3</sup> )	7.481 gallons 28.316 cubic decimeters (liters)
1 cubic inch (in <sup>3</sup> )	0.554 fluid ounce (fl oz) (or <i>f</i> $\frac{5}{8}$ ) 4.433 fluid drams (fl dr) (or <i>f</i> 3) 16.387 cubic centimeters
1 cubic meter (m <sup>3</sup> )	1 000 cubic decimeters 1 000 liters 1.308 cubic yards
1 cubic yard (yd <sup>3</sup> )	0.765 cubic meter <u>27</u> cubic feet (exactly)

<sup>22</sup> A variety of “barrels” are established by law or industry usage. Consult federal laws and regulations, state laws and regulations, and documentary standards for the industry application to ensure the use of the appropriate barrel definition. For example, federal taxes on fermented liquors are based on a barrel of 31 gallons; many state laws fix the “barrel for liquids” as 31½ gallons; a 36-gallon barrel has been used for cistern measurement; federal law recognizes a 40-gallon barrel for “proof spirits;” and by custom, 42 gallons comprise a barrel of crude oil or petroleum products for statistical purposes, and this equivalent is recognized “for liquids” by some states.

<sup>23</sup> Frequently recognized as 1¼ bushels, struck measure.



<b>Units of Capacity or Volume</b> (All <u>underlined</u> figures are exact.)	
1 cup, measuring	<u>8</u> fluid ounces (exactly) 237 milliliters $\frac{1}{2}$ liquid pint (exactly)
1 dekaliter (daL)	<u>10</u> liters (exactly) 2.642 gallons 1.135 pecks
1 dram, fluid (or liquid) (fl dr) (or <i>f 3</i> ) (U.S.)	$\frac{1}{8}$ fluid ounce (exactly) 0.226 cubic inch 3.697 milliliters 1.041 British fluid drachms
[1 drachm, fluid (fl dr) (British)]	0.961 U.S. fluid dram 0.217 cubic inch 3.552 milliliters
1 gallon (gal) (U.S.)	<u>231</u> cubic inches (exactly) 3.785 liters 0.833 British gallon <u>128</u> U.S. fluid ounces (exactly)
[1 gallon (gal) (British Imperial)]	277.42 cubic inches 1.201 U.S. gallons 4.546 liters <u>160</u> British fluid ounces (exactly)
1 gill (gi)	7.219 cubic inches <u>4</u> fluid ounces (exactly) 0.118 liter
1 hectoliter (hL)	100 liters 26.418 gallons 2.838 bushels
1 liter (L)	<u>1</u> cubic decimeter (exactly) <u>1 000</u> milliliters (exactly) 1.057 liquid quarts 0.908 dry quart 61.024 cubic inches
1 milliliter (mL)	<u>0.001</u> cubic decimeter (exactly) <u>0.001</u> liter (exactly) 0.271 fluid dram 16.231 minims 0.061 cubic inch
1 ounce, fluid (or liquid) (fl oz) (or <i>f 3</i> ) (U.S.)	1.805 cubic inches 29.573 milliliters 1.041 British fluid ounces

<b>Units of Capacity or Volume</b> (All <u>underlined</u> figures are exact.)	
[1 ounce, fluid (fl oz) (British)]	0.961 U.S. fluid ounce 1.734 cubic inches 28.412 milliliters
1 peck (pk)	8.810 liters
1 pint (pt), dry	33.600 cubic inches 0.551 liter
1 pint (pt), liquid	<u>28.875</u> cubic inches (exactly) 0.473 liter
1 quart (qt), dry (U.S.)	67.201 cubic inches 1.101 liters 0.969 British quart
1 quart (qt), liquid (U.S.)	<u>57.75</u> cubic inches (exactly) 0.946 liter 0.833 British quart
[1 quart (qt) (British)]	69.354 cubic inches 1.032 U.S. dry quarts 1.201 U.S. liquid quarts
1 tablespoon, measuring	<u>3</u> teaspoons (exactly) 15 milliliters 4 fluid drams <u>½</u> fluid ounce (exactly)
1 teaspoon, measuring	<u>½</u> tablespoon (exactly) 5 milliliters 1½ fluid drams <sup>24</sup>
1 water ton (English)	270.91 U.S. gallons <u>224</u> British Imperial gallons (exactly)

<sup>24</sup> The equivalent “1 teaspoon = 1½ fluid drams” has been found by NIST to correspond more closely with the actual capacities of “measuring” and silver teaspoons than the equivalent “1 teaspoon = 1 fluid dram,” which is given by a number of dictionaries.

<b>Units of Mass</b> (All <u>underlined</u> figures are exact.)	
1 assay ton (AT) <sup>25</sup>	29.167 grams
1 carat (c) <sup>26</sup>	<u>200</u> milligrams (exactly) 3.086 grains
1 dram apothecaries (dr ap or ℥)	<u>60</u> grains (exactly) 3.888 grams
1 dram avoirdupois (dr)	27 <sup>11</sup> / <sub>32</sub> (= 27.344) grains 1.772 grams
1 gamma (γ)	<u>1</u> microgram (exactly)
1 grain (gr)	<u>64.798 91</u> milligrams (exactly)
1 gram (g)	<u>0.001</u> kilogram (exactly) 15.432 grains 0.035 ounce, avoirdupois
1 hundredweight, gross or long <sup>27</sup> (gross cwt)	<u>112</u> pounds (exactly) 50.802 kilograms
1 hundredweight, gross or short (cwt or net cwt)	<u>100</u> pounds (exactly) 45.359 kilograms
1 kilogram (kg)	<u>1 000</u> grams (exactly) 2.205 pounds
1 microgram (μg) <sup>28</sup>	<u>0.000 001</u> gram (exactly)
1 milligram (mg)	<u>0.001</u> gram (exactly) 0.015 grain <u>0.005</u> carat (exactly)
1 ounce, avoirdupois (oz)	<u>437.5</u> grains (exactly) 0.911 troy or apothecaries ounce 28.350 grams
1 ounce, troy or apothecaries (oz t or oz ap or ℥)	<u>480</u> grains (exactly) 1.097 avoirdupois ounces 31.103 grams
1 ounce, troy (oz t)	<u>480</u> grains (exactly) 1.097 avoirdupois ounces 31.103 grams

<sup>25</sup> Used in assaying. The assay ton bears the same relation to the milligram that a ton of 2000 pounds avoirdupois bears to the troy ounce; hence the mass in milligrams of precious metal obtained from one assay ton of ore gives directly the number of troy ounces to the net ton.

<sup>26</sup> NIST Circular 43 (1913) The Metric Carat. As of July 1, 1913, the international metric carat was recognized as 200 milligrams for diamonds and other precious stones and expressed as decimal fractions. A carat is further divided where 1 carat equals 100 points. Available at <https://nvlpubs.nist.gov/nistpubs/Legacy/circ/nbscircular43.pdf>.

<sup>27</sup> The gross or long ton and hundredweight are used commercially in the United States to only a very limited extent, usually in restricted industrial fields. The units are the same as the British “ton” and the “hundredweights.”

<sup>28</sup> The SI symbol for the prefix micro is the Greek letter mu (μ).

<b>Units of Mass</b> (All <u>underlined</u> figures are exact.)	
1 ounce, apothecaries (oz ap or ℥)	<u>480</u> grains (exactly) 1.097 avoirdupois ounces 31.103 grams
1 pennyweight (dwt)	<u>1.555</u> grams
1 point	<u>0.01</u> carat (exactly) <u>2</u> milligrams (exactly) (“point” is historically used in the jewelry industry to describe gemstones)
1 pound, avoirdupois (lb)	<u>7 000</u> grains (exactly) 1.215 troy or apothecaries pounds <u>453.592 37</u> grams (exactly)
1 micropound (μlb) <sup>29</sup>	<u>0.000 001</u> pound (exactly)
1 pound, troy (lb t)	<u>5 760</u> grains (exactly) 0.823 avoirdupois pound 373.242 grams
1 pound, apothecaries (lb ap)	<u>5 760</u> grains (exactly) 0.823 avoirdupois pound 373.242 grams
1 scruple (s ap or ℥)	<u>20</u> grains (exactly) 1.296 grams
1 ton, gross or long <sup>29</sup>	<u>2 240</u> pounds (exactly) <u>1.12</u> net tons (exactly) 1.016 metric tons
1 ton, metric (t)	2 204.623 pounds 0.984 gross ton 1.102 net tons
1 ton, net or short (tn) <sup>30</sup>	<u>2 000</u> pounds (exactly) 0.893 gross ton 0.907 metric ton

<sup>29</sup> The SI symbol for the prefix micro is the Greek letter mu (μ). This is an example where SI writing style is applied to a non-SI unit abbreviation. The Greek letter mu prefix is used in combination with the abbreviation for pound (lb).

<sup>30</sup> As of January 1, 2014, “tn” is the required abbreviation for “short ton.” Devices manufactured between January 1, 2008, and December 31, 2013, may use an abbreviation other than “tn” to specify “short ton.”

(Added 2013)