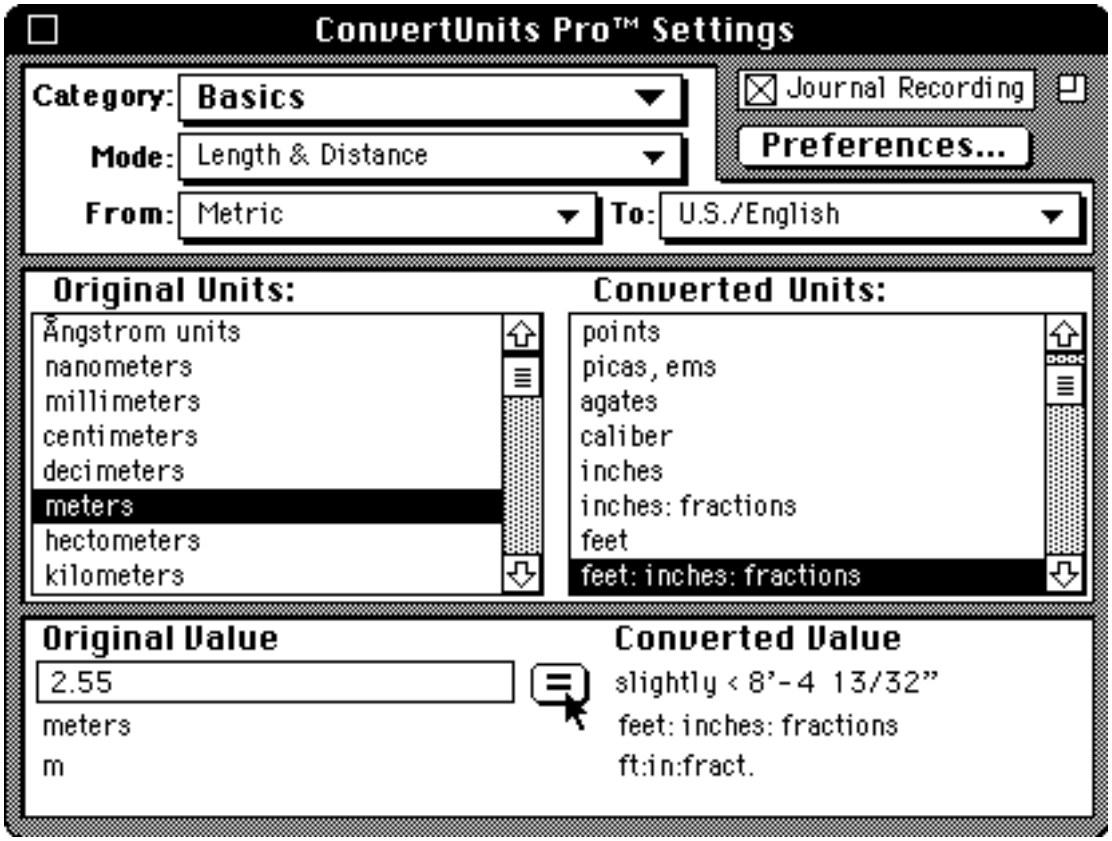
CONVERTUNITS PRO™ REFERENCE MANUAL



INTRODUCTION

ConvertUnits Pro™ is a feature-packed utility program for converting numerical quantities of measure, and is ideally suited for students, researchers, business, professionals... - in short, anyone dealing with numerical quantities of almost any description.

ConvertUnits Pro's built-in database is organized into "categories" such as Electricity, Heat, History, Light & Radiation, Mechanics, Unit Costs & Quantities, which together contain over 1500 different conversion factors organized in over 100 "modes" such as Length, Area, Volume, Force, Charge, and Heat Capacity. Thanks to a unique hierarchical access method, any one of over 120,000 different conversion combinations can be easily set up and performed.

Commonly used physical constants such as gravitational acceleration and the speed of light are also included, as well as compound units such as "feet, inches, and fractions", and "hours, minutes, and seconds". In the "World Time" mode, you can convert to the time in 97 different countries, including 28 cities in North America, using any other time and location in

the database as a reference point. In the "History" database can be found over 170 units of length, area, volume, and weight from all over the ancient world.

On the lighter side, the "Whimsy" database provides a light–hearted break to all the serious stuff, with general interest facts about the World and the Solar System (do you know how many times higher Mount Everest is than the Statue of Liberty?).

Most conversion results are precise to 14 significant figures. For the few factors in the databases that are less precise, CU Pro can be set to automatically trim the displayed answer to the appropriate precision (see Number Preferences for details).

Conversion results can be recorded into the self-contained journal and exported to a separate text file if desired, complete with original and converted to unit names and amounts.

New measurement units can be easily added with the “Add Unit” feature. Any unit in the database can just as easily be deleted.

Up to 30 conversion unit pairs of your choice can be saved in a pull-down menu for instant access without having to navigate through the database hierarchy.

Conversion tables for use as a hardcopy reference can be easily generated for any combination of units (except compound units), with any starting value, interval between values, and ending value desired. These tables are automatically written to a text file for easy viewing, editing, and printing from any word processing program.

DATA ORGANIZATION AND ABBREVIATIONS

The CU Pro database is organized into a hierarchical structure of Categories, Modes, Systems, and Units:

• CATEGORIES: The ConvertUnits database is organized into nine Categories:

Basics	History	Time
Electricity	Mechanics	Unit Costs & Quantities
Heat	Light & Radiation	Whimsy

• MODES: Units in each category are further divided into “modes”, which are groups of units of the same type, such as: Area, Length, Volume, Temperature, Diffusivity, and so on. In total there are over 100 modes.

• SYSTEMS: Individual units in each mode are further grouped into measurement systems, such as “Metric”, “U.S./English”, and “Physical

Constants”. Modes may have differing measurement system groupings of their units, or may have no measurement systems at all. For example, the mode “Computer Capacity” has no measurement system subgrouping of its units, because all the units are in the same “measurement system” (bits, bytes, kilobytes, megabytes, etc.). In ConvertUnits Pro, conversions can even be performed between different units of the same measurement system, if so desired (unlike hand-held conversion calculators). Examples of units which would be listed under physical constants are "speed of light" and "gravitational acceleration", because they are ‘absolute’ quantities of a known physical phenomenon (defined by nature), and not artificially created units of measure expressing a quantity (defined by man).

• UNITS: Units are the lowest level of the database hierarchy and this is the level at which conversions are performed. In total there are over 1500 different measurement units, and over 120,000 different conversion unit combinations are possible.

Included in the database are many compound units such as: "tons, pounds, and ounces", "hours, minutes, and seconds", and "feet, inches and fractions". Inch fractions are rounded to the nearest user-definable denominator, and the least common denominator is calculated automatically. Many complex units such as "miles/gallon" and "liters/100 kilometers" are also included, which are difficult to convert in a conventional manner because they require several mathematical operations.

ABBREVIATIONS USED IN THE DATABASE

U.S. - United States versions of volume and capacity units.

dry - Dry versions of U.S. volume and capacity units.

liq - Liquid versions of U.S. volume and capacity units. If a unit of volume has liquid and dry versions (as in U.S. volume units) then they are liquid unless otherwise noted.

Imp - Imperial versions of volume and capacity units. These units are used mostly in English speaking countries outside the United States.

avdp - Avoirdupois weight units are used for general purposes. Pounds, ounces, and drams are avoirdupois unless otherwise noted. The avoirdupois versions of the pound and the ounce are the ones in common use.

apoth - Apothecary units of weight (used in pharmacy).

IT - International Table. Used to identify types of international British Thermal Units (BTU's) and calories.

tc - Thermochemical. Used to identify types of thermochemical British Thermal Units (BTU's) and calories.

tr - Troy weight units are used for jewels and precious metals.

HISTORICAL UNITS

Over 170 historical units of measurement are included in this category. Obviously, unit names and conversion factors for ancient measurement units are very difficult to establish with any degree of certainty, and tend to vary depending on whose research is used as a reference. We have attempted to incorporate the more widely accepted conversion factors. The information contained in this category, however, is not meant to be a scholarly treatise on the subject. Rather, it should be mainly considered as a quick refrence guide for comparing relative sizes of mesurements of the

ancient world. Reference sources for these units can be found in the bibliography.

THE WHIMSY CATEGORY

The Whimsy category contains some interesting conversions which are quite out of the ordinary. The modes in this category contain conversions in the fields of Astronomy, Geography, and History. Other miscellaneous conversions are classified as Trivia.

The following examples show the kind of conversions possible in Whimsy:

Question - How many times greater is the surface area of the Sun than the Earth's?

Answer - Select the "Astronomy-Areas" mode
- Select "Sun" in the Original Units list
- Select "Earth" in the Converted Units list
- Enter "1" in the Original value box and perform the conversion.

ConvertUnits Pro™ will calculate the number of "Earth (surface) areas" which will fit on one "Sun (surface) area". (11,744 times).

INSTALLING CONVERTUNITS PRO™

Install CU Pro by dragging the icon of the CU Pro application to your hard disk. If you are running System 7 and put CU Pro into the Apple Menu folder in your System folder, CU Pro will appear in the Apple menu, ready to be launched desk accessory style. Note that you should have Geneva 10,12, and 14 font sizes in your System Folder for best results.

PERFORMING A CONVERSION

1. Open CU Pro by double clicking on its icon or clicking on it once and selecting “Open” from the “File” menu. CU Pro can also be launched as a desk accessory under System 7 by dragging it into the “Apple Menu” Folder in the System Folder.

2. The current category will be displayed in a box next to the word “Category” near the top of the Settings window. Click in this box and hold the mouse button down and a hierarchical pop-up menu will appear listing all the categories with submenus listing the "modes" (Unit groupings) in each corresponding category. Select the desired category, and when the submenu with the mode list appears, select the desired mode. At this point, if the mode selected contains units that are all in the same system of measurement, then a list of measurement units will now appear in each of the scrolling fields. Skip step 4 below.

3. Select the direction of the conversion you wish to perform by selecting the desired measurement system from the pop-up menus which appear when clicking in the boxes next to the “from” and “to” labels (located just under the Mode box). A list of measurement units will appear in each corresponding scrolling field as each measurement system is selected.

4. Select the appropriate unit from each list for the conversion desired. The name and symbol of the selected unit will appear under the values boxes.

5. Enter the value (numerical quantity) you wish to convert in the "Original Value" box and click on the "equals" button or press the "Enter" or "Return" keys. Note that you do not have to click in the "Original Value" box; any typing will automnatically be inserted. The answer will now appear in the "Converted Value" box. Depending on the preference settings, the converted value will also be automatically put in the clipboard, replacing anything that was in the clipboard previously. If you

are using Compound Units such as “feet & inches”or World Times, refer to the appropriate sections in the following pages for more information on entering numerical quantities for these special formats.

ENTERING COMPOUND UNIT VALUES

Compound units are quantities that are expressed with more than one unit name, such as “degrees, minutes,seconds” and “miles,feet”. These units can be entered simply by typing the amounts for each unit separated by either a space or a colon (:).

Thus, 10 miles and 275 feet can be entered as “10 275” or “10:275”. A special type of compound unit are “inches,fractions” and “feet,inches, fractions”, which can be entered with spaces or colons or dashes separating the number groups, as follows: 3-4 1/2 (note that apostrophes are not required and not recommended). Refer to the ‘Number Formatting’ section for setting the denominator of the converted value.

ENTERING WORLD TIMES

World time values can be entered in 12 hour format (using a.m. and p.m. suffixes) or 24 hour format (i.e.: 20:32 for 8:32 p.m.). ConvertUnits Pro will also accept the following variations for 12-hour format: 8:32 p.m. or 8:32 PM or 8:32 P.M. Typing “now” into the original value box will insert the current time from the Mac’s internal clock. Obiously, this only makes sense to do if you have selected your present location in the ‘from’ list. Noon is 12:00 p.m. and midnight is 12:00 a.m. "Noon" or "Midnight" can also be typed. The message "previous day" or "next day" will be displayed in the converted value if appropriate. The program does NOT adjust for Daylight Savings Time (DST) and the user must make the adjustment manually if DST is in effect in either of the locations selected. If both locations have DST in effect then an adjustment is not necessary.

CURRENCY CONVERSIONS

When performing currency conversions (located in the ‘Basics’ category) a message will remind you to check the currency exchange rates in the database to ensure they are up to date. Updating an exchange rate is a matter of:

1) Selecting the currency to be updated from the 'Original Units' list,
2) Selecting "Update Exchage Rate..." from the "ConvertUnits" menu, and
3) Entering the new exchange rate in the field which now appears. Note that exchange rates are to be expressed in terms of U.S. dollars (that is, how many U.S. dollars it takes to purchase one unit of that currency).

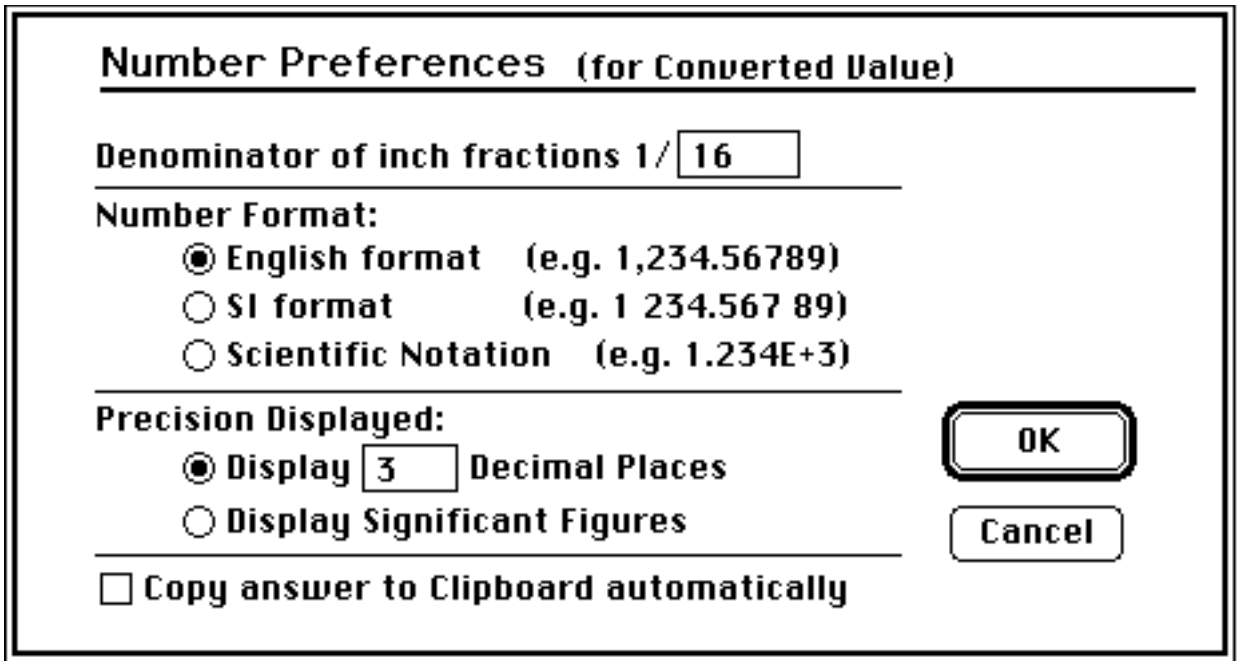
In order to add or delete currencies from the list, the "Add New Unit..." and "Remove Unit" menu items under the "ConvertUnits" menu should be used (see 'Adding and Removing Units' help section).

THE ZOOMING WINDOW

The zoom button in the upper right corner of the CU Pro settings window allows you to reduce the size of the window, showing only essential information, to allow you to perform multiple conversions with the same measurement units while allowing you to see as much of another open document as possible. The zoom feature is only accessible when both measurement units have been selected. Conversions can be performed

when in the zoomed down view and preference settings can be changed, but measurement units cannot be changed.

NUMBER FORMATTING OPTIONS



Clicking on the "Preferences..." button presents a dialog box for you to set the format for converted values, such as:
1) The number of decimal places desired in the converted value,

2) The denominator desired in conversions involving fractions of an inch, (the least common denominator will be automatically calculated and displayed),

3) English versus International versus Scientific notation.
example of English notation: 21,234.56789 (note commas)
example of International (SI) notation: 21 234.567 89 (note spaces)
example of Scientific notation: 2.123456789E+4

4) Display of either a fixed number of decimal places as selected above or the number of significant figures of the least precise of either the original value input by the user or the conversion factors contained in the database. This feature is useful to prevent displaying a converted value which is more precise than the least precise of either the input value or the conversion factors used in the calculation.

THE SIGNIFICANCE OF SIGNIFICANT FIGURES
When doing any mathematical calculation, the result is only precise to the least number of significant figures of any one of the values used in the calculation. The digits to the right of the number of least significant figures

in the answer will be meaningless.

ConvertUnits Pro™ uses conversion factors stored in its database to calculate converted values. Most of the factors are stored to 14 significant figures, but a few have less. If you choose the Significant Figures setting, conversion results will be rounded to the least number of significant figures contained in either the factors used in the conversion or in the original input value, whichever has fewer.

Example: • Original value entered is 1234 (four significant figures)

- The conversion factors is 0.12344321 (eight significant figures)
- A calculator would yield an answer of 152.32892114 (11 figures)
- The correct answer (assuming 1234 is a measured, not exact, value) is 152.3
  (precise only to the nearest tenth of a unit)

Because the original value only has a precision of four significant figures, the digits to the right of the "3" in the result are meaningless (a calculator assumes that all numbers entered are exact measurements, and the answer displayed by the calculator would be valid if the values used in the calculation are all known to be exact).

Use the Significant Figures setting when you know that your original value is only precise to the number of digits being entered. If the number you are entering is exactly that amount, then the significant figures setting is only needed if the conversion factors have less than 14 figures of precision.

The Significant Figures setting works in conjunction with Scientific Notation as well, so the answer 152.3 would be displayed as 1.523E+2.

Zeroes to the left of a decimal point are considered significant, so if you are entering a value that you know is less precise than the zeroes imply (for example, 2500 pounds, give or take 100 pounds) then the value should be entered in scientific notation with only the number of digits that are significant. In this case, 2.5E+2 should be entered.

AUTOMATIC CHANGE TO SCIENTIFIC NOTATION

In some case, even though you may have chosen the fixed notation display preference, the converted value will be displayed in scientific notation. This happens if the correct number of significant figures cannot be displayed properly in conventional notation, or if the number is too large to fit in the display, or if only zeroes would be displayed as a result of too few decimals being displayed in the case of very small values.

For example, an answer of 2500 implies that the precision of this value is to the nearest whole unit, when in fact the answer could be a result of an operation with numbers involving fewer than four significant figures (the rules of significant figures state that zeroes to the left of a decimal point are to be considered significant). In this case, the proper display format would be scientific notation, because it is easy to express this number with

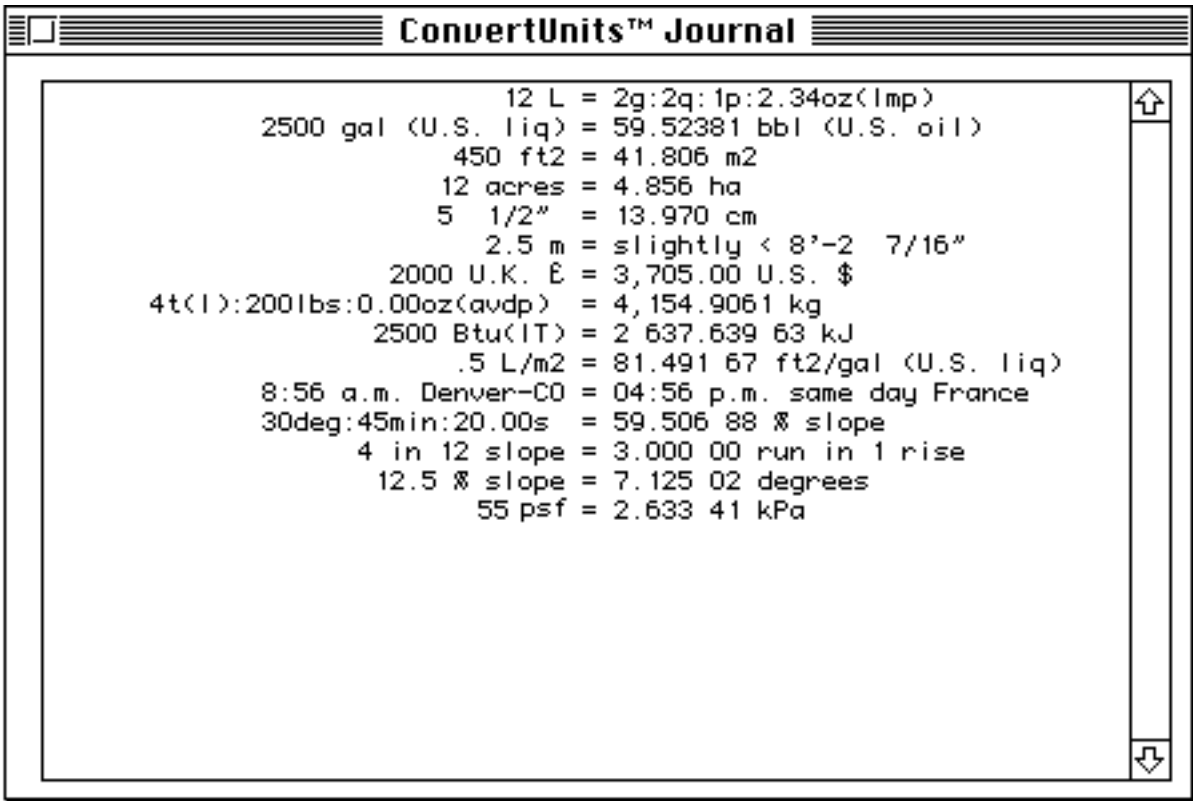
only the appropriate number of significant figures. For example, 2500 with only two significant figures would be displayed as 2.5E+2 (which is 2.5 x10 raised to the second power).

The answer will also be converted to scientific notation if the proper number of significant figures cannot be displayed because the number is too small. For example, the number 0.00000000000002345 cannot be displayed with 4 significant figures because a maximum of 14 digits can be displayed (in this case, the last 3 digits would be dropped). The answer would display in scientific notation as 2.345E-13.

The answer will also be converted to scientific notation if the number is too large or too small to be displayed in conventional notation.
For example, 0.000000000000000012 would not fit in the display and would be shown as 1.2E-18. Similarly, the number 1,234,000,000,000,000,000 would be displayed as 1.234E+18.

The answer will also be converted to scientific notation if, because of the decimal setting, all digits in the answer would appear as zeroes. For example, 0.0005 with a decimal setting of 3 would appear as 0.000, so the number will be displayed in scientific notation as 5E-4.

SAVING A RECORD OF YOUR CONVERSIONS (Journal Recording)



Conversions can be recorded in the built-in Journal, complete with the original value, converted value, and unit symbols (symbols are recorded instead of full names for reasons of space). When the "Journal Recording" button is checked, all conversions performed will be recorded. These conversions can then be cut or copied by the traditional Macintosh techniques of command-X or command-C, or otherwise export the currently selected conversion lines to a new or existing text file by selecting "Export..." from the "Journal" menu.

When a conversion table is generated (see 'Creating Conversion Tables' help section), it is saved to a new text file. All conversions in the table will also be saved to the Journal if journal recording is on.

ADDING AND DELETING MEASUREMENT UNITS FROM THE DATABASE

New measurement units can be easily added to the database by selecting “Add New Unit...” from the “ConvertUnits” menu. Then enter the new unit's name, symbol (if desired), and conversion factor based on the number of 'base' units of that mode. The 'base' unit will be displayed in the window. If you do not know the factor for the new unit in relation to the 'base' unit, then a simple conversion using (you guessed it) this program will be in order. The new unit will be added to the list of units currently displayed in the original units list, right after the last unit that was

selected in this list. Units that have been added by the user will be identified by a label under the value boxes saying "**user-defined unit**".

In order to delete a unit, it must first be selected in the original units list, then the "Remove Unit" menu item must be selected from the "ConvertUnits" menu. You will be given a chance to change your mind, because after this point the deletion is undo-able.

If desired for database security purposes, a password can be installed so that only those with the password can gain access to the “Add New Unit...” and “Remove Unit” menu items. The password can be removed at any time by selecting "Remove Password" from the menu and entering the current password. Passwords are not case-sensitive, so if a password is entered as "DataMan", the program will also accept "dataman" as the valid password.

THE USER CONVERSION LIST

Up to 30 sets of often-used conversion unit pairs can be saved under the “User Conversions” menu for instant access without having to navigate through the database hierarchy each time the conversion settings need to be changed. Conversion pairs can only be added when the “Settings” window is active, and the currently selected measurement units are added to the menu as a conversion pair when the “Add conversion pair” menu item is selected. The current number format settings are also recorded.

To remove conversion pairs from the menu list, select “Remove conversion” and a new window with a selectable list of conversion pairs will appear. Select the line to be removed and click “Remove”. Click “OK” when you have finished removing conversion pairs. Note that only one conversion pair can be removed with each click of the “Remove” button. Removal of a conversion pair from the list does NOT remove the measurement units from the main database, but only removes the "shortcut" to set up that particular conversion pair.

CREATING CONVERSION TABLES

Conversion tables can only be created when the “Settings” window is active. The currently selected measurement units will be used for the conversion table when the “Create Conversion Table” menu item is selected from the “ConvertUnits” menu. If a value exists in the original value box of the “Units” view, this value will appear automatically as the starting value in the

Conversion Table dialog box. Enter a value for the interval desired between conversions (this can be a whole number or a decimal value) and finally enter the final value desired and click “OK”.

Unfortunately, compound units are not currently supported in this feature. An alternative (and more laborious method) of creating conversion tables is by performing all the desired conversions individually with Journal Recording on, then opening the Journal and exporting the desired conversions to another text file. This method is ideal if you desire conversion tables containing compound units or if the intervals between conversions are not uniform.

SOME REMARKS FROM PAST REVIEWERS

(based on the original ConvertUnits™)

> “The program has a remarkably complete set of units, just about everything in the big CRC handbook (including furlongs and fortnights).” “All told, ConvertUnits is scientifically complete and accurate. I haven't seen a better unit-conversion program for the Mac...”

Jerry Pournelle, BYTE MAGAZINE

"I once had to change an R-value to its metric equivalent. I spent an entire day looking at conversion tables and I don't think I got the right answer, anyway. I performed the same conversion with ConvertUnits in less than a minute. Saved 7 hours, 59 minutes. You can do some amazing unit conversions with this program." "…a desk accessory that is more fun than Crystal Quest…"

Craig Savage, MACINTOSH CONSTRUCTION FORUM

"It is a very handy utility if you are in design, engineering, business, research, education, school, or even if you have curious seven year olds who just have to know."

"All in all, it is a very impressive program, professionally done and extremely useful to
the right people."

THE COMPUTER PAPER

APPENDIX 1 - LIST OF MODES

The following is a list of the Modes contained in the database, followed by the "base unit", used for calculating the conversion factors. This fact is not important to you, but might be handy to know for identifying the correct mode to use. The last item is the Category where it can be found.

MODES	BASE UNIT	CATEGORY
Acceleration (angular)	radian/second squared	Mechanics
Acceleration (linear)	meter/second squared	Mechanics
Area	square meter	Basics
Astronomy -Areas	square meter	Whimsy
Astronomy -Distances	meter	Whimsy
Astronomy -Gravity	1/meters per second squared	Whimsy
Astronomy -Volumes	cubic meter	Whimsy
Atomic Lengths	meter	Mechanics
Calorific Value by Mass	joule/gram	Heat
Calorific Value by Volume	joule/liter	Heat
Capacitance	farad	Electricity
Charge	coulomb	Electricity
Computer Capacity	byte	Electricity
Conductance & Admittance	siemen	Electricity
Cost/Unit Area	cost/square meter	Unit Costs and Quantities

Cost/Unit Length	cost/meter	Unit Costs and Quantities
Cost/Unit Mass	cost/kilogram	Unit Costs and Quantities
Cost/Unit Volume	cost/liter	Unit Costs and Quantities
Coverage	square meter/liter	Unit Costs and Quantities
Current	ampere	Electricity
Current Density	ampere/square meter	Electricity
Density & Concentration	kilogram/cubic meter	Mechanics
Diffusivity	square centimeter/day	Mechanics
Dynamic Viscosity	pascal second	Mechanics
Elapsed Time	second, mean solar	Basics, Time
Electrical Energy	watt second	Electricity
Field Strength	volt/meter	Electricity
Force	newton	Mechanics

Force/Unit Length	newton/meter	Mechanics
Frequency	hertz	Mechanics
Fuel Consumption, Automotive	kilometer/liter	Basics
Geography -Areas	square meter	Whimsy
Geography -Length & Distance	meter	Whimsy
Heat Capacity & Entropy	joule/°Celsius	Heat
Heat Density	joule/square meter	Heat
Heat Flow Rate	joule/second	Heat
Heat Flux Density & Irradiance	watt/square meter	Heat
Heat Quantity & Thermal Energy	joule	Heat
Heat Transfer Coefficient (U)	watt/square meter °Celsius	Heat
Illumination (Surface Flux Dens)	lux	Light and Radiation
Impedance & Resistance	ohm	Electricity
Inductance	henry	Electricity
K Value	watt/meter °C	Heat
Kinematic Viscosity	meter squared/.second	Mechanics
Length & Distance	meter	Basics
Luminance (Surface Brightness)	candela/square meter	Light and Radiation
Luminous Energy	lumberg	Light and Radiation
Luminous Flux	lumen	Light and Radiation
Luminous Intensity	candle (Int'l)	Light and Radiation
Magnetic Flux	weber	Electricity
Magnetic Flux Density	tesla	Electricity
Magnetic Moment	hertz/tesla	Electricity
Magnetizing Force	ampere-turn/meter	Electricity
Magnetomotive Force	ampere-turn	Electricity
Mass & Standard Weight	kilogram	Basics, Mechanics
Mass Flow Rate	kilogram/minute	Mechanics
Mass Resistivity	ohm gram/square meter	Mechanics
Mass-Energy Equivalents	kilogram	Heat, Mechanics
Mass/Unit Area	kilogram/square meter	Mechanics
Mass/Unit Length	kilogram/meter	Mechanics
Moment of Force & Torque	kilonewton meter	Mechanics
Moment of Inertia	kilogram square meter	Mechanics
Momentum (angular)	kilogram square meter/second	Mechanics
Momentum (linear)	kilogram meter/second	Mechanics
Plane Angles	radian	Mechanics
Potential	volt	Electricity
Power	watt (joule/second)	Electricity

Power Density.....watt/square meter.....Electricity
Pressure & Stress.....kilopascal.....Mechanics
Quantity/Unit Area.....quantity/square meter..Unit Costs and Quantities
R Value.....RSI.....Heat
Rotatory Power.....radian/centimeter.....Mechanics
Second Moment of Area.....centimeter to fourth power Mechanics
Section Modulus.....centimeter to third power Mechanics
Solid Angles.....square degree.....Mechanics
Specific Energy.....joule/gram.....Heat
Specific Heat Capacity by Mass.....joule/kilogram °Celsius .....Heat

Specific Heat Capacity by Volume.....kilojoule/cubic meter °Celsius.....Heat
Specific Volume.....cubic meter/kilogram...Mechanics
Speed.....meter/second.....Mechanics
Surface Tension.....dyne/centimeter.....Mechanics
Temperature.....kelvin unit.....Basics, Heat
Temperature Differential....kelvin unit.....Heat
Thermal Conductance.....watt/square meter °Celsius Heat
Thermal Conductivity (K)....watt/meter °Celsius.....Heat
Thermal Resistance (R).....RSI.....Heat
Thermal Resistivity.....meter °Celsius/watt.....Heat
Thermal Transmittance.....watt/sq. meter °Celsius Heat
U Value.....watt/sq. meter °Celsius Heat
Velocity (angular).....adian/second.....Mechanics
Velocity (linear).....meter/second.....Mechanics
Volume & Capacity.....liter.....Basics
Volume.....cubic meter.....Basics
Volume Resistivity.....ohm meter.....Mechanics
Volumetric Flow Rate.....liter/second.....Mechanics
Weight.....kilogram.....Basics
Work & Mechanical Energy.joule.....Heat, Mechanics
World Time.....Int'l Date Line.....Time

APPENDIX 2 - LIST OF PHYSICAL CONSTANTS

LIGHT & RADIATION CATEGORY
Compton neutron wave lengths Atomic Lengths
Compton proton wave lengths Atomic Lengths
Compton electron wave lengths Atomic Lengths
Classical electron radii.....Atomic Lengths

MECHANICS CATEGORY
Standard gravities (free fall)...Acceleration (linear)
Water, pure (m3).....Mass and Standard Weight
Water, pure (US liq gal).....Mass and Standard Weight
Water, pure (Imp gal).....Mass and Standard Weight
Atomic mass units.....Mass-Energy Equivalents
Electron rest masses.....Mass-Energy Equivalents
Neutron rest masses.....Mass-Energy Equivalents
Proton rest masses.....Mass-Energy Equivalents

Rydberg constant.....Mass-Energy Equivalents
Kilometres on Earth, average. Plane Angles
Miles on Earth, average.....Plane Angles
Standard atmospheres.....Pressure and Stress
Technical atmospheres.....Pressure and Stress
Speed of light, vacuum.....Velocity (linear)
Sound speed, air, 18° C.....Velocity (linear)
Sound speed, fresh water.....Velocity (linear)
Sound speed, sea water.....Velocity (linear)

Sound speed, Hydrogen, 18° CVelocity (linear)
Sound speed, Nitrogen, 0° C . Velocity (linear)
Sound speed, Oxygen, 0° C ...Velocity (linear)

TIME CATEGORY
Cesium atom vibrations.....Elapsed Time

APPENDIX 3 - A HISTORY OF MEASUREMENT

EARLY CIVILIZATIONS
Early civilizations, quite naturally, chose parts of the human body as standards of linear measurement. These included the digit, the width of a finger; the palm, the width of four fingers;the span, the distance from outstretched thumb to little finger; the cubit, the distance from the elbow to the tip of the middle finger; and the fathom, the distance of outstretched arms.

STANDARDIZATION
Standardization of linear measurement was formalized in Babylon and Egypt before 2000 B.C. Egypt used the Royal cubit, equivalent to 7 palms or 28 digits. The foot came from northern India, and was used by the Romans, who divided it into 12 "nails"-"uncia" in latin, hence "inch".

In Anglo-Saxon England, farming produced the distance an oxen team could plow before resting, a "furrow long", or furlong, of 660 modern feet. Farmers drove their teams with an "ox-goad"-a stick of 15 northern feet or 16 1/2 modern feet long. An area one furlong long by an ox-goad width was a rood, and four roods were an acre.

Measures were standardized in medieval England in 1305 by a statute of Edward I, with three grains of barley making an inch, twelve inches a foot, three feet an ulne (now the yard) five and a half ulne a rod, and forty rods by four rods an acre. In 1497 Henry VII had a one yard length of bronze divided into feety and inches-about 4/100's of an inch shorter than the modern yard.

In 1588 a law decreed by Elizabeth I established a yard which was about 1/100th of an inch short of the modern yard, and the mile as eight furlongs (8 x 660 = 5280 feet). In 1624 Edmund Gunter invented the chain of 22 yards-with 10 cjains equal to a furlong and an area of 10 chains an acre. The chain is still used in modern surveying.

THE IMPERIAL SYSTEM

In 1824 an English statute legalized measurement standards, which became known as "Imperial" standards. The result of the legislation was a legalized hodgepodge-a conglomeration of traditional units.

Physical standards were adopted-in 1855 a yard was set as the distance between two gold studs in a gunmetal bar at 62° Farenheit. Today we can measure a yard as 1,420,213.28 wavelengths of cadmium red light.

Most English speaking countries adopted the Imperial system, but often with variations. In the United States, the Imperial system is still used for most measurement. However, there are some notable differences between the U.S. system and the original Imperial system, primarily in volume and capacity measurements, and units derived from them.

APPENDIX 4 - METRIC SYSTEMS

ORIGIN OF THE METRIC SYSTEM

The metric system was developed in France about 200 years ago to bring some order to the chaotic measurement system used at the time. In 1875, the "Treaty of the Metre" was signed in Paris by a number of countries, including the United States. Originally, the basic unit was the length equal to one ten millionth of the distance from the Equator to the North Pole, named the metre (also spelled meter). In 1889 a standard bar of platinum and iridium alloy was made with graduations marked on its length to define a meter at 0° centigrade. Today we can measure a meter as 1,553,164.12 wavelengths of cadmium red light. Over the years, units were added to the metric system until there was a need to establish a version of the metric system which could be an international standard.

THE INTERNATIONAL SYSTEM (SI)

The new system established in 1960 is known as the International System of Units, commonly referred to as SI, which is derived form its French name, Le Systeme International d'Unites.

Countries which have adopted SI as their official system include England and most other European countries, Canada, Australia, New Zealand, China, Japan, and India, to name a few.

METRIC AND SI IN THE UNITED STATES

In 1866, Congress passed an act authorizing the metric system as a legal measurement system. The metric system was first used by the U.S. government in the first survey of the east coast. (In fact, the meter was the first unit of measurement ever officially used by the U.S. government!) It has been used since then mainly in scientific and technical applications. In 1957 the U.S. Army issued a regulation instituting metric standards for its weapons and equipment.

In 1975 Congress passed the "Metric Conversion Act" declaring the International System of Units as the country's basic measurement system, setting up the process for voluntary conversion to SI. Examples of current usage include capacity measurements, such as for some dairy products, liquor, and automobile engine sizes.

An extremely important use for SI measurement in the United States is the export market to the many countries that have adopted SI as their only

official standard of measurement-even the British are using the metric system in commerce.

INTRODUCTION TO SI

The International System of units (SI) is composed of only seven base units and two supplementary units. Standard prefixes are used to express multiples and sub-multiples of the units. The prefixes are all based on powers of ten, so that a great deal of arithmetic only involves shifting the decimal point (unlike our U.S./English system).

All other SI units are derived from mathematical combinations of these nine units below, along with the stanadrd prefixes. Some of the derived units have special names, such as the newton.

SI BASE UNITS, ABBREVIATIONS, AND TYPE OF MEASUREMENT

ampere (A) electric current
candela (cd) luminuous intensity
kelvin (K) thermodynamic temperature
kilogram (kg) mass

meter (m) length
mole (mol) amount of substance
second (s) second

SI SUPPLEMENTARY UNITS
radian (rad) plane angle
steradian (st) solid angle

SI DERIVED UNITS WITH SPECIAL NAMES, WITH ABBREVIATION, TYPE, AND DERIVATION
becquerel (Bq) radioactive activity (=1 disintegration/second)
coulomb (C) electric charge (=1 ampere second)
degree Celsius (°C) temperature (=kelvin unit-273.15)
farad (F) electric capacitance (=1 coulomb/volt)
gray (Gy) radioactive absorption (=1 joule/kilogram)
henry (H) inductance (=1 volt second/ampere)
hertz (Hz) frequency (=1 cycles/second)
joule (J) work, energy, quantity of heat (=1 newton metre)
lumen (lm) luminuous flux (=1 candela steradian)
lux (lx) illumination (=1 lumen/square metre)
newton (N) force (=1 kilogram metre/second squared)
ohm (Ω) electric resistance (=1 volt/ampere)
pascal (P) pressure, stress (=1 newton/meter squared)
siemens (S) electric conductance (=1/Ω)
tesla (T) magnetic flux density (=1 weber/square metre)
volt (V) electric potential (=1 watt/ampere)
watt (W) power (=1 joule/second)
weber (Wb) magnetic flux (=1 volt second)

SI PREFIXES, ABBREVIATIONS, AND THEIR VALUES
exa (E) = 1 000 000 000 000 000 000 (1 x 10^18)
peta (P) = 1 000 000 000 000 000 (1 x 10^15)
tera (T) = 1 000 000 000 000 (1 x 10^12)
giga (G) = 1 000 000 000 (1 x 10^9)
mega (M) = 1 000 000 (1 x 10^6)
kilo (k) = 1 000 (1 x 10^3)
hecto (h) = 100 (1 x 10^2)
deka (da) = 10 (1 x 10^1)

deci (d) = 0.1 (1 x 10^-1)
centi (c) = 0.01 (1 x 10^-2)

milli (m) = 0.001 (1 x 10^-3)
micro (d) = 0.000 001 (1 x 10^-6)
nano (µ) = 0.000 000 001 (1 x 10^-9)
pico (p) = 0.000 000 000 001 (1 x 10^-12)
femto (f) = 0.000 000 000 000 001 (1 x 10^-15)
atto (a) = 0.000 000 000 000 000 001 (1 x 10^-18)

APPENDIX 5 - MASS AND STANDARD WEIGHT

INTRODUCTION

ConvertUnits Pro™ has units of mass and standard weight listed together, even though the concepts of mass and weight are fundamentally different. In many common conversion problems, units of mass in the metric system, such as the kilogram, are normally related to units of weight (or force) in the U.S./English systems, such as the pound.

This works well as long as conversions between these units relate only to objects at rest at or near the Earth's surface.

WEIGHT OR MASS?

Weight is the measure of force acting on an object due to gravitational forces exerted by the Earth or other celestial body. Mass is the measure of a quantity of matter in an object, or put another way, the measure of an object's resistance to acceleration. Many people use the term weight when they mean mass.

STANDARD WEIGHT

The weight of an object varies in direct proportion with any variation of the force of gravity. The standard weight of an object is the weight it would have if it was at rest at a a point on the Earth's surface where 'g' has the standard value of 9.80665 meters per second per second. (The actual value of 'g' varies slightly depending on latitude and altitude, but for general purposes the average, or standard, value of 9.80665 m/s2 is generally accepted and is the value used in ConvertUnits Pro.

Knowing the standard weight, location, and acceleration (if any) of an object, its mass can be directly computed. In the U.S./English systems, an object with a standard weight of 32 pounds at rest at or near the Earth's surface has a mass of about one 'slug'.

For strict scientific uses involving objects being accelerated, conversions between units of mass and standard weight should be avoided. In these instances, the object's weight, if needed, would have to be calculated by other means, taking into account the gravitational force or forces acting on the object wherever it happens to be.

VERSIONS AND VARIATIONS OF THE OUNCE, POUND, AND TON

In the U.S./English system of weight measures, there are two versions of the pound and two versions of the ounce (avoirdupois, and troy or apothecary) and several versions of the ton (short, long, and assay). The terms ounce

and ton are also used for units of volume (such as fluid ounces and freight tons) adding to the general confusion.

The avoirdupois pound was introduced in England by Edward I in order to reduce the confusion of two similarly sized pounds in general use at the time. Its name comes from a French word meaning "goods and weight", and was meant to be used primarily in commerce. It contained 16 ounces, and was traditionally used to weigh groceries, base metals, wool, tallow, hemp, drugs, bread, and other basic commodities. The avoirdupois pound and ounce are the ones in common usage in the U.S. today.

Troy weight, with 12 ounces to the pound, were (and still are) used to measure jewels as well as gold, silver, and other precious metals. The assay ton is normally considered a unit of troy weight. Apothecary weights are traditionally used for pharmaceuticals. Apothecary grains, ounces, and pounds are identical in size to their troy counterparts.

The two common variations of the ton are both based on avoirdupois pounds: the short ton, containing 2000 pounds, and the long ton, with 2240 pounds. It is believed the two versions originated when merchants wanted to give their customers the impression they were getting more for their money by selling goods by the short ton after having bought their raw materials in long ton measure.

APPENDIX 6 - UNITS OF ELAPSED TIME

ELAPSED TIME

Many systems of time measurement have been established for different purposes, and the most common ones have been included in the Elapsed Time mode in the Time Category.

SIDERIAL TIME

Sidereal time is determined by measuring the relative position of the sun against the celestial "backdrop" of the universe, and is used mainly in astronomy.

MEAN SOLAR TIME

The fundamental unit of time in the SI system is the second, defined by the International Committee of Weights and Measures in 1964 as 9,192,631,770 oscillations of the Cesium-133 atom. The SI second has been defined to be equivalent to the mean solar in duration (at least to the limits of verifiable measurement).

TROPICAL YEAR

A complete revolution of the Earth around the Sun actually consists of about 365.25 days. This value is not consistant due to many complex forces acting on the Earth, so it was necessary, for scientific purposes, to pick a "standard" year to use as a benchmark. The year chosen was A.D. 1900, and is officially known as the tropical year. In ConvertUnits Pro™, elapsed time units greater than one year, such as decades and centuries, are based on the tropical year.

APPENDIX 7 - VOLUME AND CAPACITY

The database lists dry and liquid units of volume together to allow conversion between, for example, cubic meters to liters, or cubic feet to liquid gallons. Some conversion pairs whcih are possible seem nonsensical, such as conversions from teaspoons to cords of wood, but are mathematically valid. We leave this to your discretion.

U.S. SYSTEM

The U.S. system has some units which are different in size depending on whether dry or liquid material is being measured. Where dry and liquid units of volume have the same name but are different size, they are displayed as "Gallons (U.S. liq)" or "Gallons (U.S. dry)".

THE IMPERIAL SYSTEM

The Imperial system makes no distinction between dry and liquid units of volume. Thus the database does not identify any Imperial units as being dry or liquid.

THE METRIC SYSTEM

The Metric system uses the cubic meter as the official unit of volume for both dry and liquid measure, although the liter is more commonly used for liquid measurements. (One liter equals one cubic decimeter - one thousandth of a cubic meter).

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