# Chapter 12.   Numbers and Measurements

12.1.   Counting

Counting can be done in Nwehu Nuswei either using the language's native base 16 system, or the more familiar base 10. Two sets of 256-word GENI (ᚳ↳-- *Ti--* and ᚳᚱ-- *Ta--*) are set aside for basic counting, and additional words are made available to express larger numbers, negatives, fractions, and special numbers used in mathematics. Note that "Qualitative Concepts" are related and begin with ᚳ↲- *Te-* but are discussed in their own chapter, "Love and Hate".
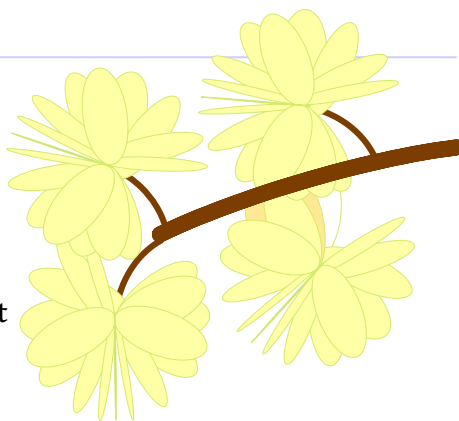
12.1.1.   Basic Numbers

- Basic **hexadecimal** numbers 0-255 are the GENUS beginning ᚳ↳- *Ti-*
- Basic **decimal** numbers 0-100 are are the GENUS beginning ᚳᚱ- *Ta-*, but forms ending -ᚴ↲ *-we* through -ᚴᚵ *-woi* and ᚳᚱᚳ↳ *Tati* through ᚳᚱᛣᚵ *Tabwoi* are defined as 'meaningless'. Undefined forms ᚳᚱᚳ↳ – *Tati* through ᚳᚱᛣᚵ *Tabwoi* may be used for other concepts, but all forms ᚳᚱᛁ↳ *Tahi* through ᚳᚱ↳ᚵ *Tacwoi* are reserved to prevent ambiguity.
- **Negative** numbers are indicated with a ᚴ *w* in the first vowel of the basic numbers: geni ᚳᚴ-- *Twi--* and ᚳᚤ-- *Twa--*.
- Basic **negative decimal** numbers -1 through -100 are are the series beginning ᚳᚤ- *Twa-*, with forms ending -ᚴ↲ *-we* through -ᚴᚵ *-woi* and ᚳᚤᚳ↳ *Twati* through ᚳᚤᛣᚵ *Twatwoi* are undefined, as in the positive numbers. Similarly, undefined forms ᚳᚤᚳ↳ *Twati* – ᚳᚤᛣᚵ *Twabwoi* may be used for other concepts, but all forms ᚳᚤᛁ↳ *Twahi* through ᚳᚤ↳ᚵ *Twacwoi* are reserved to prevent ambiguity.

12.1.1.1.   Hexadecimal Numbers – Base 16

Because NN is based on hexadecimal numbers, the "native" way of counting is in base-16.

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
tihu	tihi	tihe	tihei	tiha	tihai	tiho	tihoi	tihw	tihwi	tihwe	tihwei	tihwa	tihwai	tihwo	tihwoi
10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
tixu	tixi	tixe	tixei	tixa	tixai	tixo	tixoi	tixw	tixwi	tixwe	tixwei	tixwa	tixwai	tixwo	tixwoi
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
tisu	tisi	tise	tisei	tisa	tisai	tiso	tisoi	tisw	tiswi	tiswe	tiswei	tiswa	tiswai	tiswo	tiswoi
30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
tifu	tifi	tife	tifei	tifa	tifai	tifo	tifoi	tifw	tifwi	tifwe	tifwei	tifwa	tifwai	tifwo	tifwoi

40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
tiru	tiri	tire	tirei	tira	tirai	tiro	tiroi	tirw	tirwi	tirwe	tirwei	tirwa	tirwai	tirwo	tirwoi
50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
tiyu	tiyi	tiye	tiyei	tiya	tiyai	tiyo	tiyoi	tiyw	tiywi	tiywe	tiywei	tiywa	tiywai	tiywo	tiywoi
60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
tinu	tini	tine	tinei	tina	tinai	tino	tinoi	tinw	tinwi	tinwe	tinwei	tinwa	tinwai	tinwo	tinwoi
70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F
timu	timi	time	timei	tima	timai	timo	timoi	timw	timwi	timwe	timwei	timwa	timwai	timwo	timwoi
80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
tiku	tiki	tike	tikei	tika	tikai	tiko	tikoi	tikw	tikwi	tikwe	tikwei	tikwa	tikwai	tikwo	tikwoi
90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
ticu	tici	tice	ticei	tica	ticai	tico	ticoi	ticw	ticwi	ticwe	ticwei	ticwa	ticwai	ticwo	ticwoi
A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
titu	titi	tite	titei	tita	titai	tito	titoi	titw	titwi	titwe	titwei	titwa	titwai	titwo	titwoi
B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
tipu	tipi	tipe	tipei	tipa	tipai	tipo	tipoi	tipw	tipwi	tipwe	tipwei	tipwa	tipwai	tipwo	tipwoi
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
tigu	tigi	tige	tigei	tiga	tigai	tigo	tigoi	tigw	tigwi	tigwe	tigwei	tigwa	tigwai	tigwo	tigwoi
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
tiju	tiji	tije	tijei	tija	tijai	tijo	tijoi	tijw	tijwi	tijwe	tijwei	tijwa	tijwai	tijwo	tijwoi
E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
tidu	tidi	tide	tidei	tida	tidai	tido	tidoi	tidw	tidwi	tidwe	tidwei	tidwa	tidwai	tidwo	tidwoi
F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF
tibu	tibi	tibe	tibei	tiba	tibai	tibo	tiboi	tibw	tibwi	tibwe	tibwei	tibwa	tibwai	tibwo	tibwoi

12.1.1.2. Decimal Numbers – Base 10

Since most people are far more accustomed to base 10 numbers, GENUS ꓕꓩ-- *ta*-- is entirely dedicated to decimal numbers from 0 to 99. All are shown in the following table. In order to avoid confusion, the 156 unused words in this genus are permanently defined as "meaningless".

0	1	2	3	4	5	6	7	8	9
tahu	tahi	tahe	tahei	taha	tahai	taho	tahoi	tahw	tahwi
10	11	12	13	14	15	16	17	18	19
taxu	taxi	taxe	taxei	taxa	taxai	taxo	taxoi	taxw	taxwi
20	21	22	23	24	25	26	27	28	29

tasu	tasi	tase	tasei	tasa	tasai	taso	tasoi	tasw	taswi
30	31	32	33	34	35	36	37	38	39
tafu	tafi	tafe	tafei	tafa	tafai	tafo	tafoi	tafw	tafwi
40	41	42	43	44	45	46	47	48	49
taru	tari	tare	tarei	tara	tarai	taro	taroi	tarw	tarwi
50	51	52	53	54	55	56	57	58	59
tayu	tayi	taye	tayei	taya	tayai	tayo	tayoi	tayw	taywi
60	61	62	63	64	65	66	67	68	69
tanu	tani	tane	tanei	tana	tanai	tano	tanoi	tanw	tanwi
70	71	72	73	74	75	76	77	78	79
tamu	tami	tame	tamei	tama	tamai	tamo	tamoi	tamw	tamwi
80	81	82	83	84	85	86	87	88	89
taku	taki	take	takei	taka	takai	tako	takoi	takw	takwi
90	91	92	93	94	95	96	97	98	99
tacu	taci	tace	tacei	taca	tacai	taco	tacoi	tacw	tacwi

12.1.2.   Additional Number-Bases

Not to slight any other potential ways of counting, NN offers words for numbers based on several bases.

- *tux-* ꓕꓴꓡ   Names for **number bases**: base 2 through base 16
- twe- ꓕꓧ   **Non-Integer** Number Bases:
  - *tweh- → twef-* ꓕꓧꓲ- → ꓕꓧꓡꓲ-   Numbers base Pi π (nπ)
  - *twer- → twem-* ꓕꓧ�- → ꓕꓧꓞꓲ-   Numbers base Phi φ (nφ)
  - *twek- → twep-* ꓕꓧꓬꓲ- → ꓕꓧꓡꓲ-   Numbers base square root of two √2
  - *tweg- → tweb-* ꓕꓧꓰꓲ- → ꓕꓧꓲꓲ-   Numbers base e (ne)

12.2.   Multipliers and Dividers

To extend the basic numbers, NN provides several sets of exponents to serve as multipliers and dividers of the basic numbers.

First syllable	IPA	NN	Semantics
teih-	tɛjh	ꓕꓡꓲ	Powers of 2 (1 to 7, -1 to -8)
teix-	tɛjʃ	ꓕꓡꓡ	Powers of 2 (8 to 15, -9 to -16)
teis-	tɛjs	ꓕꓡꓶ	Powers of 10 (1 to 7, -1 to -8)
teif-	tɛjf	ꓕꓡꓡ	Powers of 10 (8 to 15, -9 to -16)
teir-	tɛjɹ	ꓕꓡꓶ	Powers of 16 (1 to 7, -1 to -8)
teiy-	tɛjʒ	ꓕꓡꓞ	Powers of 16 (8 to 15, -9 to -16)

First syllable	IPA	NN	Semantics
tein-	tɛjn	⏌⏌⎰	Powers of e (1 to 7, -1 to -8)
teim-	tɛjm	⏌⏌⎩	Powers of e (8 to 15, -9 to -16)
teik-	tɛjk	⏌⏌⎧	Powers of i (1 to 7, -1 to -8)
teic- to teib-			(undefined)

Each of these ɢᴇɴɪ is organized in the same way. ⏌ᵈⱼɪ- *teh-* is given as an example:

Roman	IPA	NN	Meaning	Value
teihu	tɛj'hə	⏌ᵈ⎧ⁱᵉ	Powers of 2	
teihi	tɛj'hi	⏌ᵈ⎧ⁱ⎣	$2 \wedge 1$	2
teihe	tɛj'he	⏌ᵈ⎧ⁱᵈ	$2 \wedge 2$	4
teihei	tɛj'hɛj	⏌ᵈ⎧ⁱᵈ	$2 \wedge 3$	8
teiha	tɛj'ha	⏌ᵈ⎧ⁱᴘ	$2 \wedge 4$	16
teihai	tɛj'haj	⏌ᵈ⎧ⁱᴃ	$2 \wedge 5$	32
teiho	tɛj'hɔ	⏌ᵈ⎧ⁱᵈ	$2 \wedge 6$	64
teihoi	tɛj'hɔj	⏌ᵈ⎧ⁱᵝ	$2 \wedge 7$	128
teihw	tɛj'hu	⏌ᵈ⎧ⁱᵞ	$2 \wedge -1$	0.50000000
teihwi	tɛj'hwi	⏌ᵈ⎧ⁱ⎩	$2 \wedge -2$	0.25000000
teihwe	tɛj'hwe	⏌ᵈ⎧ⁱᴙ	$2 \wedge -3$	0.12500000
teihwei	tɛj'hwɛj	⏌ᵈ⎧ⁱᴚ	$2 \wedge -4$	0.06250000
teihwa	tɛj'hwa	⏌ᵈ⎧ⁱᴨ	$2 \wedge -5$	0.03125000
teihwai	tɛj'hwaj	⏌ᵈ⎧ⁱᴃ	$2 \wedge -6$	0.01562500
teihwo	tɛj'hwɔ	⏌ᵈ⎧ⁱᴙ	$2 \wedge -7$	0.00781250
teihwoi	tɛj'hwɔj	⏌ᵈ⎧ⁱᴃ	$2 \wedge -8$	0.00390625

Words beginning with ⏌ᵈ⎣- *Tei-* express powers of 2, 10, 16, e, and i (see table below). They can be used combined with the basic numbers. If the basic number precedes the ⏌ᵈ⎣- *Tei-* word, their values are multiplied; if the basic number follows the ⏌ᵈ⎣- *Tei-* word, the values are added.

12.2.1.1.   Examples

Larger Numbers			
⏌ᴘ⏌ᴘ	*Tafa*	34	'thirty-four'
⏌ᴘ⎣ᵈ	*Tayo*	56	'fifty-six'
⏌ᵈ⎣ᵈ ⏌ᴘ⏌ᴘ	*Teise tafa*	134	'one hundred plus thirty-four' or 'hundred thirty-

			four'
ꓮꓑꓕꓴ ꓝꓕꓕꓭ	*Tafa teise*	3400	'thirty-four times one hundred', or
			'thirty-four hundred', or
ꓕꓴꓵꓭ ꓝꓕꓕꓭ ꓕꓑꓵꓴ ꓕꓭꓕꓭ	*Tahei teisei taha teise*	3,400	'three thousand four hundred'
ꓕꓴꓵꓭ ꓝꓕꓕꓭ ꓝꓕꓕꓭ ꓕꓑꓵꓴ ꓕꓭꓕꓭ ꓕꓵꓛꓢ	*Tahei teisei taha teise tayo*	3,456	'three thousand four hundred fifty-six'
Base 10 Fractional Numbers
ꓕꓭꓴꓬ	*Teisw*	0.1	'one tenth'
ꓕꓭꓴꓭ	*Teiswi*	0.01	'one one hundredth'
ꓮꓑꓕꓴ ꓕꓭꓴꓬ	*Tafa tesw*	3.4	'34 times 0.1'
ꓮꓑꓕꓴ ꓕꓭꓴꓭ	*Tafa teswi*	0.34	'34 times 0.01'
ꓕꓭꓴꓭ ꓮꓑꓕꓴ	*Teiswi tafa*	34.01	'0.01 plus 34'
ꓮꓕꓛꓢ ꓕꓭꓴꓬꓭ ꓮꓑꓕꓴ	*Tayo teiswe tafa*	34.56	'56 times 0.01 plus 34'

In larger numbers with decimal fractions, the fractional part is introduced by a basic number. This results in two adjacent basic numbers, resulting in the addition of the clusters of basic and multiplier (see next example)

Tahe teise tafa tayo teiswi	Tahe teise tafa tayo teiswi	234.56	'two hundred thirty-four point five six', or (2 * 100 + 34) + (56 * 0.01)

12.3.   General Number and Measurement Concepts

SPECIES ꓬꭤ-- *Tu--* provides representation of a wide variety of concepts related to numbers and measurements. Each is discussed briefly in this section.

- tuh-   təh   ꓬꭤɪ   **Types of Numbers**: not yet defiined.
- tux-   təʃ   ꓬꭤʟ   **Number bases**: base 2 through base 16
- tus-   təs   ꓬꭤꓲ   **Branches of Mathematics**: Several theoretical and applied areas are defined
- tun-   tən   ꓬꭤꓩ   **Algebraic Concepts**: not yet defined
- tuk-   tək   ꓬꭤꓵ   **Geometry**: not yet defined
- tuj-   tədʒ   ꓬꭤꓕ   **Calculus**: not yet defined
- twai-   twaj   ꓬꭤ-   **Constants**: Pi, e, Square root of -1, etc.: not yet defined

- tug-   təg   ꓬꓲꓔ   **Trigonometry**: The following diagram illustrates the basic concepts of Trig and their NN equivalents:


Tugu (Trigonometry)
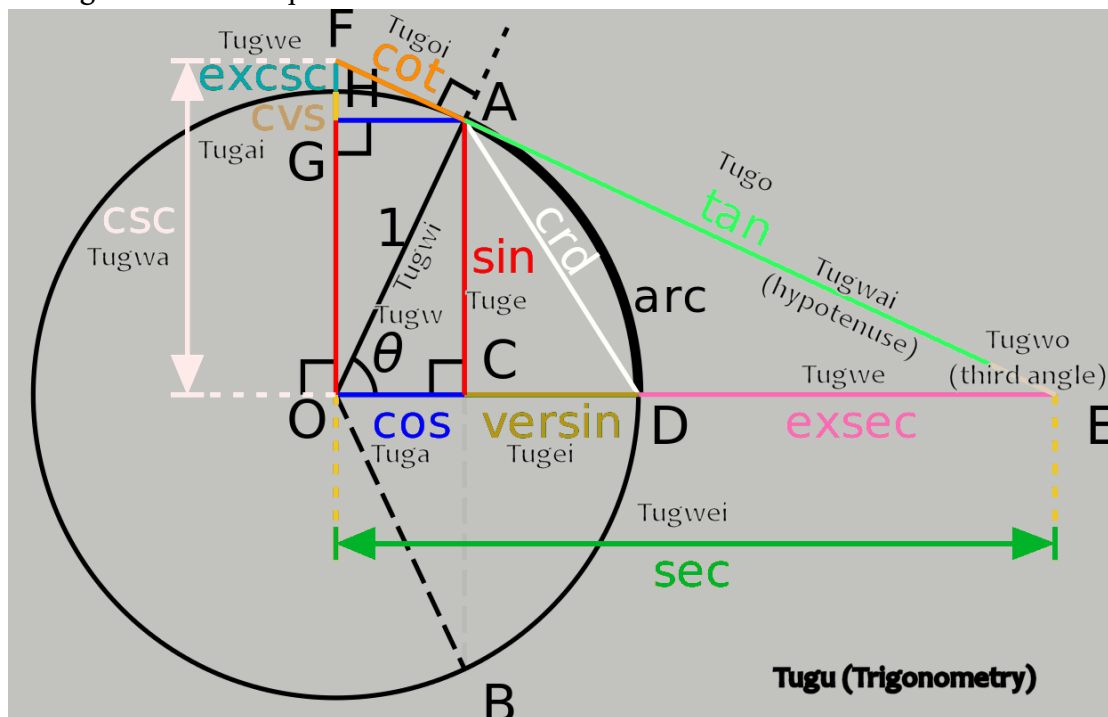
- tuf-   təf   ꓬꓲꓛ   **Whole and Parts**: Words in the ꓬꓲꓛ *Tuf-* SPECIES refer to functional and structural aspects of an object's parts. In case the size of an object's parts is of interest, the usual three size-ranges are provided (small, mid, large). Beyond very simple objects, most things are composed of assemblies of smaller parts, which form "systems". A "system" is collection of parts combined in such a way as to produce a desired result. ꓬꓲꓥꓳ *Tufi* indicates a basic component, whose size may be unmentioned, or small: ꓬꓲꓥꓬ *tufei*, mid-size ꓬꓲꓥꓲ *tufai*, or large: ꓬꓲꓥꓳ *tufoi*. In most cases, the basic elements ꓬꓲꓥꓳ *tufi*, are combined into sub-systems ꓬꓲꓥꓲ *tufwi*, which in turn combine to make systems, ꓬꓲꓥꓴ *tufw*. At each system-level, it is possible to add a vowel to indicate relative size (as illustrated above with *tufi*). Viewed as a collection of parts or as a system of systems, an object as a whole can be referred to as ꓬꓲꓥꓴꓔ *Tufwo.*

- tur-   təɹ   ꓬꓲꓩ   **Mathematical Operations**
  - Add: ꓬꓲꓩꓲ *turi*
  - Multiply: ꓬꓲꓩꓮ *ture*
  - Raise to a power: ꓬꓲꓩꓵ *tura*
  - Divide: ꓬꓲꓩꓸ *turo*
  - Negation: ꓬꓲꓩꓴ *turw*
  - Subtract: ꓬꓲꓩꓹ *turwi*
  - Numeric root: ꓬꓲꓩꓯ *turwa*

- Negative power: ꓱⲅꞵ *turwo*
- Mathematics (the field of study): ꓱⲅꞗ *turu*

■ tuy- təʒ ꓱꞗꓔ **Logic Operations**: A logical operation is ꓱꞗꞗ *tuyu*, and 15 logical operations are defined from ꓱꞗꓡ *tuyi* through ꓱꞗꞵ *tuywoi*:
→ Material condition 'imply', ⊤ Truth, tautology, ∃ 'there exists', ∧ Conjunction 'and', ∀ 'for all', ∨ Disjunction 'or', ↮ Exclusive or, ¬ Negation 'not', ← Converse implication 'if', ⊥ Falsity, contradiction, ↔ Biconditional 'if and only if', ↛ material nonimplication 'but not', ↑ Alternative denial 'not both', ↓ Joint denial 'neither nor', ∅ Absurd (not standard logical operator).

■ tum- təm ꓱꞗꓚ **Size Ranges**: "Size range" in this context indicates the relative size of objects or entities. The purpose of having such words in NN is to allow people to talk about imprecise sizes while giving an idea of the scale. The English words "large" and "small" have meaning only if the context is known: a "large rabbit" and a "large man" are are not close to the same size. Words in this SPECIES can be used either to indicate a general range, or as a modifier to qualify words indicating relative size ꓱꞗꓚ - *Tup-* or quantity ꓱꞗꓩ- *Tub-*, like "big" or "small". Sizes range from 'below sub-atomic scale' through 'human scale' to 'universal, relative to creation as we know it'.

■ tup- təp ꓱꞗꓩ **Comparative Sizes**: these words are used within a size-range to indicate wihere within that range something fits.

■ tub- təb ꓱꞗꓩ **Comparative Quantities**: these words work for quantity just like "comparative sizes" work.

■ tuc- təʧ ꓱꞗꓡ **Basic shapes**: not yet defined

- tud-   təd   ⟨ɪⱱ⟩   **Circle parts and measurements**: these two diagrams illustrate the words for describing circles.

Tudu   **(circle)**
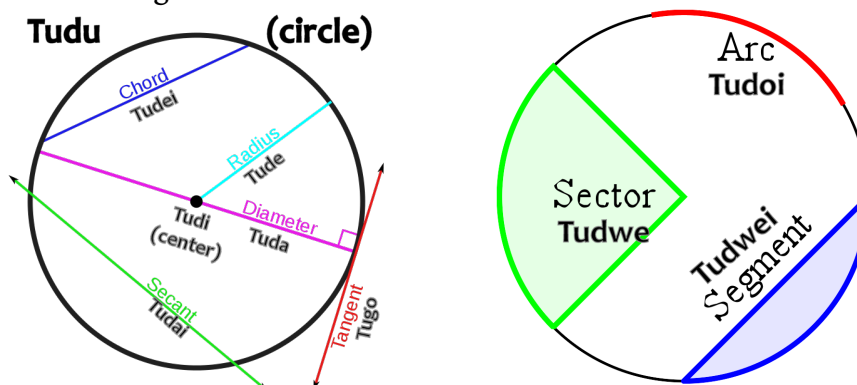
- tut-   tət   ⟨ɪⱱ⟩   **Dimensions**: not yet defined

12.4.   Measurements

12.4.1.   General Measurements

GENUS ⟩ɣ- *Two-* represents useful length, weight/mass, volume, and speed measurements.

NN uses the SI – "Système International" (meter, liter, gram – these are the units accepted throughout most of the world) as the basis for its measurements, but provides words for "English units", used in the US and (to some extent still) in the UK. Space is also set aside for measures in other systems as well.

The "native" measurements within NN provide units of each measurement (meter, liter, gram) that increase and decrease by 16 (rather than by 10 as in the standard metric system). NN words for the base 10 measures are, of course, provided as well.

Speed is measured in units of *length per unit of time*. Metric and English are both based on the standard second, but NN's time measurement system is based on sixteenths of a day (more elsewhere). Thus separate SPECIES are required for speeds based on standard time units and NN time units.

Finally, NN offers three SPECIES for discussion of astronomical measurements. The first two are based on the Astronomical Unit (AU: 149.6 million kilometers, the mean distance from the center of the earth to the center of the sun) while the third expresses measures in Paralax Units (Parsecs: .648000/π*au, or approximately $3.0856775814913673 \times 10^{16}$ meters).

The table below presents the GENUS ⟩ɣ- *Two-*:

Roman	IPA	NN	Semantics
twoh-	twɔh	ꓵꓤꓮI	Length – Nwehu Nuswei SI Hexadecimal units
twox-	twɔʃ	ꓵꓤꓮL	Length – SI (Système International)
twos-	twɔs	ꓵꓤꓮ⌐	Length – English units
twof-	twɔf	ꓵꓤꓮ⌐	Length and Speed – other units
twor-	twɔɾ	ꓵꓤꓮ⌐	Weight/Mass – native Nwehu Nuswei units
twoy-	twɔʒ	ꓵꓤꓮꓔ	Weight/Mass – SI (Système International)
twon-	twɔn	ꓵꓤꓮ⌐	Weight/Mass – English units
twom-	twɔm	ꓵꓤꓮꓔ	Weight/Mass – other units
twok-	twɔk	ꓵꓤꓮᒥ	Volume – native Nwehu Nuswei units
twoc-	twɔtʃ	ꓵꓤꓮ⌐	Volume – CGPM (metric)
twot-	twɔt	ꓵꓤꓮꓘ	Volume – English units
twop-	twɔp	ꓵꓤꓮ⌐	Length – Nwehu Nuswei AU-based units
twog-	twɔg	ꓵꓤꓮꓔ	Length – Astronomical Units (AU)
twoj-	twɔdʒ	ꓵꓤꓮꓔ	Length – Paralax Units (Parsecs)
twod-	twɔd	ꓵꓤꓮꓔ	Speed – Nwehu Nuswei SI Hex + Hex Time units
twob-	twɔb	ꓵꓤꓮꓔ	Speed – Newhu Nuswei AU-based units

12.4.2.   Measure of Energy, Waveforms

GENUS ꓤ꓿ *Twoi-* is to represent "Measures of Energy, Waveforms"; further measures of physical and chemical phenomena may be represented in the K- and G- families, but none of these have not yet been defined.

12.5.   Time

12.5.1.   Time Concepts

Like most other time measurement systems, NN begins with the rotation of the earth and its revolution around the sun. Vocabulary space is also provided for planets with other rotation / revolution times, and for situations where the night-day distinction is not relevant. Vocabulary for the currently-standard time measurement system is also provided, of course.

12.5.1.1.   Time: Larger Units

Genus ⅃ₗ-- *To--* represents years and multiples of years, seasons, Gregorian months, lunar months, and standard weekday names. In addition, several NN calendar day-names in groups from 3 to 16 days, plus festivals and half-months are represented. The NN calendar system is complex and offers several options for dividing the year into groups, so the calendar is discussed in its own chapter.

12.5.1.2.   Time: Smaller Units

Divisions of time within a day are represented in genus ⅃ₗ-- *Toi--*. The standard 24-hour day with 60 minutes per hour and 60 seconds per minute are each given a name. So to refer to 9 a.m., the single word ⅃ₗ⌐Ꚍ *toinwe* can be used (Ꚍ⅃Iꚍ is 9_{16} and ⅃⌐IꚍH *tahwe* is 9_{10}).

Beginning with sunrise, the "native" NN day is divided into 16 units, each of which is divided into 16 smaller units:
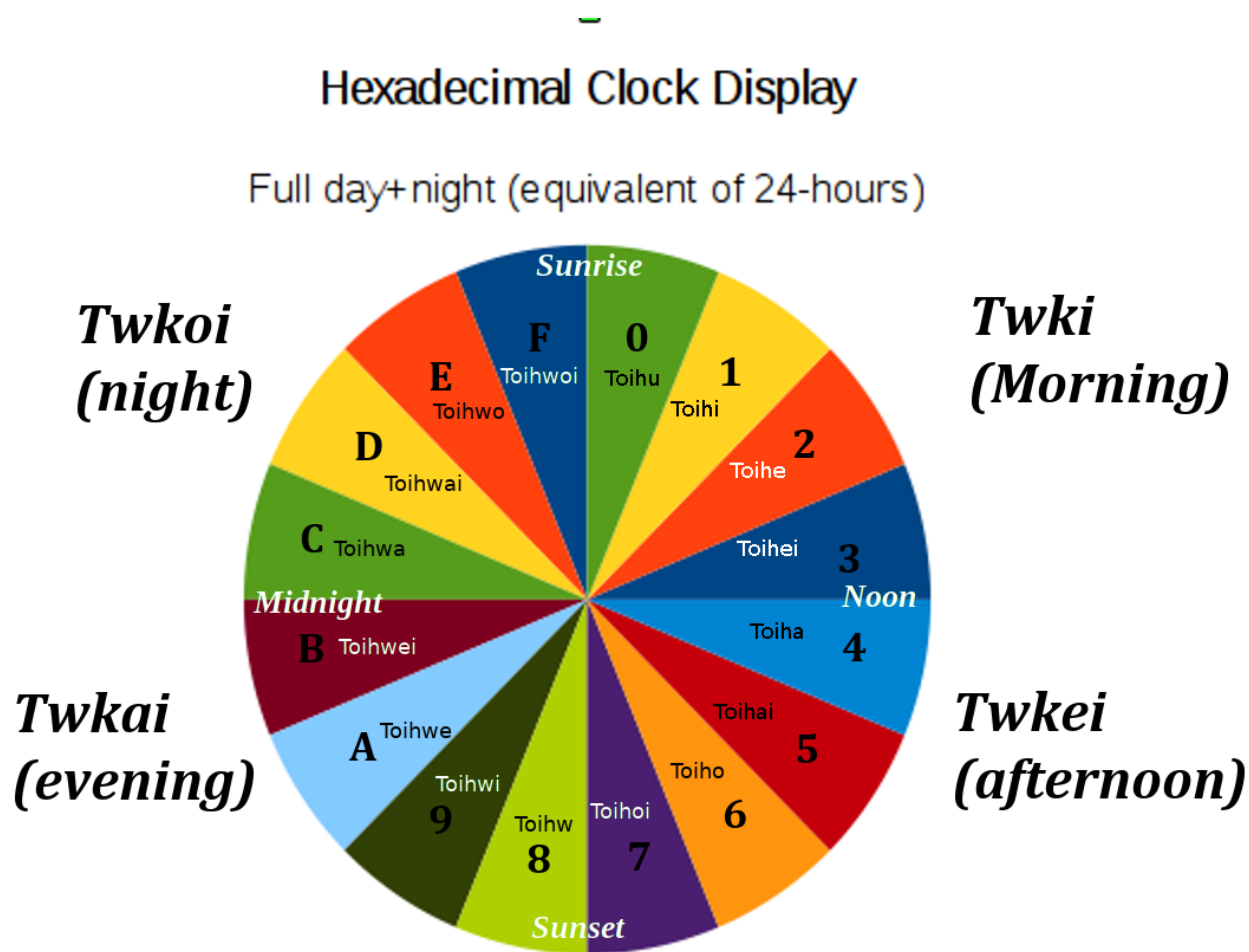
Each of these units is further subdivided into sixteenths, down to ꓔ𝟾ᒋ𝟾 *toirwoi* which is approximately 2.92734586571086E-16 of a standard second.

This concludes the discussion of numbers and measurements in Nwehu Nuswei.