

# Proposal for the Universal Unit System

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## Abstract

The Universal Unit System based on the combination of fundamental physical constants and the GCD Unit System for calendar time based on the combination of the rotation and revolution of the Earth are proposed.<sup>2</sup> The former is pure duodecimal, and the latter is 2:10;(2:12.) mixed-radix. The Universal Unit System with the GCD Unit can be constructed. The Earth local extension has been newly designed and introduced for local use on Earth.

## 1. The Universal Unit System

### 1.1. Before the Universal Unit System

A unit of measure is “a quantity that is used as the basis for expressing a given quantity and is of the same type as the quantity that is to be expressed”. A unit that is used in exchanges between people must be guaranteed to have a constant magnitude within the scope of that exchange. Quantities that can, by consensus, serve as common standards over a broad scope were sought and selected to serve as units. The ultimate example of such a quantity is an entity common to all of humankind, the Earth itself, which was selected as the foundation for the metric system.

### 1.2. The next stage?

Of course, we can consider going beyond the framework of the Earth and defining units with concepts for which agreement can be reached within a broader scope. The quantities that then become available to serve as the standards for defining units include the quantities of the fundamental physical constants, quantities such as the speed of light in vacuum ( $c_0$ ), the quantum of action ( $\hbar$ ), the Boltzmann constant ( $k_B$ ), and so on. These quantities are believed to have values that

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<sup>1</sup> In this paper, SI units are combined only with the decimal figures (indicated by a period “.” as the radix point), and units of the Universal Unit Systems are combined only with duodecimal figures (indicated by a semicolon “;” as the radix point. ‘X’ expresses ten and ‘E’ expresses eleven). Both notations may use a comma “,” and “\_” as the digit group separator. Non-dimensional quantities are mostly expressed using all figures in duodecimal first, with the decimal given parenthetically.

<sup>2</sup> This paper revises the paper currently retrievable at <http://dozenal.com>. See also footnote 21. The first Japanese version was released May 1194;(1984.)

remain constant everywhere in the universe. When trying to construct a coherent unit system, however, it is not possible to use all of the fundamental physical constants in the definitions of units. Therefore, would not we expect the fundamental physical constants that were not used in defining units to have fractional magnitudes of unit quantities of the same dimension?

For example, the Rydberg constant ( $R_\infty$ ) is 115,3789;470305/ft (10973731.568539/m)<sup>3</sup> and the Bohr radius ( $a_B$ ) is 0;X8EE6E525 × 10;<sup>-9</sup>ft (5.2917721092 × 10.<sup>-11</sup> m). Therefore, the relation between these two constants is:

DOZENAL	DECIMAL	
$R_\infty^{-1} = \text{EE6;06603 } a_B$	$R_\infty^{-1} = 1,722.04515 a_B$	(1)

If one of these two constants is chosen as a unit quantity, the other constant cannot be expressed as a unit quantity.

By surprising coincidences<sup>4</sup> described in Appendix E and §2.1 of <http://dozenal.com>, however, if the duodecimal number system is used to express the speed of light in vacuum and the quantum of action as the defining constants such that these constants are strictly multiples of integer powers of twelve of the unit quantities, it is possible to construct a coherent unit system in which not only the constant that was used in the definition but also the Rydberg constant, the Bohr radius, the unified atomic mass unit ( $u$ ), and half the value of the Planck length ( $l_p/2 = (1/2)\sqrt{G\hbar/c_0^3}$ ) can be approximated to about or within an error of 2 per gross (1<sup>1</sup>/<sub>2</sub>%) by a multiple of integer powers of twelve of the unit quantities.

In that case, many other physical constants, including the charge and mass of an electron, the fine structure constant, the molar volume of an ideal gas under standard conditions, the black-body radiation at the ice point, the density and surface tension of water, and others, can be approximated by multiples of integer powers of twelve of the unit quantities. Moreover, by adding the Boltzmann constant and using it in the definition of thermodynamic temperature, the gas constant of an ideal gas can be approximated by a multiple of an integer power of twelve of the unit quantity and the Stefan-Boltzmann constant, and the specific heat of water can be approximated by multiples of integer powers of twelve of the unit quantities with a factor 2 remaining. These conclusions are shown in Table 4.<sup>5</sup>

**For putting these coincidences to use, the duodecimal number system is the only choice.**

It seems that the combination of fundamental physical constants “forces” us to use base twelve.

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<sup>3</sup> In this paper, plane angle phase factor  $2\pi$  is often treated as a non-dimensional parameter and omitted in order to simplify the explanation. See §A.2 and 3.2.2 of the paper <http://dozenal.com>.

<sup>4</sup> To prevent any misunderstanding, let me emphasize that **these are simply coincidences as far as physical science is concerned**.

<sup>5</sup> A more detailed table is retrievable at <http://www.asahi-net.or.jp/~dd6t-sg/univunit-e/condensed.xls>.

We define the Universal Unit System as “the unit system that is constructed by using the duodecimal number system and the speed of light in vacuum, the quantum of action, and the Boltzmann constant as the defining constants in such a way that these constants become strict multiples of integer powers of twelve of the unit quantities, and the Rydberg constant, the unified atomic mass unit, the Bohr radius, and half the value of the Planck length can be approximated by multiples of integer powers of twelve of the unit quantities”.

### 1.3. Variation of the Universal Unit Systems

To define three units for time, length, and mass, the Universal Unit System uses the speed of light in vacuum and the quantum of action. Another constant is necessary to define these three units. Therefore, the Universal Unit System has some variations in the constant that the system chooses as the last definition constant.

Universal Unit System with constant  $A$  is the Universal Unit System that uses constant  $A$  as the last definition constant and whose unit quantity of the last dimension is equal to constant  $A$  or its multiples of integer powers of twelve. In particular, the Universal Unit System with the Rydberg constant whose length unit is  $10;^6 / R_\infty$  ( $12.^6 / R_\infty$ ) and velocity unit is  $10;^{-8} c_0$  ( $12.^{-8} c_0$ ) is called the Universal System of Units Standard<sup>6</sup> corresponding to the International System of Units Standard (SI). We will use a symbol corresponding to the SI unit symbol suffixed with ‘u’ as a new symbol required by the Universal System of Units Standard; ‘u’ is the ‘universal’ system suffix. The noun form is ‘univer’. For example, the length unit is  $m_u$  and is called the ‘universal meter’ or simply the ‘univer’<sup>7</sup>, and the time unit is  $s_u$  and is called the ‘universal second’<sup>8</sup>. **This unit system is comprised of six quartets.** The units of this system are listed in the 5th column of Table 3, and physical, material, and astronomical constants expressed by means of this system are presented in the 3rd column of Table 4. The ratio of the time unit  $s_u$  and the SI second is 0;4824707(0.3902675).

The Universal Unit System with the Bohr radius whose length unit is  $10;^9 a_B$  ( $12.^9 a_B$ ) and velocity unit is  $10;^{-8} c_0$  ( $12.^{-8} c_0$ ) can be defined in the same way. Its time unit is 1;005E857  $s_u$ (0.3916171 s). Roughly speaking, **if a time constant or its multiples of integer powers of twelve falls within the range between 1;  $s_u$  (0.3902675 s) and 1;005E857  $s_u$  (0.3916171 s), we can construct the Universal Unit System using the constant as a time unit.**

<sup>6</sup> The Universal System of Units Standard is strictly defined in §3 of the paper <http://dozenal.com>.

<sup>7</sup> The noun form of the system suffix is considered to be the abbreviation of the length unit like the length unit of the metric system is ‘meter’.

<sup>8</sup> Note that there is no vagueness at all even if the suffix is omitted if the notation of footnote 1 is adopted. Suffixes are necessary to identify plural Universal Unit Systems mutually.  $4 \times 10.^7 m$ ,  $4 \times 10;^7 m_u$ , and the Earth’s meridian length are nearly equal.  $10.^5 s$ ,  $10;^5 s_u$ , and  $1\frac{1}{8}$  days are nearly equal.

## 2. The GCD Unit System

### 2.1. Basic Concept

The length of the tropical year is 265;2XX6 days (365. days 5 hours 48. minutes 45. seconds in year 1218;(2036.)). For human activities on Earth, year and day cannot be ignored as calendar time units. However, the ratio of year and day is not simple. **Therefore, any calendar time unit system must be a mixed radix system.** The ratio of one tropical year and one day is:

DOZENAL

$$\frac{\text{year}}{\text{day}} = 265; + \frac{27;}{X8;} = 1;003628 \times 264;6 = 1;003628 \times \frac{3^6}{2}$$

DECIMAL

(2)

$$\frac{\text{year}}{\text{day}} = 365. + \frac{31.}{128.} = 1.002036.. \times 364.5 = 1.002036.. \times \frac{3^6}{2}$$

Because one year consists of twelve months, it is reasonable to adopt twelve as one of the radices. Though this ratio contains the extra factor 3 six times,<sup>9</sup> by multiplying by factor  $2^6$  ( $= 8 \times 8$ ) twice, we can cancel factor 3 and obtain powers of twelve ( $= 3 \times 2 \times 2$ ):

DOZENAL

$$\frac{2^6 \text{ year}}{2^{-6} \text{ half-day}} = 2^6 \times 1;003628 \times \frac{3^6}{2} \times 2^7 = 1;003628 \times 10;^6$$

DECIMAL

(3)

$$\frac{2^6 \text{ year}}{2^{-6} \text{ half-day}} = 2^6 \times 1.002036.. \times \frac{3^6}{2} \times 2^7 = 1.002036.. \times 12.^6$$

If we define ‘octal century’ as  $2^6$  years, and define ‘clock’ as  $2^{-6}$  of a half-day, the relation between these two units is:

$$\text{octal century} = 1;003628 \times 10;^6 \text{ clocks} \quad (4)$$

There are some interesting coincidences. Also, please see Table 1.

- One clock is the difference between a tropical year and a Julian year.
- One clock is the greatest common divisor (GCD) of the length of a day and a tropical year.
- Two octal centuries are the least common multiple (LCM) of the length of a day and a tropical year, and so leap year rules become simpler than those of the Gregorian calendar.
- The geometric mean of one octal century and one clock is approximately one fortnight.

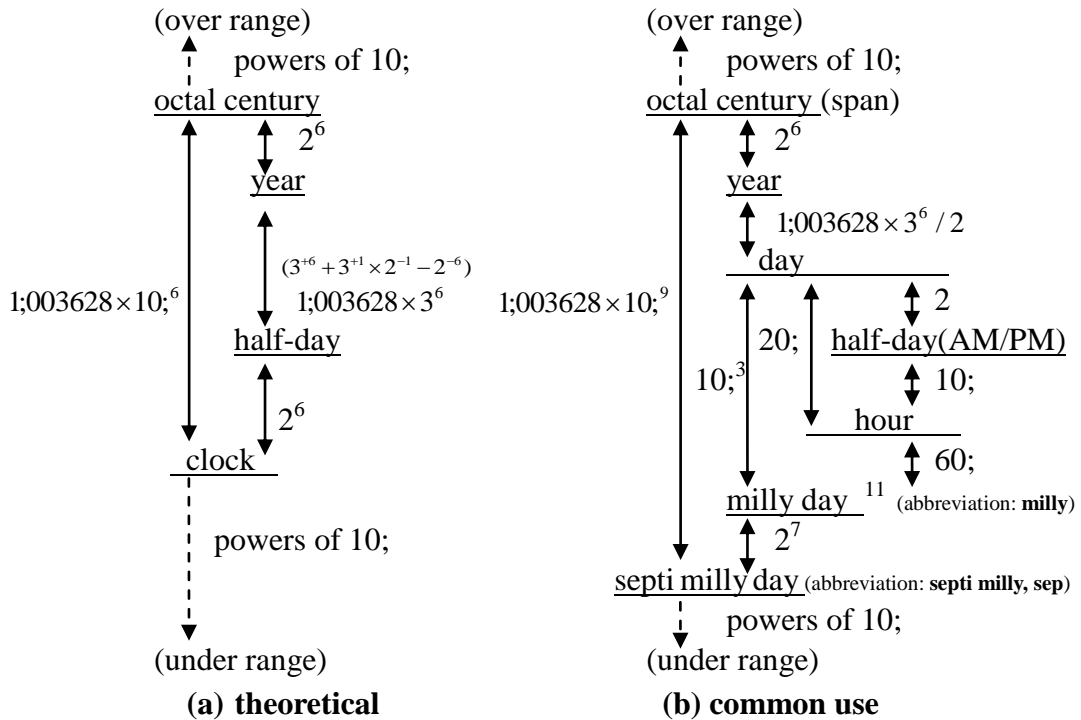
<sup>9</sup> Yang Xiong (45;(53.) BCE–16;(18.)) used the ratio  $3^6/2$  in his Tai Xuan calendar (太玄曆).

See Hideki Kawahara “Chinese Scientific Thought (中国の科学思想)” 11X4;(1996.) [ ISBN: 978-4423194126] and Wikipedia [http://en.wikipedia.org/wiki/Yang\\_Xiong\\_\(author\)](http://en.wikipedia.org/wiki/Yang_Xiong_(author)).

**Table 1 Coincidences of rotation and revolution of Earth and other planets**

Quantity A	Quantity B	Type	Common Quantity
day	Julian year	GCD	1/4 day
		LCM	4 years
	tropical year	GCD	$1/X8;(2^{-7})$ day
		LCM	$X8;(2^7)$ years
year	rotation of Venus	LCM	2 years and -3 rotations
	revolution of Venus		8 years and 11;(13.) revolutions
	revolution of Mars		28;(2 <sup>5</sup> ) years and 15;(17.) revolutions

It seems that the combination of the rotation and revolution of the Earth “forces” us to use base two in the middle of the calendar time range. People have a proclivity for using large units for large quantities and small units for small quantities, so we can cover a wide calendar time range by a duodecimal number system using the hierarchy shown in Figure 1 (a).<sup>10</sup>



**Figure 1 The GCD Unit hierarchy**

We define ‘the GCD Unit’ as “the GCD of the length of a day and a tropical year, or its multiples of integer powers of twelve”, and ‘the GCD Unit System’ as “the 2:10;(2:12.) mixed-radix calendar time system using a day, a tropical year, and the GCD Unit”. To put it simply, **it is very natural to adopt a unit of calendar time that is integer division of both a year and a day.**

<sup>10</sup> A more detailed figure is retrievable at <http://www.asahi-net.or.jp/~dd6t-sg/univunit-e/TimeScale.pdf>.

<sup>11</sup> A milly day is equal to H. C. Churchman's ‘moment’. Please see <http://www.dozenal.org/archive/DuodecimalBulletinIssue112-web.pdf>.

## 2.2. Common use

Calendar time units are the most conservative units. Considering the easiness of the shift from the present 10;50;(12.:60.) mixed-radix system to the future 2:10;(2:12.) mixed-radix system, there are some variations of connection points of the binary number system and duodecimal number system<sup>12</sup>. A variation designed for common use is shown in Figure 1 (b) and Table 7.

$$1 \text{ day} = 10;^3 \text{ milly days} = 10;^3 \times 2^7 \text{ septi milly days} \quad (5)$$

This is a variation that is designed to maximize the range expressed by multiples of integer powers of twelve of a day. This permits ‘half-day(AM/PM)’ and ‘hour’ to be used for clock notations. That is, the following four clock notations are all available. The notation ‘hour’ may fade out.

**Table 2 Clock Notations**

clock notation	format	2:10;(2:12.) system	10;50;(12.:60.) system
10;-hour clock notation	H:MM'SS;ss...(AM/PM)	3:16'28;0 PM	3:15:12.5 PM
20;-hour clock notation	HH: MM'SS;ss...	13:16'28;0	15:15:12.5
1000;-milly clock notation	DMM'SS;ss...	776'28;0	Not used
10;-dour clock notation	MM(to[-]/after[+])D	46; millies to 8 <sup>th</sup> dour	15 minutes after 3 PM

In accordance with the Titius-Bode law, the orbital semi-major axis of planets can be approximated by  $(3 \times 2^N + 4)$  light solar milly days (see also Table 7), where  $N = -\infty, 0, 1, 2, 4, 5, 6$  (Mercury, ..., Uranus). The ratio  $2^7:1$  is the same as the ratio of the U.S. liquid gallon and fl oz. The ratio  $2^7:10;^2$  (8:9) corresponds to the major tone of the just intonation.

## 3. The Universal Unit System with the GCD Unit

The GCD Unit is derived from the combination of the rotation and revolution of the Earth without using the Universal Unit System concept. However, we encounter the final surprising coincidences. 1; septi milly day is equal to a day/(10;<sup>3</sup> × 2<sup>7</sup>). It is equivalent to 1;0016EE1 s<sub>u</sub> (0.3906250 s). Therefore the equivalent value of 1; septi milly day falls within the range between 1; s<sub>u</sub> (0.3902675 s) and 1;005E857 s<sub>u</sub> (0.3916171 s). We can construct the Universal Unit System with the GCD Unit!<sup>13</sup> The Dozenal Society of America seems to recommend ‘dour’(day/10;) and ‘moment’(day/10;<sup>3</sup>). Of course these units are all available, but because the calendar time unit system includes ‘year’ by all means, it does not become a pure duodecimal system even if we choose 1/10;<sup>2</sup> of ‘moment’ as a unit. **We can enjoy all the advantages of Table 4 if we choose not 1/10;<sup>2</sup> but 1/2<sup>7</sup>.**

We will use the suffix ‘e’ for units of the Universal Unit System with the GCD Unit. ‘e’ is the GCD of calendar time units of the ‘earth’ system suffix. The noun form is GCD, too. For example, the time unit is s<sub>e</sub> and is called the ‘GCD second’.

<sup>12</sup> See detailed discussion in <http://z13.invisionfree.com/DozensOnline/index.php?showtopic=371>.

<sup>13</sup> See the sheet ‘Clock’ in <http://www.asahi-net.or.jp/~dd6t-sg/univunit-e/condensed.xls>.

Because of tidal friction, the physical time length of a day is not constant and becomes longer little by little.<sup>14</sup> A length unit can be redefined exactly as  $100,1700;/R_{\infty}$  so that a physical time unit becomes approximately  $1;0016EE1\ s_u$  (0.3906250 s) similar to the redefinition of SI units to provide better stability and reproducibility. The calendar time unit length will strictly correspond to the physical time length of a day about 20; octal centuries (1400. years) later. We call this redefined system ‘the Harmonic Universal Unit System with the GCD Unit’, ‘the Harmonic Universal Unit System’, or simply ‘the Harmonic System’ and will use the suffix ‘h’ for units of this system. ‘h’ is for ‘human’ or ‘harmonic universal’ system suffix. The noun form is ‘harmon’. For example, the length unit is  $m_h$  and is called ‘harmonic universal meter’, ‘harmonic meter’, or simply ‘harmon’. The units of this system are listed in the 7th column of Table 3 and physical, material, and astronomical constants expressed by means of this system are presented in the 4th column of Table 4. Please see also Table 5 and Table 6 for details.

The unit quantities and constant expressions with the suffix ‘h’ are almost the same as the quantities with the suffix ‘e’ over six digits. Therefore, if you don’t need the precision of having to distinguish suffix ‘h’ from suffix ‘e’, you should merely indicate that a unit is duodecimal in accordance with footnote 8. For example, in this situation you can call both GCD second and harmonic second as dozenal second. In the future, if the variation of the Universal Unit Systems to use is selected and the notation of footnote 1 is adopted widely, we can omit the unit system suffix of the selected variation. It means that the speed of light in vacuum,  $c_0$ , is expressed as  $1\_0000,0000; m/s$  (299,792,458. m/s).

The approximations shown in Table 4 are remarkable. For putting coincidences described in this paper to use, the duodecimal number system is indispensable. **I hope that the Harmonic Universal Unit System is acceptable for humans on Earth.**

## A. The Earth local extension

The Earth local extension, which consists of one prefix, four units, and three supplementary constants, is designed for local use on Earth. Please see Table 7.

In this scheme, the CGD unit system is treated as part of the Earth local extension. **To distinguish calendar time units from physical time units, the dimension of calendar time units is regarded as plane angle.**<sup>15</sup> However, prefix ‘septi’ can be combined with units other than calendar time units like ‘septi cube’.

<sup>14</sup> See Stephenson, F. R.; Morrison, L. V. (April 11X3;(1995.)) “Long-term fluctuations in the Earth's rotation: 700 BC to AD 1990.” retrievable at <http://adsabs.harvard.edu/abs/1995RSPTA.351..165S> .

<sup>15</sup> See Seaman, Rob (April 11XB;(2003.)) “A Proposal to Upgrade UTC” retrievable at <http://iraf.noao.edu/~seaman/leap/> . It seems that the dimension of the quantity of a day (=calendar time) should be a plane angle rather than physical time. The calendar time is, in a word, the rotation angle of the Earth derived by using the direction of the sun as a coordinate origin.

The newly introduced temperature unit °S (degree S) is designed to meet the relationship that 100; °S corresponds to the boiling point of water (99.9839 °C). The quantity expressed by the unit °S is the difference between thermodynamic temperature and 118,2356; K<sub>h</sub> (approximately -74.36°C). The interval of unit °S is one Super Kelvin (=1,0000; K<sub>h</sub> ÷ 1.210724 K).

The supplementary constant  $g_E$  is used to represent any force quantity as a corresponding mass quantity. The supplementary constants  $s_E$  and  $m_E$  are used to represent any physical time and length quantity as a corresponding plane angle quantity.

## B. Gravitational constant and gravity field equations

The equations of some categories<sup>16</sup> can be used easily if new constants are introduced. At this time, the total solid angle of a sphere<sup>17</sup>,  $\Omega_2$ , and the speed of light in vacuum,  $c_0$ , appear in the equations. This is the reason that the speed of light in vacuum should strictly be multiples of integer powers of the base number of the unit quantities.

**When representing the mass of a celestial body by means of the Universal Unit System, the gravitational radius (half the Schwarzschild radius) is used rather than using mass directly.** Because the accuracy of measuring the Newtonian constant of gravitation is poor, representing the mass of a celestial body directly in terms of mass results in poor accuracy, but the gravitational radius can be measured to an accuracy of around ten digits.

If we define a new constant that has the dimension ‘force’ as ‘the Planck force’, there is a good chance that the geometrical parts can be separated from the coefficients in the formula<sup>18</sup>. Make the Planck force,  $F_P = c_0^4 G^{-1} = \hbar c_0 / l_P^2 = 35. \hbar c_0 / m_G^2$ , then:

$$\text{gravitational radius, } r_m = \frac{Gm}{c_0^2} = \frac{mc_0^2}{F_P} \quad (\text{half the Schwarzschild radius}) \quad (6)$$

$$\text{gravitational force, } f = F_P \frac{r_m r_m}{r^2} = c_0^2 \frac{r_m m}{r^2} \quad (7)$$

$$\text{gravitational acceleration, } g = c_0^2 \frac{r_m}{r^2} = \frac{r_m}{(r/c_0)^2} \quad (8)$$

$$\text{gravity field equation, } \frac{T_{ik}}{F_P} = \frac{1}{2\Omega_2} \left( R_{ik} - \frac{1}{2} R g_{ik} - \Lambda g_{ik} \right) \quad (9)$$

<sup>16</sup> For a case of electromagnetism, see §B of the paper <http://dozenal.com>. In the electromagnetic field, the natural unit of impedance,  $\Omega_n (=Z_P$ : the Planck impedance), plays the role of the Planck force in the gravitational field.  $\Omega_n$ ,  $e$ ,  $\theta_W$ , and  $F_P$  are constants for the four fundamental forces.

<sup>17</sup> See electromagnetic units in Appendix D and §3.2.2 of the paper <http://dozenal.com>.

<sup>18</sup> Please note that Eq. (8) and (9) are geometrical and have no mass dimension.



## C. Tables

**Table 3 Units with special names and symbols<sup>19</sup>**

ALL VALUES DECIMAL

Unit Category		Dimension	The Universal Unit Systems			
			with the Rydberg constant(u)		with the GCD Unit(h)	
Coherent	base units that are not natural units	length	$m_u$	272.102883 mm	$m_h$ or $hm^{20}$	272.352206 mm
		time	$s_u$	390.267520 ms	$s_h$ or $nc$	390.625115 ms
		energy	$J_u$	64.143270 mJ	$J_h$	64.084550 mJ
		temperature <sup>21</sup>	$K_u$	58.441045 $\mu K$	$K_h$	58.387545 $\mu K$
	base units that are natural units	plane angle	rad	$(2/\pi)$ arc sin(1)		
		logarithm	neper	$\log(e)$		
		amount of substance	$mol_n$ or $N_A^{-1}$	$mol / 6.02214129 \times 10^{23}$		
		impedance	$\Omega_n, Z_p$ or $nh$	$29.9792458 \Omega (=1sr/(\epsilon_0 c_0)$ strict <sup>22</sup> , is called ‘nohm’)		
	derived units of electromagnetic quantities	charge	$C_u$	28.896577 mC		
		electric current	$A_u$	74.042997 mA	$A_h$	73.975215 mA
		field strength	$O_u^{17,23}$	272.113976 mA/m	$O_h$	271.615995 mA/m
		flux density	$G_u^{23}$	390.283430 mC/m <sup>2</sup>	$G_h$	389.569194 mC/m <sup>2</sup>
	derived units of dynamical quantities	mass	$g_u$	131.950070 g	$g_h$ or $ll$	131.829278 g
		power	$W_u$	164.357182 mW	$W_h$	164.056401 mW
		force	$N_u$	235.731680 mN	$N_h$	235.300280 mN
		pressure	$P_u$	3.183843 Pa	$P_h$	3.172201 Pa
Non coherent	defining constants	wave number	$R_\infty$	10,973,731.568539/m ( is called ‘Rydberg’)		
		velocity	$c_0$	299,792,458 m/s (defined, and is called ‘light’)		
		action	$\hbar$	$1.054571726 \times 10^{-34} J_s$ ( is called ‘quantum’)		
		heat capacity	$k_B$	$1.3806488 \times 10^{-23} J/K$ ( is called ‘Boltzmann’)		

<sup>19</sup> Please see also <http://www.asahi-net.or.jp/~dd6t-sg/univunit-e/units.pdf> and <http://z13.invisionfree.com/DozensOnline/index.php?showtopic=371&st=6> for details.

A web based unit converter is available at <http://hosi.org/cgi-bin/conv.cgi>.

<sup>20</sup> ‘harmon’, ‘nic’, ‘looloh’, and ‘nohm’ constitutes a quartet. These are alias for common use.

<sup>21</sup> The unit of thermodynamic temperature has been changed. The new unit is one-1,0000;<sup>th</sup> of the old unit in the paper <http://dozenal.com> along with the introduction of the Earth local extension.

<sup>22</sup> If we adopt the elementary charge as one of definition constants,  $\Omega_u$  is used in substitution for  $\Omega_n$ .

<sup>23</sup> The unit symbol O(Ørsted) and G(Gauß) are associated with the units of CGS unit system.

Non coherent	supplementary constants	total solid angle of a hypersphere	$\Omega_k$	$\frac{2\pi^{\frac{k+1}{2}}}{\Gamma(\frac{k+1}{2})} \text{ rad}^k$	$k=0,1,2$ $\Omega_0=2$ $\Omega_1=2\pi \text{ rad}$ (circle, cycle) $\Omega_2=4\pi \text{ sr}$ (sphere, turn)
		logarithm of an integer	$f_k$	$\log(2^k)$	$k=1(\text{bit}), d(\text{figure}), 4(\text{nibble}), 8(\text{byte}), \dots$ $d=\log_2(12.)$
		amount of substance	$\text{mol}_u$	132.007609 mol	$(=12.^{24}/N_A)$
		elementary charge	$e$	$1.602176565 \times 10^{-19} \text{ C}$	$(= \sqrt{\frac{ah}{\Omega_n}})$

**Table 4 Physical, material and astronomical constants<sup>24</sup>**

ALL VALUES DOZENAL

Constant Symbols and Name (UNDERLINE INDICATES CONSTANT MAINTAINS SAME VALUE BETWEEN SYSTEMS u, e AND h)		Constant Value expressed by the Universal Unit Systems		Exponent N of $\times 10;^N$	Unit Symbol (u and h suffixes omitted)
		with the Rydberg constant (u)	with the GCD Unit (h)		
$R_\infty$	Rydberg constant	1	1;00170000	6;	$\Omega_1/\text{m}$
$c_0$	<u>speed of light in vacuum</u>	1		8;	m/s
$\hbar$	<u>quantum of action</u>	1		-26;	J s
$k_B$	<u>Boltzmann constant</u>	1		-20;	J/K
$N_A$	<u>Avogadro constant</u>	1		20;	$\text{mol}^{-1}$
$R$	<u>gas constant</u>	1		0;	J/(mol K)
$u$	unified atomic mass unit	1;0009061	1;0024073	-20;	$\text{g}^{25}$
$a_B$	Bohr Radius	1;005E85688	1;00447X743	-9;	m
$\alpha$	<u>fine structure constant</u>	1;07399405		-2;	-
$e$	<u>elementary charge</u>	1;0374439E		-14;	C
$m_e$	electron mass	0;E469222	0;E48324X	-23;	g
$\sigma$	<u>Stefan-Boltzmann constant</u>	1;E82E29		-1E;	$\text{W}/(\text{m}^2\text{K}^4)$
$m_G$	gravitic meter ( $\sqrt{2E}; l_P$ )	1;0018	1;0001	-27;	m
$l_P$	Planck length	2;0444	2;0412	-28;	m
$F_P$	Planck force ( $\hbar c_0/l_P^2$ )	2;XE25	2;XEE7( $\neq 2;E$ ) <sup>26</sup>	35;	N

<sup>24</sup> If CODATA (2010) values are required, see <http://physics.nist.gov/cuu/Constants/index.html> .

<sup>25</sup> Because  $g_u$  is approximately 100;<sup>10</sup>;  $u$ , I add alias name ‘looloh’(lú:loo/əu) to  $g_h$ .

<sup>26</sup> If this is expressed as 2;E, the error from CODATA (2010) becomes -0;78(-0.64) times of a standard deviation. The Gravitic Universal Unit System can be derived from 35G ( $m_G$ ),  $c_0$ ,  $\hbar$  and  $k_B$  .

$G$	Newtonian constant of gravitation ( $c_0^4/F_P$ )	4;1571	4;1460	-X;	( $m^4/s^4$ )/N
$\theta_W$	<u>weak mixing angle</u>	E;304		-2;	$\Omega_1$
$V_m$	molar volume of an ideal gas under standard conditions	1;02X468	1;025664	2;	$m^3/mol$
	black-body radiation at the ice point	0;EX2466	0;EX8783	2;	$W/m^2$
	maximum density of water	1;088184	1;092X47 ( $\div 15;14;$ )	2;	$g/m^3$
	density of ice at the ice point	0;E7E9	0;E85E	2;	$g/m^3$
	specific heat of water <sup>27</sup>	0;6052	0;6045 ( $\div 1/2$ )	0;	$J/(g\ K)$
	surface tension of water at 25°C	0;EE68	0;EEE4	-1;	N/m
atm	standard atmosphere	1;65008E	1;659967 ( $\div 1;66$ )	4;	P
$g_n$	standard gravitational acceleration	5;5X54XE9	5;5E21264 ( $\div E;2$ )	0;	$m/s^2$
$r_E$	gravitational radius of Earth	2;41E8982X13	2;4180306535	-2;	m
au	astronomical unit	8;X67575537	8;X55509X33	X;	m
	<u>astronomical unit</u>	9;E91731X53		-3;	$c_0\ s_E\ day$

**Table 5 Power prefixes**

name	symbol	Plain text	value	name	symbol	Plain text	value
dirac		D	$10;^1$	dour		d	$10;^{-1}$
hecty		H	$10;^2$	centy		c	$10;^{-2}$
kily		K	$10;^3$	milly		m	$10;^{-3}$
<b>super</b>		<b>S</b>	<b><math>10;^4</math></b>	<b>sub</b>		<b>s</b>	<b><math>10;^{-4}</math></b>
<b>cosmic</b>	+	<b>_+</b>	<b><math>10;^8(=M)</math></b>	<b>atomic</b>	-	<b>_-</b>	<b><math>M^{-1}</math></b>
by-cosmic	2+	<b>_2+</b>	$M^2$	by-atomic	2-	<b>_2-</b>	$M^{-2}$
try-cosmic	3+	<b>_3+</b>	$M^3$	try-atomic	3-	<b>_3-</b>	$M^{-3}$
quadry-cosmic	4+	<b>_4+</b>	$M^4$	quadry-atomic	4-	<b>_4-</b>	$M^{-4}$
penty-cosmic	5+	<b>_5+</b>	$M^5$	penty-atomic	5-	<b>_5-</b>	$M^{-5}$
hexy-cosmic	6+	<b>_6+</b>	$M^6$	hexy-atomic	6-	<b>_6-</b>	$M^{-6}$
septy-cosmic	7+	<b>_7+</b>	$M^7$	septy-atomic	7-	<b>_7-</b>	$M^{-7}$
...	...	...	...	...	...	...	...

A prefix with no corresponding unit is treated as a noun form, which means the abbreviation of the corresponding plain angle unit prefixed to  $\Omega_1$ . The above-proposed is an explanation of the prefixes put on the unit. As for number counting, I propose duodecimal myriad system replacing ten/hundred with dozen/gross.<sup>28</sup> ‘y’ is pronounced [ai] and is treated as a duodecimal context mark. The notation ‘ $M(=10;^8)$  to the power of octal number’ is used for exponential expression of big pure numbers.

<sup>27</sup> This corresponds to the definition of thermodynamic calorie.

<sup>28</sup> See <http://www.asahi-net.or.jp/~dd6t-sg/univunit-e/myriad.pdf>.

**Table 6 Examples of natural scale quantity representation** <sup>29</sup>

quantity	symbol	plain text	value	refer to
2E; penty-cosmic Newton	2E;N <sub>5+h</sub>	2E;N_5+h	2E;×M <sup>5</sup> [harmonic] Newton	the Planck force
6;by-cosmic second	6;s <sub>2+h</sub>	6;s_2+h	6;×M <sup>2</sup> [harmonic] [second]	the age of the universe
cosmic super bit [Boltzmann]	Sf <sub>+1</sub> [k <sub>B</sub> ]	Sf_+1 [k_B]	M <sup>1@4</sup> log2 <sup>1</sup> [Boltzmann]	1.01 Tera Byte(=2 <sup>43</sup> .bit)
cosmic meter	m <sub>+h</sub>	m_+h	M <sup>1</sup> harmon[ic meter]	the speed of light in vacuum
atomic dour meter	dm <sub>h</sub>	dm_-h	M <sup>-1@1</sup> harmon[ic meter]	the Bohr radius
by-atomic Coulomb	C <sub>2-u</sub>	C_2-u	M <sup>-2</sup> [universal] Coulomb	the elementary charge
by-atomic sensible Watt <sup>30</sup>	W <sub>2-sen[h]</sub>	W_2-sen[h]	M <sup>-2</sup> [harmonic]sensible Watt	a photon energy (540.THz)
try-atomic gram	g <sub>3-h</sub>	g_3-h	M <sup>-3</sup> [harmonic] gram	the unified atomic mass unit
2; quadry-atomic meter	2;m <sub>4-h</sub>	2;m_4-h	2;×M <sup>-4</sup> harmon[ic meter]	the Planck length

**Table 7 The Earth local extension for the Harmonic Universal Unit System**

category		name / description		symbol	plain text	value
Non coherent calendar time	prefix	septi		sep or “,”		2 <sup>-7</sup> ( <u>se</u> venth <u>p</u> ower of <u>t</u> wo <u>i</u> nversed)
	units	day		day		1 Ω <sub>1</sub>
						‘day’ corresponds to 86,400. s at the beginning of year 1900.
		year		y or a		265’27 days (365.+ 31./128. )days
		span or octal century		span or “^,”		64. years
Non coherent unit and constants		difference between thermodynamic temperature and 118,2356; K <sub>h</sub> (≐ -74.36°C)		°S	deg S	1,0000; K <sub>h</sub> (≐1.210724 K ÷ 23./19. K)
						100; 0000°S is 99.9839 °C
						78;0000°S is 37.0262°C
						61;0000°S is 14.0225°C
						51;5026°S is 0.0000°C
		approximate formula				99.9839 °C is the boiling point of water at the standard atmosphere.
	supple-mentary constants	the gravitational acceleration of the Earth (is called ‘gee [of Earth] ’)		g <sub>E</sub>	g_E or gee	5;611X615 m <sub>h</sub> /s <sub>h</sub> <sup>2</sup> g <sub>E</sub> is defined as c <sub>0</sub> <sup>2</sup> r <sub>E</sub> (m <sub>E</sub> rad) <sup>-2</sup>
		the rotation period of the Earth (is called ‘[Earth] solar’) at the beginning of year 1900.		s <sub>E</sub>	s_E or solar	0;EEEEEE153586 s <sub>h</sub> /septi milly day (This should be ‘coordinated’ . <sup>15</sup> )
		the meridian length of the Earth (is called ‘[Earth] meridian’)		m <sub>E</sub>	m_E or meridian	4124,216E; m <sub>h</sub> /Ω <sub>1</sub>

<sup>29</sup> The part enclosed with ‘[]’ can be omitted in Table 6 and Table 7.

<sup>30</sup> Units for quantity weighted by dimensionless human sensitivity are indicated by ‘sensible’.

W<sub>sen</sub> corresponds to 1;by-cosmic photon (540.THz) / harmonic second and 115.667202 lumen.

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## E. Ratios of fundamental physical constants

### E.1. The fine structure constant and the elementary charge

The fine structure constant,  $\alpha$ , a dimensionless quantity, was originally introduced for the purpose of explaining of the fine structure spectral emission lines.

$$\alpha = \frac{e^2}{4\pi\epsilon_0 c_0 \hbar} \quad (\text{X})$$

By multiplying both sides of Eq. (X) by  $\frac{c_0 \hbar}{r^2}$ , we get

$$\alpha \frac{c_0 \hbar}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{e^2}{r^2} \quad (\text{E})$$

The right side of Eq. (E) expresses the Coulomb force acting between two elementary charges (i.e. the electrical charge of an electron) separated by a distance of  $r$ . The left side indicates that this force is proportional to  $\frac{c_0 \hbar}{r^2}$  by a factor of  $\alpha$ . For this reason, the fine structure constant,  $\alpha$ , can be interpreted as a dimensionless quantity that represents the strength of electromagnetic interaction.

The value of the fine structure constant,  $\alpha$ , is close to  $10^{-2}$  ( $12^{-2}$ ).

DOZENAL

$$\alpha = \frac{1}{\text{E5;0522588}} = 1;07399404\text{E} \times 10^{-2}$$

DECIMAL

(10;)

$$\alpha = \frac{1}{137.03599907} = 1.050818770 \times 12^{-2}$$

Therefore, the ratio of the elementary charge,  $e$ , and “the dimensioned quantity of charge, which is derived from the speed of light in vacuum,  $c_0$ , and the quantum of action,  $\hbar$ ” is:

DOZENAL

$$\alpha^{\frac{1}{2}} = \frac{e}{\sqrt{4\pi\epsilon_0 c_0 \hbar}} = 1;0374439\text{E}3 \times 10^{-1}$$

DECIMAL

(11;)

$$\alpha^{\frac{1}{2}} = \frac{e}{\sqrt{4\pi\epsilon_0 c_0 \hbar}} = 1.025094518 \times 12^{-1}$$

### E.2. The Rydberg constant and the Bohr radius

The deviation of the fine structure constant,  $\alpha$ , from an integer power of twelve is nearly the

same as the deviation of  $4\pi$  from twelve.

DOZENAL

$$4\pi = 1;069683171 \times 10;^1 = \frac{1}{E5;6150822} \times 10;^3$$

DECIMAL

(12;)

$$4\pi = 1.047197551 \times 12^1 = \frac{1}{137.5098708} \times 12^3$$

The ratio of the Bohr radius,  $a_B$ , and “the dimensioned quantity of length,  $L=R_\infty^{-1}$ , where  $R_\infty$  is the Rydberg constant” is:

DOZENAL

$$\frac{a_B}{L} = \frac{\alpha}{4\pi} (\text{strict}) = 1;005E85688 \times 10;^{-3}$$

DECIMAL

(13;)

$$\frac{a_B}{L} = \frac{\alpha}{4\pi} (\text{strict}) = 1.003458009 \times 12^{-3}$$

### E.3. The electron mass and the unified atomic mass unit

The ratio of the mass of an electron,  $m_e$ , and “the dimensioned quantity of mass,  $M$ , which is derived from  $L$ , the speed of light in vacuum,  $c_0$ , and the quantum of action  $\hbar$ ,”

$$M = \frac{\hbar}{c_0 L}, \quad (14;)$$

is:

DOZENAL

$$\frac{m_e}{M} = \frac{4\pi}{\alpha^2} (\text{strict}) = 0;E4692217 \times 10;^5$$

DECIMAL

(15;)

$$\frac{m_e}{M} = \frac{4\pi}{\alpha^2} (\text{strict}) = 0.948359447 \times 12^5$$

The ratio of the mass of an electron,  $m_e$  and the unified atomic mass unit,  $u$ , is:

DOZENAL

$$\frac{m_e}{u} = \frac{1}{107X;X7E4} = \frac{4\pi}{\alpha^2} \times 0.EEE2E66 \times 10;^{-8}$$

DECIMAL

(16;)

$$\frac{m_e}{u} = \frac{1}{1822.8885} = \frac{4\pi}{\alpha^2} \times 0.9995641 \times 12^{-8}$$

This ratio corresponds to the ratio of typical nuclear energy and chemical energy. The deviations of ratio Eq. (15;) and ratio Eq. (16;) from multiples of an integer power of twelve are

nearly of the same magnitude. Therefore:

DOZENAL	DECIMAL	
$\frac{u}{M} = 1;0009060E \times 10;^8$	$\frac{u}{M} = 1.00043606 \times 12^8$	(17;)

#### E.4. The Planck length

The ratio of the general expression of the Planck length,  $\sqrt{\frac{Gh}{c_0^3}}$ , and  $L$  is close to 2, when factors of multiples of an integer power of twelve are eliminated.

DOZENAL	
$\sqrt{\frac{Gh}{c_0^3}} / L = 2 \times 1;02223 \times 10;^{-22}$	
DECIMAL	
$\sqrt{\frac{Gh}{c_0^3}} / L = 2 \times 1.01515 \times 12^{-26}$	(18;)

Taking the expression  $\sqrt{\frac{Gh}{c_0^3 \alpha}}$ , which has been adjusted<sup>32</sup> by the fine structure constant,  $\alpha$ , in order to express the tensile force in a superstring in terms of the Planck length, the ratio of the adjusted Planck length and  $L$  then becomes:

DOZENAL	
$\sqrt{\frac{Gh}{c_0^3 \alpha}} / L = 2 \times 0;EX72E \times 10;^{-21}$	
DECIMAL	
$\sqrt{\frac{Gh}{c_0^3 \alpha}} / L = 2 \times 0.99030 \times 12^{-25}$	(19;)

The Gravitic Universal Unit System uses 140.0 to approximate  $\alpha^{-1}$ (=137.03599907). Because 1,0017;(20,755.=35.  $\times$  593.) is divisible with 2E;(35.), we can approximate  $G$  by Eq.(1X;) within a standard deviation error of CODATA(2010):

$$G \doteq \frac{(5 \times 7)^8 \times 415;^2 c_0^3}{\cancel{5 \times 7} \times \hbar R_\infty^2} \times 10;^{-4x} = \frac{5 \times 7 \times 415;^2 c_0^3}{\hbar R_\infty^2} \times 10;^{-4x} \quad (1X;)$$

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<sup>32</sup> See E. Witten, 'Reflections on the fate of spacetime' p. 24. in April 11X4;(1996.) *Physics Today*.