leɿ–\ɾȷɪµɔ–ᴅɪ ȷcl leɿ–ᴅɪ ȷcl ȷeᵓɾɭe–\µcᵊᴅɪɿɔ

aaaaaaaaaaA, the language of *Rymako*

uruwi

IIIIIIIIIIIIIII
aaaaaaaaaaaaaaaaa

A complete grammar

September 16, 2017

Dedicated to Isoraķatheð.

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0.1 | Introduction

1 | Phonology and orthography

1.1 | Phoneme inventory

Table 1.1: The consonants of aaaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	m	n	ɲ	ŋ	▨
Plosive	p b	t d	c ɟ	k g	ʔ
Fricative	f	s	ʃ	x	
(coarticulated)	θx	fx		fʃ	▨
Affricate		ts	tʃ		
Lateral fricative	▨	ɬ			▨
Approximant		ɹ	j	w	
Lateral approximant	▨	l			▨
Trill		r		▨	▨

Table 1.2: The vowels of aaaaaaaaaaA.

Spread	Half-rounded	Rounded
i	y̜	y
ɯ	u̜	u
ɛ		œ
ʌ		ɔ
ä		

In addition to consonants and vowels, aaaaaaaaaaA has rod signals, represented by numbers. Rod A is blue and held by one's dominant hand and B is red and held by one's non-dominant hand.

1. Rod A is raised to one's chest, while B is pointed down.
2. Rods A and B are crossed in the front.
3. Rod B is raised upwards in front of the nondominant arm, while rod A is lowered.

4. Rod A is pointed sideways near one's nondominant arm, while rod B is lowered.
5. Rods A and B are extended to the sides.
6. Rods A and B are extended, facing forward.
7. Rod A is raised forward, while B is pointed to the side.
8. Rod B is raised forward, while A is pointed to the side.

Lowering both rods is interpreted as an absence of a rod signal.
If the use of rods are unavailable, the numerals of the positions may be pronounced.

1.2 | Hacmisation

aaaaaaaaaaA uses the hacm script with superscript letters to indicate phonemes not found in Arka. The transcriptions can be found in Tables 1.3 and 1.4.

Table 1.3: The consonants of aaaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	ᴅ	n	n^{ɥ}	n^{φ}	▨
Plosive	d b	ʃ Ω	ʃ^{ɥ} Ω^{ɥ}	ɿ φ	.
Fricative	ɑ	ȷ	ɭ	h	
(coarticulated)	ȷ^{h}	ɑ^{h}		ɑ^{ɭ}	▨
Affricate		ʃȷ	ʃɭ		
Lateral fricative	▨	s			▨
Approximant		µ	ɥ	o	
Lateral approximant	▨	l			▨
Trill		ɗ		▨	▨

Table 1.4: The vowels of aaaaaaaaaaA.

Spread	Half-rounded	Rounded
c	c^{ə}	c^{ɔ}
ə^{c}	ə	ə^{ɔ}
e		e^{ɔ}
ɔ^{e}		ɔ
ı		

Rod signs are represented by the hacm digits ⟨ㄱ ɺ ʔ ɱ ɬ ʕ ᑫ Δ⟩ attached to the end of the verbs they encompass. Proper words are preceded by a backslash ⟨\⟩.

Vowels that are inferrable from context are sometimes omitted. For example, /ɹɛfan/ (to speak) is written ⟨µeɑn⟩, but /ɹɛfin/ (to spread), which is less common, is written ⟨µeɑcn⟩, with the second vowel. Most of this grammar will leave all vowels written.

1.3 | Phonotactics

An onset consists of one of the following:

- any single consonant other than /l/ (the exceptions are ⟨leɿ⟩ [lɛk] and related words),
- any obstruent followed by an approximant other than /l/,
- or any plosive followed by /r/,
- or any nasal followed by /j/ or /w/.

A nucleus consists of one vowel.
A coda consists of one of the following:

- nothing,
- a nasal,
- a voiceless plosive (excluding /ʔ/),
- /ɹ/, /s/ or /l/

1.4 | Stress

Stress falls on the last syllable with a coda, or otherwise the second-to-last syllable.
See table 1.5 for examples.

Table 1.5: Examples of stress locations.

Orthography	Location of stress (# from last)
ᗡɪȷɪ	2
nɪ.cn	1
.əᵓſəlɔ	2
ɿɪȷnedcᵊ	3

1.5 | Vowel harmony

For the purposes of vowel harmony, vowels are divided into front and back vowels. /a/ is neutral. A root with neither front nor back vowels acts as if it has front vowels.

2 | Syntax

2.1 | Basic word order

The basic word order is VSO. Descriptors follow what they modify.

2.2 | Questions

Binary questions have the interrogative polarity marker and no change to syntax.

In wh-questions, the wh-word is pulled to the front (i. e. before the verb). This requires case marking for the wh-word:

ʃlen µeac^{ə}ȷhı nc^{ɔ}ɤ
who-ACC speak-FAR.PAST-Q PR.FAR.SG
Whom did you speak to?

This applies only to questions, not interrogative-mood clauses that act as relative clauses:

µeac^{ə}ȷhı nc^{ɔ} ʃlel, ɥıʃ µɔ.
speak-FAR.PAST-Q PR.FAR.SG who, see-NEAR.PAST PR.ANAPH_OBJ.INT
I saw the person whom you talked to.

2.3 | Multiple clauses

A sentence might have multiple clauses. Each clause in a sentence follows the basic VSO order, and clauses are separated with commas.

3 | Nouns

Nouns are declined for number, case and definiteness.

3.1 | Number

aaaaaaaaaaA has many grammatical numbers:

Table 3.1: The discrete grammatical numbers of aaaaaaaaaaA.

Number	Constraint on $x \in \mathbb{Z}$
Integral	none
Nullary	$x = 0$
Singular	$\lvert x\rvert = 1$
Dual	$\lvert x\rvert = 2$

Table 3.2: The continuous grammatical numbers of aaaaaaaaaaA.

Number	Constraint on $x \in \mathbb{R}$
Nullary	$x = 0$
Subsingular	$\lvert x\rvert < 1$
Supersingular	$1 \leq \lvert x\rvert < 2$
Plural	$\lvert x\rvert \geq 2$ or x is unknown

3.2 | Case

In a clause with both the subject and object directly expressed in that order, both the subject and object are declined in the nominative case (and their roles are inferred through word order). In a clause where only one is present, or where both are expressed in the opposite order, the subject will receive the nominative case and the object will receive the accusative case.

3.3 | Noun classes

There are three overarching groups of noun classes.

3.3.1 | Countable

Nouns in these classes are declined for a discrete number.

1. Sentient – such as humans, AIs, deities.
2. Animate – nonsentient animals.
3. Inanimate – anything else.

3.3.2 | Measurable

Nouns in this class are declined for a continuous number.

4. Measure – all measurable nouns, especially units of measurement.

3.3.3 | Uncountable

Nouns in these classes are not declined for number, and require compounding with a countable or measurable noun in order to be quantified.

5. Fluid – liquids and gases.
6. Edible – edible (to humans) non-fluids.
7. Inedible – inedible (to humans) non-fluids.
8. Abstract – abstract ideas.

3.4 | Definiteness

The definite form of a noun is formed regularly by reduplicating the first syllable (without the coda): ⟨DIJIJ⟩ “a person” becomes ⟨DIDIJIJ⟩ “the person”.

3.5 | Declension table

3.5.1 | Countable classes

Note that noun declensions respect vowel harmony. For nouns with back vowels, replace the front vowels with the back vowels of the same height and rounding, and vice versa.

Table 3.3: Declensions for countable nouns.

	Integral	Nullary	Singular	Dual

	Integral	Nullary	Singular	Dual
Sentient: ⟨ᴅɪȷɪ⟩ “person”				
Nominative	ᴅɪȷɪ	ᴅɪȷɪɿe	ᴅɪȷɪȷ	ᴅɪȷɪl
Accusative	ᴅɪȷɪn	ᴅɪȷɪnᵠɿe	ᴅɪȷɪncȷ	ᴅɪȷɪnɪl
Sentient: ⟨ȷʰɪ.en⟩ “magician”				
Nominative	ȷʰɪ.en	ȷʰɪ.eɾe	ȷʰɪ.eȷ	ȷʰɪ.el
Accusative	ȷʰɪ.eμcn	ȷʰɪ.enᵠɿe	ȷʰɪ.eμcȷ	ȷʰɪ.eμcl
(Note that the final consonant is preserved only in the integral nominative form.)				
Animate: ⟨ᴅənᵠɔ⟩ “rabbit”				
Nominative	ᴅənᵠɔ	ᴅənᵠɔɿɔᵉ	ᴅənᵠɔȷ	ᴅənᵠɔ.əᶜ
Accusative	ᴅənᵠɔn	ᴅənᵠɔnɾɔᵉ	ᴅənᵠɔn	ᴅənᵠɔnəᶜ
Animate: ⟨ȷcᵊl⟩ “fox”				
Nominative	ȷcᵊl	ȷcᵊɾe	ȷcᵊȷ	ȷcᵊ.c
Accusative	ȷcᵊμcn	ȷcᵊnᵠɿe	ȷcᵊμcȷ	ȷcᵊμc
Inanimate: ⟨hɪɾdəᵓ⟩ “statue”				
Nominative	hɪɾdəᵓ	hɪɾdəᵓɿɔᵉ	hɪɾdəᵓɿ	hɪɾdəᵓȷ
Accusative	hɪɾdəᵓᴅ	hɪɾdəᵓᴅdɔᵉ	hɪɾdəᵓdɔᵉ	hɪɾdəᵓɑəᶜ
Inanimate: ⟨.cᴅen⟩ “house”				
Nominative	.cᴅen	.cᴅeɾe	.cᴅeɿ	.cᴅeȷ
Accusative	.cᴅeμcᴅ	.cᴅeμcᴅde	.cᴅeμcde	.cᴅeμcɑc

3.5.2 | Measurable classes

Table 3.4: Declensions for measurable nouns.

	Plural	Nullary	Subingular	Supersingular
Measure: ⟨μəᴅəᶜ⟩ “day (continuous)”				
Nominative	μəᴅəᶜ	μəᴅəᶜμəᵓ	μəᴅəᶜɾ	μəᴅəᶜn
Accusative	μəᴅəᶜn	μəᴅəᶜμəᵓn	μəᴅəᶜnɾɔᵉ	μəᴅəᶜnəᶜn
Measure: ⟨ᴅel⟩ “volume” (in expressions such as ⟨ᴅel–ɥəȷɔᵉ⟩ “cupful”)				
Nominative	ᴅel	ᴅeμcᵓ	ᴅeμcɾ	ᴅeμcn
Accusative	ᴅeμcn	ᴅeμcᵓn	ᴅeμcnɾe	ᴅeμcncn
(Note that the final consonant is preserved only in the plural nominative form.)				

3.5.3 | Uncountable classes

Notably, uncountable-class noun declensions do not respect vowel harmony.

Table 3.5: Declensions for measurable nouns.

	Mass
Fluid: ⟨ɑᶩəμəᵓ⟩ “water”	
Nominative	ɑᵊμəᵓ
Accusative	ɑᵊμəᵓn
Fluid: ⟨ɷeɿleᴅ⟩ “nitrogen”	

	Mass
Nominative	ɷeʅeᴅ
Accusative	ɷeʅeᴅcn
(Here, the coda is preserved in the accusative as well.)	
Edible: ⟨ʃeµ.cᵓ⟩ “beef”	
Nominative	ʃeµ.cᵓ
Accusative	ʃeµ.cᵓn
Edible: ⟨ᴅɪn⟩ “rice”	
Nominative	ᴅɪn
Accusative	ᴅɪncn
Inedible: ⟨µəᵓʃɔ⟩ “gold”	
Nominative	µəᵓʃɔ
Accusative	µəᵓʃɔbe
Inedible: ⟨ʅıᑎıȷ⟩ “stone”	
Nominative	ʅıᑎıȷ
Accusative	ʅıᑎıȷde
Abstract: ⟨ɑʰəᵓᴅɔ⟩ “empathy”	
Nominative	ɑʰəᵓᴅɔ
Accusative	ɑʰəᵓᴅɔnᵠ
Abstract: ⟨φcȷ⟩ “[the number] five”	
Nominative	φcȷ
Accusative	φcȷcnᵠ

3.6 | Pronouns

Personal pronouns are not divided into first, second and third persons as in most languages. Instead, they fall into four categories which exhibit different behaviour depending on whether they occur as the first or second noun in the clause:

Table 3.6: Pronoun persons and their functions.

Person	Role in first position	Role in second position
Near	The speaker.	The first argument of the sentence.
Far	The listener.	If the first argument is the speaker, then the listener. Otherwise, the speaker.
Other	A third entity.	An entity that is neither the speaker, the listener nor the first argument.
Generic	A generic entity (akin to “one”).	
Anaphoric Subject	The subject of the previous clause.	
Anaphoric Object	The object of the previous clause.	

In wh-questions, the wh-word assumes the second position and the other argument becomes the first.

If a clause has no explicit arguments, the first argument is understood to be the subject.

Table 3.7: Personal pronouns. ⟨–n⟩, ⟨–en⟩ or ⟨–ɔᵉn⟩ is suffixed for the accusative case.

(continuous)	Pl. / Sub. / Sup.	Nullary	▨	▨
(discrete)	Integral	Nullary	Singular	Dual
Near	ſɪ	ɿeſɪ	ᴅe	ɑcμc
Far	dɔ	ɿɔᵉdɔ	nəᶜ	bμɪ
Other	nc	ɿenc	scᵓ	ɿɪμc
Anaph. Sub.	μɪ	ɿeμɪ	.cᴅ	nᵠcμc
Anaph. Obj.	μɔ	ɿɔᵉμɔ	.əᶜᴅ	nᵠəᶜμɔ
Generic	.əᵓ			

(For the observant readers: notice the similarity to Kavinan's system.)

3.6.1 | Last-clause pronouns

The anaphoric pronoun ⟨beȷ⟩ (accusative: ⟨beȷen⟩) is grammatically an other pronoun, and it refers to the previous clause said. Likewise, ⟨bedcȷ⟩ (accusative: ⟨bedcn⟩) refers to the clause before the previous one.

3.7 | Compounding

Nouns can be compounded together in a head-initial manner. When that happens, only the leftmost noun is the one to be declined.

ᴅel–μəȷɔᵉ–ɑˡəμəᵓ–φcȷ
volume-cup-water-five
five cupfuls of water

Note that integral pronouns can modify other nouns, in which personal possession is indicated:

ᴅel–μəȷɔᵉ–ɑˡəμəᵓ–φcȷ–ſɪ
volume-cup-water-five-PR.NEAR.INTEGRAL
(arg1)'s five cupfuls of water

Descriptors can also compound on nouns. This compounding is productive in aaaaaaaaaaA.

ᴅɪȷɪ–ɿəᵓſɪ
person-old
old people
(Compare to ᴅɪȷɪ ɿəᵓſɪ "person old-SENTIENT".)

3.8 | Possession

“X’s Y” is translated as ⟨Y=ᴅɪ ɟcl X⟩. The possessive construction is also used to create appositives.

Observe that possession marks the head, and ⟨–ᴅɪ⟩ is a clitic, not an affix, as in the following example:

ᴅəᴅənᵠɔɟ–ɑˡəɥəᵓ–ᴅɪ ɟcl ɟʰɪ.eɟ
DEF~rabbit-SING-water=GEN POS magician-SING
the magician’s water rabbit

In more casual speech, ⟨ɟcl⟩ may be dropped.

4 | Verbs

Verbs are conjugated for person of the subject, tense, polarity and tellicity, in two paradigms. Conjugation respects vowel harmony.

Table 4.1: Person-tense conjugations for verbs, using ⟨ᴅɪɿɪn⟩ "(S) eats (O)".

	Nonpast	Past
Near	ᴅɪɿɪn	ᴅɪɿɪɾ
Far	ᴅɪɿɪn	ᴅɪɿcᵊȷ
Other	ᴅɪɿɪ	ᴅɪɿcᵊ
Anaph. Sub.	ᴅɪɿe	ᴅɪɿel
Anaph. Obj.	ᴅɪɿc.e	ᴅɪɿc.el
Generic	ᴅɪɿcᵓ	ᴅɪɿcᵓ

Table 4.2: Person-tense conjugations for verbs, using ⟨µeɑcn⟩ "(S) spreads (O)".

	Nonpast	Past
Near	µeɑcn	µeɑcɾ
Far	µeɑɪn	µeɑcᵊȷ
Other	µeɑɪ	µeɑcᵊ
Anaph. Sub.	µeɑe	µeɑel
Anaph. Obj.	µeɑc.e	µeɑc.el
Generic	µeɑcᵊ	µeɑcᵊ

to which a suffix is added:

Table 4.3: Polarity-tellicity suffixes for verbs. The interrogative affix can also follow a negative affix.

	Positive	Negative	Interrogative
Telic	–·	–ɿe / –ɿɔᵉ	–hɪ
Atelic	–ᴅc / –ᴅəᶜ	–ȷɪ	–ɭcᵊ / –ɭə

Notes:

- "Negative atelic" means something akin to "unsuccessfully tried to avoid doing X".
- The interrogative polarity, in addition to marking questions, is used to mark clauses that may or may not be true but are referred to later in the sentence.

Some examples:

ᴅɪlɪn sɪɾde ʃlɔμɔ.
eat-NEAR.NONPAST fish flower
Fish eat flowers.

ᴅɪlɪn sɪɾde ʃlɔμɔ, ᴅɪlɪn nɥɪμɪ μɪ.
eat-NEAR.NONPAST fish flower, eat-NEAR.NONPAST cat PR.ANAPH_SUB
Fish eat flowers, and cats eat fish.

ᴅɪlɪn sɪɾde ʃlɔμɔ, ᴅɪle μɪʃɪbe.
eat-NEAR.NONPAST fish flower, eat-ANAPH_SUB.NONPAST grass-ACC
Fish eat flowers, and they eat grass.
(Grass is inedible to humans, but edible to fish.)

ᴅɪlɪnle ʃlɔμɔ sɪɾde.
eat-NEAR.NONPAST-NEG flower fish
Flowers don't eat fish.

dμɪ scᵓ hμchμcɷel, ȷenɪn ʃɪ beȷ.
carry-OTHER.NONPAST PR.OTHER.SG DEF~book-SG, worry-NEAR.NONPAST PR.NEAR.INT PR.LAST_CLAUSE
He has the book; that worries me.
or: That he has the book worries me.

dμɪhɪ scᵓ hμchμcɷel, ȷenɪn ʃɪ beȷ.
carry-OTHER.NONPAST-INTERROGATIVE PR.OTHER.SG DEF~book-SG, worry-NEAR.NONPAST PR.NEAR.INT PR.LAST_CLAUSE
He might have the book; that worries me.
or: That he might have the book worries me.

4.1 | Aspect

Verbs can also be marked for aspect, either using a rod sign directly on the verb, or a particle with a rod sign, placed anywhere between the verb it modifies and the next verb.

Table 4.4: Aspect markers. Those with hyphens are attached to verb. Those without hyphens are placed as separate particles anywhere after the verb.

Aspect name	Marking	Meaning
Imperfect	–1	An action that is currently going on. Also used to distinguish static actions as opposed to dynamic (e. g. *wear* as opposed to *put on*).
Interrupted	ɾlcl1	An action that was interrupted.
Perfect	–˩	An action that has already finished. Changes present tense to immediate past. Also used to distinguish dynamic actions as opposed to static (e. g. *put on* as opposed to *wear*).
Gnomic	–ʔ	A general truth or aphorism, or an action done habitually.
Gnomic dubitative	ɾlclʔ	A general truth or aphorism that the speaker considers to be false.
Deontic necessity	–ɱ	An action that the speaker insists on happening.
Epistemic necessity	ɿəᶜᴅɱ	An action that the speaker infers that is happening.
Deontic potential	–ɟ	An action that the speaker permits to occur.
Epistemic potential	ɿəᶜᴅɟ	An action that the speaker infers that might happen.
Unexpected	–ʕ	An action that is unexpected (akin to using "but").
Nonexclusive subject	ɿc1	Indicates that the subject comprises not only of what is explicitly mentioned, but also other things.
Nonexclusive object	ɿcʔ	Indicates that the object comprises not only of what is explicitly mentioned, but also other things.
Nonexclusive argument	ɿcɱ	Combination of both nonexclusive subject and nonexclusive object.

An example:

ɾuɱɪɾᴅc1 ᴅe nc, ɭcnc.elʕ dənᵠɪdɔᵉ–µɪ.
fight-NEAR.PAST-ATELIC-IMPERFECT PR.NEAR.SG PR.OTHER.INT, shoot-ANAPH_OBJ.PAST-UNEXPECTED knee-SG.ACC-PR.ANAPH_SUB.INT
I tried to fight them, but they shot my knee.

4.2 | Obliques

aaaaaaaaaaA lacks oblique arguments. Instead, equivalent expressions employ serial verb constructions. For instance, “he ate soup with a spoon” would be reduced to “he held a spoon and ate soup”:

dɥcᵊ scᵓ ɑɔᵉɿɔᵉɿ, ɒɪɿel sɪdȷcn.
INST-OTHER.PAST PR.OTHER.SG spoon-SG, eat-ANAPH_SUB.PAST soup-ACC
He held a spoon and ate soup.
or: He ate soup with a spoon.

Likewise:

nɪ.ɪ nc ȷəȷəɿ–hɪ.ɪɥ, ncɒe hɪhɪɾəᵓdɔᵉ.
TEMPORAL-OTHER PR.OTHER.INT DEF~day-SG-spring, dance-ANAPH_SUB DEF~statue-SG.ACC
They will wait until the spring equinox and dance around the statue.
or: They will dance around the statue on the spring equinox.

A similar construction can be used for the negation of obliques:

dɥcᵊɿe scᵓ ɑɔᵉɿɔᵉɿ, ɒɪɿelʕ sɪdȷcn.
INST-OTHER.PAST-NEG PR.OTHER.SG spoon-SG, eat-ANAPH_SUB.PAST-UNEXPECTED soup-ACC
He did not hold a spoon, but ate soup.
or: He ate soup without a spoon.

4.3 | Conjunctions

Conjunctions such as “and” are treated like obliques. For instance, “and” is represented by the verb ⟨ɑcn⟩, and precedes the clause in which the two are used:

ɑcᵊ \ɥcᵊȷe \ɾɪɥəl, ɒɪɿel ɾeɥ.cᵓn.
and-OTHER.PAST Ryse Tarul, eat-ANAPH_SUB.PAST beef-ACC
Ryse and Tarul ate beef.

Sufficiently complex nesting may be unrepresentable using only anaphoric referents. The easiest way to resolve this issue is to use definite nouns in place of anaphoric referents.

ɑcᵊ \ɥcᵊȷe \ɾɪɥəl, ɑcᵊ ɾeɥ.cᵓ sɪdȷc, ɒɪɿcᵊ ɒɪɒɪȷɪl ɥɪ.
and-OTHER.PAST Ryuse Tarul, and-OTHER.PAST beef soup, eat-OTHER.PAST DEF~person-DU PR.ANAPH_SUB.CONT
[They,] Ryse and Tarul ate beef and soup.

4.4 | Subordinate clauses

Ideas such as "if" or "because" are also expressed with verbs. For example, ⟨nı.cn⟩ "wait, when" is also used for "if":

ſeɥıʅehı, nı.cn ſı beȷ, aehcn.
rain-OTHER-NEG-Q, wait-NEAR PR.NEAR.INT ANAPH_CLAUSE, play-NEAR
If it doesn't rain, we will play.

Note the clausal argument to ⟨nı.cn⟩, since our condition is an entire clause instead of a noun.

4.5 | Ditransitive-like constructions

In English, some verbs such as *give* take two objects: the item being given and the recipient of the item. Since clauses in aaaaaaaaaA can take only one object, translating such verbs requires multiple clauses:

ſıφıſ ᴅe hɥchɥcɑen, nebel \ɥc^{ə}ȷen.
lose-NEAR.PAST PR.NEAR.SG DEF~book, give_to-ANAPH_SUB.PAST Ri^{u}se-ACC
I gave the book to Ryse.

4.6 | Transitivisation

Verbs that are intransitively (i. e. have no object passed at this time) can be turned into a causative form with the prefix ⟨φc–⟩:

ſlcɦcſ aɥeaɥen^{ч}e.
fall-NEAR.PAST DEF~coin
The coins fell.

ᴅe φcſlcɦc^{ə} aɥeaɥen^{ч}e
PR.NEAR.SG TRANS-fall-OTHER.PAST DEF~coin
I dropped the coins.

Note that the word order changes to SVO. In addition, the verb is conjugated for its object, rather than the subject as expected. If the following clause uses an anaphoric subject, it refers to the object of the current clause.

Moreover, the verb does not need to be one that can never take an object. In the above example, ⟨ſlcɦcn⟩ means "(S) falls on (O)". However, if the verb in question is taking an object, it cannot be transitivised directly and a more roundabout way is required:

ſlcɦcſ aɥeaɥen^{ч}e ɥıſı.
fall-NEAR.PAST DEF~coin grass

The coins fell on the grass.

ᴅe φcʃlcɾlcᵊ aɥeaɥenᶣe, ʃlcɾlel ɥɪʃibe.
PR.NEAR.SG TRANS-fall-OTHER.PAST DEF~coin, fall-ANAPH_SUB.PAST grass-ACC
I dropped the coins; they fell on grass.
or: I dropped the coins on grass.

4.7 | Clauses with nullary arguments

A clause with one or more arguments that are nullary or modified by nullary-number nouns (either through compounding or possession) will have a negative verb as well:

ᴅəʃinɿe ᴅɪȷiɿe.
recall-NEAR-NEG person-NULL
No one knows.

ʃȷclʃinɿe ᴅe ȷɪɥʃiᴅɪ ȷcl ȷʰɪ.eɿe.
want-NEAR-NEG PR.NEAR.SG ring=GEN POS magician-NULL
I don’t want the rings of any magician.

4.8 | The copula

The copula ⟨ȷcn⟩ can take a noun as an object, in which case it can mean identity or membership. (Location is expressed with ⟨ɿɪn⟩ “be at”.) With no object at all, it is used to denote existence.

It can also accept a descriptor, in which case the descriptor is attached before ⟨ȷcn⟩ in the dictionary form.

5 | Descriptors

Descriptors act as adjectives or adverbs. They follow what they modify, and are inflected for the noun class or verbal person of their antecedents.

Table 5.1: Descriptor declensions, using the descriptors ⟨heᴅʃı⟩ “large” and ⟨ɿəᵓʃı⟩ “old”.

Class or person	Declined form	
Sentient	heᴅʃı	ɿəᵓʃı
Animate	heᴅʃı	ɿəᵓʃı
Inanimate	heᴅʃe	ɿəᵓʃɔᵉ
Measure	heᴅʃıȷ	ɿəᵓʃıȷ
Fluid	heᴅʃeȷ	ɿəᵓʃɔᵉȷ
Edible	heᴅʃc	ɿəᵓʃəᶜ
Inedible	heᴅʃeᵓ	ɿəᵓʃɔ
Abstract	heᴅʃcᵊ	ɿəᵓʃə
Near	heᴅʃıµ	ɿəᵓʃıµ
Far	heᴅʃıµ	ɿəᵓʃıµ
Other	heᴅʃeµ	ɿəᵓʃeµ
Anaph. Sub.	heᴅʃıµ	ɿəᵓʃıµ
Anaph. Obj.	heᴅʃeµ	ɿəᵓʃeµ
Generic	heᴅʃcᵓµ	ɿəᵓʃəᵓµ

5.1 | Conversion

A noun can be converted to a descriptor by appending ⟨–ȷı⟩.

A descriptor can be converted to an abstract noun meaning “the nature of being ~” by replacing the final ⟨–ı⟩ with ⟨–cnel⟩.

6 | Tree mode

As mentioned in section 4.3, anaphoric referents in a linked-list sentence are sometimes insufficient for expressing even simple sentence structures. While the easiest method of resolving this issue is using definite nouns, aaaaaaaaaA also provides a mode where sentences are not linked lists of clauses, but rather (binary) trees.

6.1 | Activation

Tree mode is enabled automatically when the treeing particle ⟨nᶣı9⟩ is used, and disabled at the end of a sentence.

6.2 | Branch-switching

The aforementioned particle ⟨nᶣı9⟩ marks the beginning of the right branch of the tree. The right branch is ended by the particle ⟨nᶣıΔ⟩, which causes the next clause to join the left and right branches.

(N. B. ⟨nᶣı9⟩ and ⟨nᶣıΔ⟩ can occur only between clauses. If the particles are represented by left and right brackets, respectively, then the brackets should match.)

6.3 | Anaphoric pronouns in joiner clauses

In clauses that join two branches, anaphoric pronouns require marking whether the antecedent occurs in the left predecessor ⟨nᶣı9⟩ or the right predecessor ⟨nᶣıΔ⟩. This is done by marking the pronoun with ⟨–9⟩ or ⟨–Δ⟩.

Likewise, verbs can be modified with ⟨–9⟩ or ⟨–Δ⟩ to indicate which branch the subject came from.

6.4 | Errors

The following are ungrammatical:

- Using the particle ⟨nᶣıΔ⟩ or the branched anaphoric pronouns when tree mode is disabled

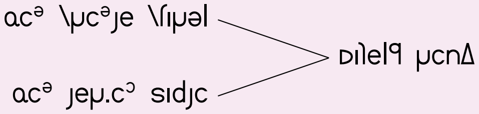
- Using the particle ⟨nᶣɪΔ⟩ other than to close a corresponding ⟨nᶣɪᑫ⟩
- Using the unbranched anaphoric pronouns in clauses with two predecessors
- Using the branched anaphoric pronouns in clauses with one predecessor
- Starting a new branch with ⟨nᶣɪᑫ⟩ when the current branch is empty

6.5 | Example

The second example in section 4.3 can be expressed as follows:

ɑcᵊ \μcᵊȷe \ɾɪμəl, nᶣɪᑫ ɑcᵊ ȷeμ.cᵓ sɪdȷc, nᶣɪΔ ᴅɪɿelᑫ μcnΔ.

The resulting tree is shown below:



7 | Numerals

aaaaaaaaaaA uses a mixed-base system for its numerals. Numerals are abstract nouns. A Perl 6 program to convert numerals can be found in Section 9.7.

7.1 | Single-digit numerals

Here are the numerals for $n < 17$:

Table 7.1: The cardinal numbers from 0 – 16.

base 10	base v	word
0	0	μəᴅ
1	1	ɑcᵊl
2	˩	ʃıȷ
3	ʔ	Ωᶣeᵓn
4	ɱ	ɑˡıμ
5	↿	φcȷ
6	ʕ	ᴅɥe
7	q	ʃȷcȷ
8	Δ	dəᵓn
9	L	hed
10	F	bənᵠ
11	7̵	nəᶜ
12	£	leᵓ
13	♯	ȷʰcd
14	A	ɥın
15	∀	ɿel
16	ψ	.ıμ

Note that digits above 9 use capital hacm letters.

7.2 | Numerals up to $19 \cdot 17$

These are represented by two digits. The multiples of 17 are shown below:

Table 7.2: Multiples of 17, up to $18 \cdot 17$.

base 10	base v	word
17	10	selcᵊ
34	⅃0	ᴅılcᵊ
51	ʔ0	Ωᶣeᵓlcᵊ
68	ɱ0	ſıᴅlcᵊ
85	ϯ0	φcȷſcᵊ
102	ʕ0	ᴅɥelcᵊ
119	90	ſȷcȷſcᵊ
136	Δ0	dəᵓnə
153	L0	helcᵊ
170	F0	bənᵠə
187	70	nəᶜlə
204	₤0	ɩeᵓlcᵊ
221	ǂ0	ȷʰcdlcᵊ
238	A0	ɥıncᵊ
255	∀0	ʅelɥcᵊ
272	Ψ0	.ılɥcᵊ
289	Ð0	ȷılscᵊ
306	Ψ̵0	heᴅdcᵊ

Thus $y \cdot 17 + x$ is written $\langle x\text{-}y \rangle$.

7.3 | Numerals up to $13 \cdot 19 \cdot 17 = 4199$

These are represented by three digits. The multiples of $19 \cdot 17$ are listed below:

Table 7.3: Multiples of $19 \cdot 17$, up to $12 \cdot 19 \cdot 17$.

base 10	base v	word
323	100	hıȷıſın
646	⅃00	ſıȷıſın
969	ʔ00	Ωᶣeᵓȷeſın
1292	ɱ00	ɑˡıμıſın
1615	ϯ00	φcȷıſın
1938	ʕ00	ᴅɥeȷıſın
2261	900	ſȷcȷıſın
2584	Δ00	dəᵓnıſın
2907	L00	heɑıſın
3230	F00	bənᵠıſın

base 10	base v	word
3553	7̵00	nəᶜȷıɾın
3876	£00	leᵓȷıɾın

Thus $(z \cdot 19 \cdot 17) + (y \cdot 17) + x$ is written ⟨z-x-y⟩.

7.4 | Numerals up to and including $4199 \cdot (4199 + 1)/2 = 8817900$

The numeral for 4199 is ⟨ɿə.ɔləᶜ⟩, written as ⟨1:000⟩.

Likewise, two ⟨ɿə.ɔləᶜ⟩ is written as ⟨⅃:000⟩ and pronounced ⟨ɿə.ɔləᶜ–ɾıȷ⟩, but the second ⟨ɿə.ɔləᶜ⟩ is one smaller than the first. In other words, ⟨⅃:000⟩ = $4199 + (4199 - 1) = 8397$.

Table 7.4: “Multiples” of ⟨ɿə.ɔləᶜ⟩.

“Multiple”	Difference from last	Total
(0)		0
1:000	4199	4199
⅃:000	4198	8397
ʔ:000	4197	12594
ɲ:000	4196	16790
ᛅ:000	4195	20985
...		
£ᛘ∀:000	3	8817897
£ᛘΨ:000	2	8817899
1::000:000	1	8817900

Thus the nth “multiple” differs from the $(n-1)$th multiple by $(4199+1-n)$ (given $1 \leq n \leq 4199$), and the sum of the first n “multiples” is

$$
\begin{aligned}
y(n) &= \sum_{i=1}^{n} (4200 - n) \\
&= \frac{1}{2} \cdot (8399 \cdot n - n^2)
\end{aligned}
\tag{7.1}
$$

And likewise, for some given y, the largest “multiple” of ⟨ɿə.ɔləᶜ⟩ not smaller than y has the index

$$
N(y) = \left\lfloor \frac{1}{2} \cdot \left(8399 - \sqrt{70543201 - 8 \cdot y}\right) \right\rfloor \tag{7.2}
$$

In other words, for any numeral ⟨n_1:n_2⟩, $n_1 + n_2$ must be less than 4199.

7.5 | Higher numerals

The *bases* of higher numerals b_i can be derived from the recurrence relation

$$b_i = \begin{cases} 4199 & \text{if } i = 1 \\ \dfrac{b_{i-1} \cdot (b_{i-1} + 1)}{2} & \text{otherwise} \end{cases} \tag{7.3}$$

Then b_i acts as a new triangular base. Equations 7.1 and 7.2 can be generalised to the following:

$$y(n, b_i) = \sum_{i=1}^{n} (b_i + 1 - n) \tag{7.4}$$

$$= \frac{1}{2} \cdot (n \cdot (2 \cdot b_i + 1 - n)) \tag{7.5}$$

$$N(y, b_i) = \left\lfloor \frac{1}{2} \cdot \left(2 \cdot b_i - \sqrt{4 \cdot b_i^2 + 4 \cdot b_i + 1 - 8 \cdot y} \right) \right\rfloor \tag{7.6}$$

It follows that $y(n_1, b_i) + n_2$ is represented as $\langle n_1 \vdots^{i} n_2 \rangle$ (i colons), and such a numeral must satisfy $n_1 + n_2 < b_i$.

Here are the names of the bases themselves:

Table 7.5: Names of higher bases.

Base	base v	word
b_1	1:000	ɿə.ɔləᶜ
b_2	1::000:000	ᴅeµcᵓʃɪ
b_3	1:::000:000::000:000	ʃˡlµə
b_4		ɷencoɪ

7.6 | Cardinal and ordinal numerals

Cardinal numerals compound to their antecedents; ordinal numerals use the possessive ⟨–ᴅɪ ȷcl⟩ construction:

ᴅcɑɪ–ɷᶣeᵓn
child-three
three children

ᴅcɑɪȷᴅɪ ȷcl ɷᶣeᵓn
child-SG=GEN POS three
the third child

8 | Names

Names fall into two grammatical categories:

- *Nominal names* act as nouns. They are usually single words.
- *Clausal names* are entire clauses. These names usually refer to places, although a few people have clausal names. In extreme cases, such a name can span multiple clauses.

8.1 | Nominal names

These names act as nouns, and they are preceded by a backslash ⟨\⟩. If the name spans multiple words (as common in foreign names), spaces are escaped by backslashes. No distinction is made between native and foreign names.

Only personal names can stand on their own, and even then, only given or full names. Other names must modify a common noun describing the nature of what is named, in the integral number without definiteness.

Table 8.1: Some examples of nominal names.

Name	Type
\μcᵊȷe	Personal (native)
\ʃıμəl	Personal (native)
\μeᴅcn	Personal (foreign)
dμeᵓᴅe–\oılı.c	Place (foreign)

Native names will usually respect vowel harmony. Children of parents who work in professions demanding physical labour (e. g. bricklaying) will usually have names with back vowels. In contrast, those born to parents of professions that do not demand physical strength (e. g. computer programming) will usually bear names with front vowels.

8.2 | Clausal names

These names comprise of one or more clauses. Due to the nature of clausal names, they are all considered native. Most of these names refer to places; personal clausal names are almost always nicknames or such. Orthographically, they are put into square brackets ⟨[]⟩.

Clausal names are used by saying them as their own clauses, then using an anaphoric pronoun to backreference the entity described by the name in question. The type of anaphoric pronoun used varies from name to name. It might be the anaphoric subject pronoun, the object pronoun or the last-clause pronoun.

We call the *referent* the subject, the object or the verb of the last clause, respectively depending on the type of anaphoric pronoun used to refer to the name. If the referent is a noun, it must be declined in the integral number without definiteness.

Here, as common in maps and such, the referent will be capitalised. However, other contexts that make the type of anaphoric pronoun to use clear do not use this type of capitalisation.

Table 8.2: Some examples of clausal names.

Name	Type	Literal meaning
[AEӾѱЄᴲ dɦɪʃȷɪ ʃɔɑɔɿ]	Place	The trees *covered* the ground
[ᴅəʃɪ ΦӾEᵌÐE μcᵊɿ–\lеɷμcᵓ]	Place	The *city* remembers the Šedrŷ star
[ɑcᵊ ɿμɪʃə–ᴅɪ ȷcl ȷəμ ȷʰɪ.en–ᴅɪ ȷcl ɿɪɷcᵓ, φoeȷc.el ΦӾEᵌÐEÐ]	Place	The *city* was founded by the warrior of the sun and the wizard of the moon
[ᴅeȷɪ \ѰƎTFЭ ȷcᵊl–selcᵊ]	Personal	*Gulto* takes care of 17 foxes

An example of usage:

nɪ.ɹ bɪnen–bəȷ, [ᴅəʃɪ dμeᵓᴅe μcᵊɿ–\lеɷμcᵓ], ȷʰɪ ᴅɪᴅɪȷɪȷ .ᴄᴅ.
wait-OTHER year-future, (name), go-OTHER DEF~person-SG PR.ANAPH_SUB.SG
He will go to Muta Pröme Ryk-Šedrŷ next year.

9 | Calendar

Domain II, which contains *Rymako* has a day that is 26.99410 hours long. Other figures are given in terms of local days:

Table 9.1: Astronomical measures for Domain II.

Period	Length in local days
Local (synodic) day	1.00000
Sidereal day	0.99699
Tropical year (l_y)	301.94714
Sidereal year	302.03719
Synodic month (l_m)	30.80152
Sidereal month	27.95032

9.1 | Tides

In Domain II, the offset of the sea level due to the tide can be modeled by the following equations:

$$y = y_s + y_m \tag{9.1}$$

$$y_s = A_s \cdot (1 + A_{sa} \cdot \cos(\tau \cdot t)) \cdot \cos(2 \cdot \tau \cdot t) \tag{9.2}$$

$$y_m = A_m \cdot \left(1 + A_{ma} \cdot \cos\left(\frac{\tau \cdot t}{l_m}\right)\right) \cdot \cos\left(\frac{2 \cdot \tau \cdot (1 - l_m) \cdot t}{l_m}\right) \tag{9.3}$$

where:

$$
\begin{aligned}
\tau &= 2 \cdot \pi \\
A_s &\approx 0.675 \\
A_{sa} &\approx 0.0532 \\
A_m &\approx 1.267 \\
A_{ma} &\approx 0.176 \\
y &= \text{offset of sea level in metres} \\
t &= \text{time since HAT in local synodic days}
\end{aligned}
$$

An exact solution to $dy/dt = 0$ is not known to exist. However, the solutions to this equation can be found numerically. Consult Section 9.5 for a Sage program to do so.

As the calendar used by aaaaaaaaaaA uses the high and low tides to count time, it is not synchronised even with days. The basic unit of time in the calendar is the *tidal day* ⟨μəᴅəᶜ⟩ (l_t) – the amount of time between a high tide and the second high tide thereafter, which is, on average, 1.03356 local synodic days, but can vary considerably. Thus:

$$
\begin{aligned}
l_m/l_t &\approx 29.80148 && (9.4) \\
&\approx 4053/136 && (9.5) \\
l_y/l_m &\approx 9.80299 && (9.6) \\
&\approx 7215/736 && (9.7)
\end{aligned}
$$

This suggests that:

1. most months will have 30 days, but every 136 months, 27 months will have only 29.

2. most years will have 10 months, but every 736 years, 145 years will have only 9.

9.2 | Months

Months follow a 136-month cycle wherein the $5n+2$-numbered months (zero-indexed, $n \in \mathbb{N}$) have 29 days and the other months have 30.

The names of months, on the other hand, are determined from their positions relative to the first month of the year:

Days within a month are indexed from one.

9.3 | Years

The lengths of the year follow a 736-year cycle as specified in Figure 9.1. The code used to generate this table can be found in Section 9.6.

Table 9.2: The months of the year.

#	Name
0	ɑəᵓbəᵓ
1	ɥcᵊ.eᴅ
2	ʃȷɪφɔl
3	ᴅəɥəȷɪ
4	ͻɗeɥɪᴅ
5	ʃɔᵉᴅəʃ
6	nᵠəɥəᶜʃ
7	ⅼcbclı
8	bɔᴅəᵓ˥
9*	.cȷeᵓɥɪ

9.4 | Eras

Years are grouped further into *eras* ⟨˥ıɥɪ⟩, which change on major historical events. The start of a new era resets the month and year cycle. Eras can also start in the middle of a year of the previous era; thus, the start of the year is different for each era. The *crossover date* of an era is the date of the era that coincides with the first day of the next; in other words, it is the date immediately after the last day of the era.

Table 9.3: The months of the year.

Name	Crossover date	Days between	Cumulative
˥ıɥɪ–ɥə˥ɔᵉ	₯ ͻɗeɥɪᴅ ⅬΔ˩	889726	889726
˥ıɥɪ–˥əᵓʃı	1˩ ʃȷɪφɔl ʕ∀ʕ	642508	1532234
˥ıɥɪ–˥ıȷnedcᵊ	Δ ⅼcbclı ˩ʔ₤	207366	1739600
˥ıɥɪ–nchel	(to present)		

The first day of ⟨˥ıɥɪ–nchel⟩ coincides with the founding of the (not yet named).

Figure 9.1: Table of year lengths in a cycle.

```
    0123456789 |     0123456789 |     0123456789 |     0123456789
 0 XXXXX9XXXX |  19 XX9XXXX9XX |  38 9XXXX9XXXX |  57 XXX9XXXX9X
 1 9XXXX9XXXX |  20 XXX9XXXX9X |  39 9XXXX9XXXX |  58 XXX9XXXX9X
 2 9XXXX9XXXX |  21 XXX9XXXX9X |  40 9XXXXX9XXX |  59 XXX9XXXX9X
 3 9XXXX9XXXX |  22 XXX9XXXX9X |  41 X9XXXX9XXX |  60 XXXX9XXXX9
 4 9XXXX9XXXX |  23 XXX9XXXX9X |  42 X9XXXX9XXX |  61 XXXX9XXXX9
 5 9XXXX9XXXX |  24 XXX9XXXX9X |  43 X9XXXX9XXX |  62 XXXX9XXXX9
 6 9XXXX9XXXX |  25 XXX9XXXX9X |  44 X9XXXX9XXX |  63 XXXX9XXXX9
 7 X9XXXX9XXX |  26 XXX9XXXXX9 |  45 X9XXXX9XXX |  64 XXXX9XXXX9
 8 X9XXXX9XXX |  27 XXXX9XXXX9 |  46 X9XXXX9XXX |  65 XXXX9XXXX9
 9 X9XXXX9XXX |  28 XXXX9XXXX9 |  47 XX9XXXX9XX |  66 XXXX9XXXXX
10 X9XXXX9XXX |  29 XXXX9XXXX9 |  48 XX9XXXX9XX |  67 9XXXX9XXXX
11 X9XXXX9XXX |  30 XXXX9XXXX9 |  49 XX9XXXX9XX |  68 9XXXX9XXXX
12 X9XXXX9XXX |  31 XXXX9XXXX9 |  50 XX9XXXX9XX |  69 9XXXX9XXXX
13 X9XXXXX9XX |  32 XXXX9XXXX9 |  51 XX9XXXX9XX |  70 9XXXX9XXXX
14 XX9XXXX9XX |  33 XXXXX9XXXX |  52 XX9XXXX9XX |  71 9XXXX9XXXX
15 XX9XXXX9XX |  34 9XXXX9XXXX |  53 XX9XXXXX9X |  72 9XXXX9XXXX
16 XX9XXXX9XX |  35 9XXXX9XXXX |  54 XXX9XXXX9X |  73 9XXXX9
17 XX9XXXX9XX |  36 9XXXX9XXXX |  55 XXX9XXXX9X |
18 XX9XXXX9XX |  37 9XXXX9XXXX |  56 XXX9XXXX9X |
```

```
9: 9 months
X: 10 months
```

Listings of programs

9.5 | workfiles/7/tides.sage

```
# How many values to output

limit = int(sys.argv[1]) if len(sys.argv) > 1 else 1000

# :P

tau = 2 * pi

t = var("t")

# Constants

A_s = 0.675; A_sa = 0.0532; A_m = 1.267; A_ma = 0.176; l_m = 30.80152

# Solar component
y_s2 = A_s * (1 + A_sa * cos(tau * t)) * cos(2 * tau * t)
# Lunar component
y_m2 = A_m * (1 + A_ma * cos(tau * t / l_m)) * cos(2 * tau * t / l_m - 2 * tau * t)
y = y_s2 + y_m2
yp = diff(y, t)

# High and low tides occur at values of t where dy/dt = 0.

i = 0
time = 0
print(0)
while i < limit:
  try:
    time2 = find_root(yp == 0, time + 0.000000001, time + 0.35)
    print(time2)
    time = time2
    i += 1
  except:
    time += 0.01
```

workfiles/7/tides.sage

9.6 | workfiles/7/bins.pl6

```
# CONSTANTS

constant \MONTHS_PER_YEAR_CYCLE = 7215;
constant \YEARS_PER_YEAR_CYCLE = 736;
constant \AVG_MONTHS_PER_YEAR = MONTHS_PER_YEAR_CYCLE /
    YEARS_PER_YEAR_CYCLE;

# COMPUTATION
# For each year, take as many months as are needed
# in order to cycle to the next.

my $c = 0;
my @k;

for 0 ..^ YEARS_PER_YEAR_CYCLE -> $i {
  my $need = 1 - ($c - floor($c));
  my $objs = ceiling($need * AVG_MONTHS_PER_YEAR);
  @k[$i] = $objs;
  $c += $objs / AVG_MONTHS_PER_YEAR;
}

# DISPLAY

my \cols = 4;
my $len = @k.elems;

say ("    0123456789" xx cols).join(" | ");

my \total-rows = ceiling($len / 10);
my \rows = ceiling(total-rows / cols);

for 0 ..^ rows -> $j {
  for 0 ..^ cols -> $p {
    print(" | ") if $p != 0;
    my $q = $j + rows * $p;
    next if $q >= total-rows;
    printf("%3d ", $q);
    for 0 ..^ 10 {
      my $i = 10 * $q + $_;
      if $i >= $len { print " "; }
      else {
        print "0123456789XE".substr(@k[$i], 1);
      }
    }
  }
  say "";
}
```

workfiles/7/bins.pl6

9.7 | workfiles/7/conno.pl6

```
my $digits-str = "0123456789TKXSNVFMD";
my @digits = $digits-str.comb;

sub convert-small-fwd($n, $pad = False) {
  die "$n must be < 4199" if $n >= 4199;
  my $a = $n div (19 * 17);
  my $b = ($n div 17) % 19;
  my $c = $n % 17;
  return
    (!$pad && $a == 0 ?? "" !! @digits[$a]) ~
    (!$pad && $b == 0 && $a == 0 ?? "" !! @digits[$b]) ~
    @digits[$c];
}

sub convert-small-back($s) {
  die "$s must be 3 chars or fewer" if $s.chars > 3;
  my $c = $digits-str.index($s.substr(* - 1, 1) // "0");
  my $b = $digits-str.index($s.substr(* - 2, 1) // "0");
  my $a = $digits-str.index($s.substr(* - 3, 1) // "0");
  return $c + 17 * ($b + 19 * $a);
}

sub triangle($n, $p) {
  return ($n * (2 * $p + 1 - $n)) div 2;
}

sub sqrt-floor($y) {
  die "$y is negative" if $y < 0;
  return $y if $y < 2;
  my $small = sqrt-floor($y +> 2) +< 1;
  my $large = $small + 1;
  return $small if $large * $large > $y;
  return $large;
}
sub sqrt-ceil($y) {
  my $n = sqrt-floor($y);
  return $n if $n * $n == $y;
  return $n + 1;
}

sub untriangle($y, $p) {
  return (2 * $p + 1 - sqrt-ceil(4 * $p * $p + 4 * $p - 8 * $y + 1))
    div 2;
}

my @powers = (4199);

for 0 .. 10 {
  my $p = @powers[* - 1];
  @powers.push: $p * ($p + 1) div 2;
}

sub convert-large-fwd-h($n, $i, $pad = False) {
  # base case
  if $i == 0 {
    return convert-small-fwd($n, $pad);
  }
  # recursive
  my $super = untriangle($n, @powers[$i - 1]);
  my $infra = $n - triangle($super, @powers[$i - 1]);
  if $super == 0 && !$pad {
    return convert-large-fwd-h($infra, $i - 1, False);
  }
  return
    convert-large-fwd-h($super, $i - 1, $pad) ~
    (":" x $i) ~
    convert-large-fwd-h($infra, $i - 1, True);
}

sub convert-large-fwd($n, $pad = False) {
  my $i = 0;
  ++$i while @powers[$i] <= $n;
  convert-large-fwd-h($n, $i, $pad);
}

sub convert-large-back($s) {
  # Find the longest run of colons
  my @matches = ($s ~~ m:g/":"+/); #/"
  if (!@matches) {
    return convert-small-back($s);
  }
  my $longest-match = @matches.max(*.chars);
  my $i = (~$longest-match).chars;
  my $left = $s.substr(0, $longest-match.from);
  my $right = $s.substr($longest-match.to);
  my $sup = convert-large-back($left);
  my $inf = convert-large-back($right);
  return triangle($sup, @powers[$i - 1]) + $inf;
}

multi MAIN(Int :$fwd) {
  say convert-large-fwd($fwd);
}
multi MAIN(Str :$back) {
  say convert-large-back($back);
}
```

workfiles/7/conno.pl6

9.8 | workfiles/7/count-days.pl6

```
# Count the number of days between 1/0/0 and D/M/Y, inclusive.

# CONSTANTS

constant \MONTHS_PER_YEAR_CYCLE = 7215;
constant \YEARS_PER_YEAR_CYCLE = 736;
constant \AVG_MONTHS_PER_YEAR = MONTHS_PER_YEAR_CYCLE /
    YEARS_PER_YEAR_CYCLE;
constant \MONTHS_PER_MONTH_CYCLE = 136;
constant \DAYS_PER_MONTH_CYCLE = 4053;

# COMPUTATION
# For each year, take as many months as are needed
# in order to cycle to the next.

my $c = 0;
my @k = (0);

for 0 ..^ YEARS_PER_YEAR_CYCLE -> $i {
  my $need = 1 - ($c - floor($c));
  my $objs = ceiling($need * AVG_MONTHS_PER_YEAR);
  @k[$i + 1] = $objs;
  $c += $objs / AVG_MONTHS_PER_YEAR;
}

my @cumk = [\+] @k;

sub months-before-year($year) {
  my $whole-cycles = $year div YEARS_PER_YEAR_CYCLE;
  my $remainder = $year % YEARS_PER_YEAR_CYCLE;
  return $whole-cycles * MONTHS_PER_YEAR_CYCLE + @cumk[$remainder];
}

my @m = (0);

for 0 ..^ MONTHS_PER_MONTH_CYCLE -> $i {
  @m.push: ($i % 5 == 2) ?? 29 !! 30;
}

my @cumm = [\+] @m;

sub days-before-month($month) {
  my $whole-cycles = $month div MONTHS_PER_MONTH_CYCLE;
  my $remainder = $month % MONTHS_PER_MONTH_CYCLE;
  return $whole-cycles * DAYS_PER_MONTH_CYCLE + @cumm[$remainder];
}

sub days-before-date($d2, $m, $y) {
  my $d = $d2 - 1; # d is 0-indexed
  my $bm = months-before-year($y) + $m;
  return days-before-month($bm) + $d;
}

sub MAIN($d2, $m, $y) {
  say days-before-date($d2, $m, $y);
}
```

workfiles/7/count-days.pl6

Romanisation

In this text, the romanisation is used only to transcribe names into English. Whenever possible, the hacmisation should be used.

Table 9.4: The consonants of aaaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	m	n	ñ	ŋ	
Plosive	p b	t d	ť ď	k g	’
Fricative	f	s	š	h	
(coarticulated)	þh	fh		fš	
Affricate		ts	tš		
Lateral fricative		ł			
Approximant		r	j	w	
Lateral approximant		l			
Trill		ř			

Table 9.5: The vowels of aaaaaaaaaaA.

Spread	Half-rounded	Rounded
i	y	ŷ
ï	u	û
e		ö
ë		o
a		

Rod signs are represented by the Arabic digits ⟨1 2 3 4 5 6 7 8⟩ attached to the end of the verbs they encompass. Proper words are preceded by a backslash ⟨\⟩.