

METRIC HANDOUT

METRIC!

EAPS 100 (for reference purposes)

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I. Why Metric?

- A. The metric system is much easier. All metric units are related by factors of 10.
- B. Nearly the entire world (>95%), except the United States, now uses the metric system. U.S. economic competitiveness would be strengthened by converting to the metric system. See more and map of the world showing non-metric countries at: http://en.wikipedia.org/wiki/Metric_system.
- C. Metric is used exclusively in science -- therefore, understanding of scientific and technical issues by non-scientists will be enhanced if the metric system is universally adopted.
- D. Because the metric system uses units related by factors of ten and the types of units (distance, area, volume, mass) are simply-related, performing calculations with the metric system is much easier — thus facilitating quantitative analysis and understanding in science. **That is, mathematical manipulations using the metric system are easier which leads to fewer mistakes and less confusion and increases the chance that scientific principles and concepts can be understood!**

II. Comparison of simple conversion operations in the English (customary) and Metric systems - Notice the unusual numbers relating the various units in the English system and the simplicity of the powers of ten in Metric. (An English-Metric conversion table is contained in the Appendix of Lutgens and Tarbuck, 2014).

ENGLISH SYSTEM

METRIC SYSTEM

1. Units of Distance

12 in = 1 ft
3 ft = 1 yd
1760 yds = 1 mi
5280 ft = 1 mi

10 mm = 1 cm
100 cm = 1 m
1000m = 1 km
(basic units are m or km)

(English-Metric conversions: 1 inch = 2.54 cm; 1 mile = 1.61 km)

2. Units of Area

144 in² = 1 ft²
43,560 ft² = 1 acre
640 acres = 1 mi²

10,000 cm² = 1 m²
10,000 m² = 1 hectare
100 hectare = 1 km²
(basic units are m² or km²)

(English-Metric conversions: 1 in² = 6.45 cm²; 1 mi² = 2.59 km²)

3. Units of Volume

57.75 in³ = 1 qt
4 qt = 1 gal
42 gal (petroleum) = 1 barrel
32 qt = 1 bushel

1 cm³ = 1 ml
1000 ml = 1 liter
1000 liter = 1 m³

(basic units are liters or m³)

(English-Metric conversions: 16.39 cm³ = 1 in³; 3.79 liters = 1 gal)

4. Units of Mass

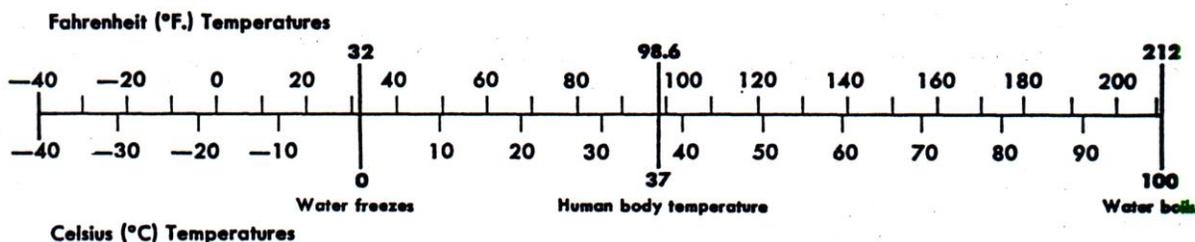
437.5 grains = 1 oz
 16 oz = 1 lb
 2000 lb = 1 short ton

1000 mg = 1 g
 1000 g = 1 kg
 1000 kg = 1 metric ton
(basic units are g or kg)

(English-Metric conversions: 453 g = 1 lb; 2.2 lb = 1 kg)

(Mass-volume conversions for water, or material of equal density, are also easy because 1 kg of water = 1 liter = 1/1000 m³ and 1 g of water = 1 cm³)

5. Units of Temperature



Fahrenheit-Celsius-Kelvin conversions:

$$T(^{\circ}\text{C}) = [T(^{\circ}\text{F}) - 32] \times 5/9$$

$$T(^{\circ}\text{F}) = T(^{\circ}\text{C}) \times 9/5 + 32$$

$$T(\text{K}) = T(^{\circ}\text{C}) + 273$$

(basic units are Kelvin or degrees Celsius/Centigrade)

Convenient Equivalences to Help in Remembering Celsius Scale

<u>T(°F)</u>	<u>T(°C)</u>	<u>Conditions</u>
-459	-273	Zero Kelvin (absolute zero)
-40	-40	extremely cold
0	-17	
32	0	water freezes
68	20	room temperature
82	28	warm day
98.6	37	body temperature
104	40	hot day
212	100	water boils

Extensive reference information on units of measurements and conversion factors are contained in the following references:

Jerrard, H.G., and D.B. McNeill, A Dictionary of Scientific Units: Including Dimensionless Numbers and Scales, 6th ed., Chapman and Hall, New York, 255 p., 1992.

Pennycuik, C.J., Conversion Factors, Univ. of Chicago Press, 47 p., 1988.

Weast, R.C. (ed.), Handbook of Chemistry and Physics, CRC Press, Cleveland, OH, 1974.

Web sites: http://en.wikipedia.org/wiki/Metric_system

<http://lamar.colostate.edu/~hillger/> www.metric.org

<http://www.metric-conversions.org/conversion-calculators.htm>

<http://www.sciencemadesimple.com/conversions.html>

Standard Metric Units

While many metric units are used for aerospace research, some are used with great frequency. These are the units for mass, length, temperature, and time. Other units commonly used are derived units—those based upon one or more base units. Included in this category are the units of volume and force.

When the metric system was developed in France in the late 18th century, the base unit for length, were taken from nature. The meter, or unit of length was defined to be one ten-millionth the distance from the equator to the North Pole along the meridian nearest Paris. Accurate measurement of this distance was difficult and, by chance, the resulting unit was very close to the English yard. The liter, a volume measurement equaling one cubic decimeter or 0.001 cubic meter, came very close to the English quart.

In 1960 the General Conference on Weights and Measures adopted the *Le Système International d'Unités* (International System of Units or SI). The modernized units proposed and periodically revised by SI are still based upon natural standards, but these standards are ones that can be measured with greater precision than the arc distance from the equator to the North Pole.

Common Metric System Units

(International System of Units—SI)

meter (m): Unit of length equal to 1 650 763.73 wavelengths in a vacuum of the orange-red line of the spectrum of krypton-86.

gram (g): Unit of mass based upon the mass of one cubic centimeter of water at the temperature of its maximum density.

liter (l): Unit of volume equal to one cubic decimeter.

kelvin (K): Unit of temperature equal to 1/273.15 of the thermodynamic temperature of the triple point of water. The temperature of 0 kelvins is absolute zero. Degrees Celsius is commonly used as a metric unit of temperature. On the Celsius scale, 0 degrees is the freezing point of water and 100 degrees is the boiling point.

newton (N): Unit of force or thrust needed to accelerate a 1 kilogram mass one meter per second squared.

Special Units for Astronomical Studies

astronomical unit (AU): The mean distance from the Earth to the Sun—approximately $1.495\,979 \times 10^{11}$ meters.

light year (ly): The distance light travels in one year's time—approximately $9.460\,55 \times 10^{15}$ meters.

parsec (pa): The parallax shift of one second of arc (3.26 light years)—approximately $3.085\,768 \times 10^{16}$ meters.

speed of light (c): $2.997\,9 \times 10^8$ meters per second.

SI Unit Prefixes†

Multiplication Factor	Prefix	Symbol	Pronunciation (USA)*	Term (USA)	Term (Other Countries)
$1\,000\,000\,000\,000\,000\,000 = 10^{18}$	exa	E	ex'a (a as in about)	one quintillion	one trillion
$1\,000\,000\,000\,000\,000 = 10^{15}$	peta	P	as in <i>petal</i>	one quadrillion	one thousand billion
$1\,000\,000\,000\,000 = 10^{12}$	tera	T	as in <i>terrace</i>	one trillion	one billion
$1\,000\,000\,000 = 10^9$	giga	G	jig'a (a as in about)	one billion	one million
$1\,000\,000 = 10^6$	mega	M	as in <i>megaphone</i>	one million	
$1\,000 = 10^3$	kilo	k	as in <i>kilowatt</i>	one thousand	
$100 = 10^2$	hecto	h	heck'toe	one hundred	
$10 = 10^1$	deka	da	deck'a (a as in about)	ten	
$0.1 = 10^{-1}$	deci	d	as in <i>decimal</i>	one tenth	
$0.01 = 10^{-2}$	centi	c	as in <i>sentiment</i>	one hundredth	
$0.001 = 10^{-3}$	milli	m	as in <i>military</i>	one thousandth	
$0.000\,001 = 10^{-6}$	micro	μ	as in <i>microphone</i>	one millionth	
$0.000\,000\,001 = 10^{-9}$	nano	n	nan'oh (an as in <i>ant</i>)	one billionth	one millardth
$0.000\,000\,000\,001 = 10^{-12}$	pico	p	peek'oh	one trillionth	one billionth
$0.000\,000\,000\,000\,001 = 10^{-15}$	femto	f	fem'toe (fem as in <i>feminine</i>)	one quadrillionth	one thousand billionth
$0.000\,000\,000\,000\,000\,001 = 10^{-18}$	atto	a	as in <i>anatomy</i>	one quintillionth	one trillionth

* The first syllable of every prefix is accented to assure that the prefix will retain its identity. Therefore, the preferred pronunciation of kilometer places the accent on the first syllable, not the second.

† Source: Metric Guide for Educational Materials

Metric/English Conversion Table (Common Units of Space Research)

	<i>Multiply</i>	<i>By</i>	<i>To Obtain</i>
Length:	inches	2.54	centimeters
	centimeters	0.393 7	inches
	feet	0.304 8	meters
	meters	3.281	feet
	statute miles	1.609 3	kilometers
	kilometers	0.621 4	statute miles
	kilometers	0.54	nautical miles
	nautical miles	1.852	kilometers
	kilometers	3 281	feet
Weight and Mass	feet	0.000 304 8	kilometers
	ounces	28.350	grams
	grams	0.035 3	ounces
	pounds	0.453 6	kilograms
	kilograms	2.205	pounds
	tons	0.907 2	metric tons
Liquid Measure	metric tons	1.102	tons
	fluid ounces	0.029 6	liters
	gallons	3.785 4	liters
	liters	0.264 2	gallons
	liters	33.814 0	fluid ounces
Temperature	degrees Fahrenheit plus 459.67	0.555 5	kelvins
	degrees Celsius plus 273.15	1.0	kelvins
	kelvins	1.80	degrees Fahrenheit minus 459.67
	kelvins	1.0	degrees Celsius minus 273.15
	degrees Fahrenheit minus 32	0.555 5	degrees Celsius
	degrees Celsius	1.80	degrees Fahrenheit plus 32
Thrust (Force) Pressure	pounds force	4.448	newtons
	newtons	0.225	pounds
	millimeters mercury	133.32	pascals (newtons per square meter)
	pounds per square inch	6.895	kilopascals (1000 pascals)
	pascals	0.007 5	millimeters mercury at 0° C
	kilopascals	0.145 0	pounds per square inch