

Archaic cuneiform numbers

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	Uruk III & earlier	ED – Ur III	OB & later
Numerals	This proposal		
Non-numeric signs	Future Pcun	Existing Xsux	

Table 1: Usage of existing, proposed, and future characters across functions and time periods.

7 Acknowledgements

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1 Summary

This document proposes encoding some numerals used in the Uruk and Early Dynastic periods in conjunction with the Sumero-Akkadian cuneiform script¹ and the proto-cuneiform script². The proposed characters are listed in section 2.

The non-numeric signs of proto-cuneiform will be the subject of a separate proposal; we need only note here that the divergence between the approaches to character identity in modern scholarship requires that proto-cuneiform be disunified from cuneiform: proto-cuneiform is effectively treated as an undeciphered script. In contrast, the cuneiform encoding model is semantic, requiring an understanding of the text to correctly encode it.

However, the *numerals* used in proto-cuneiform should be unified with ones used in the Early Dynastic period, for the reasons set forth in section 4. The proposed “curved”, or “curviform”, numerals³ should however *not* be unified with the already-encoded cuneiform numerals⁴. Since the encoding proposals for the cuneiform script twenty years ago provisionally considered the curviform numerals to be glyph variants of the cuneiform numerals, a detailed rationale is provided in section 3, including compatibility considerations in section 3.7.

The overall picture of unifications and disunifications over time is illustrated in table 1. The Script_Extensions property assignments in section 2.2 reflect the overlap.

[TODO(egg): Mention the other sections here too.]

¹ISO 15924: Xsux, Script property value long name: Cuneiform; encoded since Unicode Version 5.0.

²ISO 15924: Pcun, not yet encoded.

³ 𐎶 1-9(aš^c = N_1), 𐎵 1-5(u^c = N_{14}), 𐎶 1-9(ḫeš₂^c = N_{34}), 𐎶 1-5(ḫeš^cu^c = N_{48}), etc.

⁴ 𐎶 1-9(aš), 𐎵 1-5(u), 𐎶 1-9(ḫeš₂), 𐎶 1-5(ḫeš^cu), etc.

2 Proposed changes to the Standard

2.1 Summary of proposed characters

2.2 Properties





2.3 Character names list

2.4 Core specification text

3 Rationale for curviform–cuneiform disunification

TODO(egg): blurb.

3.1 The cuneiform encoding model


As outlined in, *e.g.*, [UTR56], the cuneiform encoding model is diachronic; each character may have wildly different glyphs depending on time period and region. For instance, the sign IM may resemble  in texts from Early Dynastic IIIa Šuruppag as in the character code charts,  later in the third millennium⁵,  in Old Babylonian cursive,  in Neo-Assyrian, but is always encoded as U+1214E CUNEIFORM SIGN IM.

This encoding model allows for the interoperable representation of editions of diachronic reference works such as sign lists⁶ and dictionaries⁷, and of composite texts⁸. By being compatible with similarly diachronic transliteration practice (that is, by avoiding distinctions finer than those made in transliteration), the encoding model also allows for automated conversion of transliterated corpora to cuneiform, which has proven useful as a processing step in analyses such as [Rom24; JJ24]⁹. The diachronic approach is also useful for pedagogical applications¹⁰.

3.2 Arguments for curviform–cuneiform unification



























In this context, the argument was made in [Ando4], as part of discussion of the cuneiform encoding¹¹ that the curviform numerals, which occasionally appear in the Ur III period and are used heavily in the Early Dynastic period, were a stylistic distinction unifiable with the cuneiform digits, and that an archaizing Ur III font or an Early Dynastic font could have curviform glyphs for the appropriate characters.

















Some co-occurrence of curviform and cuneiform digits was known and acknowledged. [Ando4, p. 3] cites [NDE93, p. 62], which is a copy of [P020054], an Early Dynastic IIIb administrative tablet from Nirsu. The excerpt cited, lines 1–3 of column 1 of the obverse, is as follows:





⁵Merging with U+1224E  NI₂.

⁶Notably [VT+14] and the online edition of [Bor10] in [Jim+23, Signs].

⁷Notably [TJV17] and the online edition of [Sch10] in [Jim+23, Dictionary].

⁸For example, there are Neo-Assyrian and Neo-Babylonian copies parts of the laws of                          



 ¹²						
1(NĖŠ ₂)	1(U)	1/2(DIŠ)	5(DIŠ <i>tenû</i>)	gi	us ₂	sa ₂
	7.5 (ropes)		5	reed	side	equal
 ¹³						
3(U)	6(DIŠ <i>tenû</i>)	gi	saṇ	sa ₂		
3(ropes)	6	reed	front	equal		
	•					
ašag-bi	1(BUR ₃)	1(EŠE ₃)	1(IKU)	1/2(IKU)		
this field						

tug_x(LAK483)-si-ga-kam¹⁴
deep ploughing



The argument made in [Ando4, p. 4] is that this is comparable to a stylistic distinction such as¹⁵


465 metres, equal lengths
198 metres, equal widths
this field: 9, 18 hectares, deeply ploughed




where the numerals have the same structure ([Ando4] contrasts this to the different structures of ASCII digits and roman numerals). That document further claims that “the number signs do not normally carry in their individual signs the meaning of what they are used to measure”, and that curviform and cuneiform numerals “are not normally mixed together in a single numerical expression”, noting the exceptions of [P232278; P232280]. In addition, [Ando4, p. 4] points out that the cuneiform numeric signs are descended from the curviform ones (this is undisputed), and claims there is only a small re-allocation of the function of signs (from  to -numerals). It therefore comes to the conclusion that the use of curviform numerals should be seen as a formatting distinction, rather than one that should be represented in plain text, and insists that the encoding should capture the lineal historical descent of those signs, presumably to take advantage of the benefits of diachronic encoding described in section 3.1.

Although they had been part of the preliminary proposal [EFT03], the curviform numerals were therefore removed from [EFT04b] and [EFT04a], which both state that “The distinction between curved numerals and their cuneiform descendants is treated as glyphic for the purposes of the present proposal; this issue will need to be revisited in subsequent encoding phases.”

The time has come to revisit this issue. As we will see in section 3.3, numerals can only be interpreted in the context of what they measure *i.e.*, as part of a metrological system. In section 3.4 we will see that in some periods:

- the functions and use of the numerals vary beyond the mere / switch;

¹²As noted in [Pow87, p. 466], this sign has a very short “tail” in this period, so that it is wider than it is tall, and can at first seem like a large  in copies. The photos in CDLI clearly show that this is in fact a vertical wedge.

¹³Note that ED IIIb  numerals have a somewhat different appearance from those of the Ur III period used in this transcription; the sign  in [P020054] looks more like Ur III .

¹⁴Transliteration after [Lec20, p. 8].

¹⁵We have taken the liberty of adjusting the analogy to use measures approximately equal to those in [P020054], instead of a field of five by twenty-five metres.

- ### 3.3 Metrology

Edubha'g D

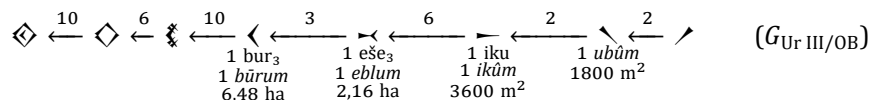
As is well known¹⁶ a sexagesimal place value system (SPVS) was used in Mesopotamia from the late third millennium onwards. One should bear in mind, however, that other systems were used; the SPVS was primarily used in calculations, with results being expressed in non-positional systems [Robo8, p. 76; Rob22]. The digits 1–59 of the SPVS have inner structure which is reflected in the encoding: the digits 1–9 are the individual characters I – III , the multiples of ten (10–50) are < – X , but the other digits 11–59 are sequences < I – X III ; in effect the base-sixty digits are themselves written in base ten, with a different set of symbols for the tens place. This reflects the origin of the sexagesimal place value system; it derives from a *non-positional* system, hereafter the *cuneiform discrete counting system* $\mathcal{S}_{\text{Ur III/OB}}$, which had different signs for the units I – III , tens < – X , sixties I – X III (with larger wedges than the units), six hundreds I – X III , three thousand six hundreds I – X III I – X III , and thirty-six thousands I – X III I – X III I – X III .







$$\diamond \xleftarrow{10} \diamond \xleftarrow{6} \nmid \xleftarrow{10} \nmid \xleftarrow{6} \prec \xleftarrow{10} \nmid \quad (S_{\text{Ur III/OB}})$$

¹⁷These diagrams, which have become standard in discussions of Mesopotamian metrology, originate with [Fri78, p. 10], where they are called *step-diagrams*.

3.3.2 The area system

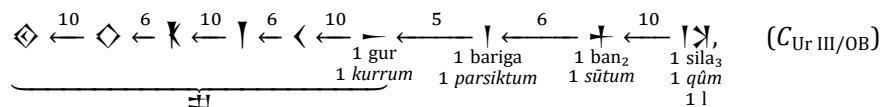
The discrete counting system was not the only non-positional system in use in the Ur III and Old Babylonian periods; different systems were in use depending on what was being counted or measured. For instance, field areas were measured using the following system, where for the named units we have provided the name of the unit in transliterated Sumerian, normalized Old Babylonian Akkadian, and the approximate metric equivalent [Fri07, p. 378; Rob19]:



Note that for the range of areas given above¹⁸, this system does not use any symbols separate from the numerals for the individual units (*ubûm*, *ikûm*, *eblum*, and *bûrum*). As mentioned in [Rob19], the whole numeric expression for the area would be followed by the sign  functioning as punctuation¹⁹, but the numerals are tied to the metrology; thus a surface of 5 *bûrû* 1 *eblum* 4 *ikû* (100 *ikû*, 36 ha) would be written²⁰  5 1 4 . Contrast this with systems where the same numerals are used for different units, and overt units are used, as in “88 acres 3 roods 33 perches”. Note also that the same signs are shared between multiple systems, with different relations; the ŠAR₂ sign  is equal to sixty times the U sign  in the area system, but to three hundred and sixty times  in the discrete counting system.

3.3.3 The capacity system

Another such system of note is the one for capacities²¹ [Fri07, p. 376; Rob19],

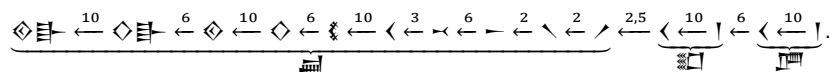


where the numerals for ban₂ are 𐎶, 𐎷, 𐎸, 𐎹, and 𐎺, and those for bariga are 𐎠, 𐎡, 𐎢, and 𐎣 (contrast ordinary 𐎢 and 𐎣 otherwise used with 𐎠-numerals). As described in [Hue1, p. 585 with notes (b) and (f)], the sign GUR 𐎡𐎠, while it is used only with volumes in excess of one gur, is written after the whole expression, after the overt unit sign 𐎶 if present, and after the word for “grain” if present, as in

²²

354 gur 3 ban₂ 6 sila₃ of grain.

¹⁸For areas smaller than a quarter *ikūm*, an overt unit is used, with 1 *mūšarum* (36 m²) written 𒄩𒄪, equal to one hundredth of an *ikūm*, then sexagesimally subdivided in 60 𒄩 (shekels). For areas greater than 3600 *būrū*, the 𒄩- and 𒄪-numerals are reused with a suffix 𒄩 (gal, Sumerian: big), as follows [Robo8, p. 295 with notes b and c; Fri07, p. 378; Rob19]:



¹⁹TODO(egg): acknowledge Proust 2020 but note that this is irrelevant to encoding concerns

²⁰As in the surface of the field of (the city of Apisal) reported on [P102305, r. 1]

²¹Used for volumes of grain, but also oil, dairy products, beer, etc., as well as to express the capacity of boats; volumes of earthworks instead use system $G_{Ur III/OB}$ based on a height of one cubit, see[[Pow87](#), p. 488; [Rob08](#), p. 294; [Rob19](#)].

In addition, there are Akkadian names for the half-rope and half-reed, see [Pow87, pp. 463 sq.].

3.3.5 Fractions

TODO

3.4 Early metrology

At first sight, the metrological systems from the Early Dynastic period match the ones previously mentioned. In particular, the discrete counting system used in the Early Dynastic period (and earlier in the Uruk period) clearly mirrors system $S_{Ur III/OB}$ [Fri07, p. 374; DE87, pp. 127, 165]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \blacktriangleright \xleftarrow{10} \blacktriangleright \xleftarrow{6} \bullet \xleftarrow{10} \blacktriangleright. \quad (S)$$

Likewise the area system used in the Early Dynastic IIIb period mirrors system $G_{Ur III/OB}$ [Dei22, p. 72; NDE93, p. 63; Fri07, p. 378; Gom16]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \bullet \xleftarrow{10} \bullet \xleftarrow{3} \blacktriangleright \xleftarrow{6} \blacktriangleright, \quad (G_{ED IIIb})$$

As noted in [And04, p. 4] (see section 3.2), the vertical \uparrow from $S_{Ur III/OB}$ becomes a horizontal \blacktriangleright in system S . It is however far from the only case of such a reallocation of function. The earlier form of System G was [DE87, pp. 141, 165; Fri07, p. 378]:

$$\bullet \xleftarrow{6} \odot \xleftarrow{10} \bullet \xleftarrow{3} \blacktriangleright \xleftarrow{6} \blacktriangleright, \quad (G)$$

Observe that, as noted in [DE87, p. 142], \odot changes meaning from $10\bullet$ in system G to $10\bullet$ in system $G_{ED IIIb}$. System G is used in the Uruk period, but also in the ED I–II period (it is the “area 2” system in [Cha03], whereas $G_{ED IIIb}$ is the “area 1” system).

3.4.1 Field lengths in Nirsu



The length system Early Dynastic IIIb of the state of Lagaš is of particular interest. As described in [Pow87, p. 466; Lec20, pp. 289 sq.], lengths are expressed in rods, but the unit sign \blacktriangleright is generally omitted; in addition, only tens of rods are used; these are equal to one rope, but the sign \blacktriangleright is not written either. Length shorter than one rope are expressed in half-ropes using the $1/2$ sign \blacktriangleright (again with no \blacktriangleright), and then in reeds, *with* the sign \blacktriangleright . Effectively, this yields the following factor diagram:

$$\begin{array}{c} \uparrow \xleftarrow{6} \blacktriangleright \xleftarrow{2} \blacktriangleright \xleftarrow{10} \blacktriangleright \blacktriangleright \blacktriangleright \\ \text{1 eše}_2 = 10 \text{ nindan} \\ \text{1 rope} = 10 \text{ rods} \\ \text{60 m} \end{array} \quad \begin{array}{c} \text{gi} \\ \text{reed} \\ \text{3 m} \end{array}. \quad (L_{ED IIIb})$$

This is the system that was used to express the sides of the field in [P020054] discussed in section 3.2. In that tablet and others from the same period, such as the ones discussed in [Lec20] areas are expressed in system $G_{ED IIIb}$, with curviform numerals²⁶; in the absence of overt units, such as when dealing with length that are integer multiples of a half-rope²⁷, the use of curviform or cuneiform numerals

























²⁶TODO(egg): Note the handful of late Urukagina tablets that start to have cuneiform areas.

²⁷This is the case of the sides of the field in [P020054, obv. ii 2–3].

therefore disambiguates a numeric expression between an area and a length, and therefore the interpretation of its numerals between systems $G_{ED IIIb}$ and $L_{ED IIIb}$. The sign GAN_2 , which would also disambiguate the interpretation as an area, is sometimes used after areas in ED IIIb Lagaš, but not systematically; in particular the area of the first field in [P020054] does not use this suffix. See [Lec20] for many examples with and without .

3.4.2 Dyke lengths in Nirsu

[Pow87, p. 466] notes that reeds “are regularly written with the normal, cuneiform end of the stylus. Higher units are usually written with the reversed (round) end of the stylus.” Powell does not elaborate on the specifics of this mixed use of numerals, but a cursory search in CDLI finds many occurrences²⁸, such as:

- [P221305]                         <

The 𒂗𒂗𒂗 and 𒂗𒂗𒂗 are generally counted using curviform numerals, and the smaller units using cuneiform 𒂗 numerals. Indeed, a search on [Mil+07] for co-occurrences of 𒂗𒂗𒂗 with either of 𒂗𒂗𒂗 or 𒂗𒂗𒂗 finds the following expressions³²:

1. [P240532, verso 4, 9] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ ³⁴
2. [P240548, verso 1, 1] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
3. [P240655, recto 7, 9] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ ³⁵
4. [P240579, verso 4, 3] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
5. [P240675, verso 2, 2] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
6. [P240609, verso 3, 1] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
7. [P240533, recto 3, 3] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
8. [P240697, recto 1, 5] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ ³⁶
9. [P240653, recto 6, 2] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
10. [P240654, recto 2, 6] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ ³⁷
11. [P240531, recto 1, 8] $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
12. [P241708, recto 1, 1]³⁹ $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$
13. [P241904, recto 1, 1]⁴⁰ $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ ⁴¹

Note that higher numbers of 𒂗𒂗𒂗 are expressed in hundreds (*mi-at* 𒂗𒂗𒂗) and then thousands (*li-im* 𒂗𒂗𒂗), as is typical in Ebla [Arc15, p. 33], e.g., in [P240532, verso 2, 3], $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$ (100 + 60 + 30 + 5 = 195 𒂗𒂗𒂗 of grain). These expressions match the following factor diagram:

$$\underbrace{\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}}_{\text{𒂗𒂗𒂗}} \xleftarrow{\frac{5}{3}} \text{𒂗} \xleftarrow{6} \text{𒂗} \xleftarrow{10} \text{𒂗} \xleftarrow{2} \text{𒂗} = \text{𒂗𒂗𒂗} \xleftarrow{\frac{5}{2}} \text{𒂗} \xleftarrow{4} \text{𒂗} \xleftarrow{6} \text{𒂗} \text{𒂗𒂗𒂗} \quad (C_{\text{Ebla}})$$

3.4.4 Use in modern publications

Because of their prevalence in the Early Dynastic period, the proposed numerals are used modern publications discussing Metrology from that period, as illustrated in figures TODO.

Since they contrast with the cuneiform numerals, they likewise appear contrastively in such publications. A remarkable example of that is found in Figure 2. The partial⁴² transliteration “4^𒂗 *a₃-da-um* 4^𒂗 *aktum* 4^𒂗 *ib₂^{tu} × 3* *sa₆ gunu₃*” is used to illustrate a discussion of the interpretation of the contrast between 𒂗 and

³²We cite here only one attestation per tablet; most tablets contain several expressions mixing curviform 𒂗𒂗𒂗 and larger with cuneiform 𒂗𒂗𒂗 and smaller. In all cases the transcriptions given here are based on the EbDA transliterations, but the shape and orientation of the numerals was checked³³ on a photograph (from EbDA unless noted otherwise).

³³As we will see in Section 3.6.1, CDLI transliterations indicate numeral shape; however, as of this writing, they do so incorrectly on the Ebla corpus, claiming that all numerals are curviform, so we were not able to rely on them in this specific case.

³⁴ba-ri₂-zu₂, a variant spelling.

³⁵Short for 𒂗𒂗𒂗 .

³⁶Note the omitted 𒂗𒂗𒂗 .

³⁷Instead of the expected 𒂗𒂗𒂗 .

³⁸ 𒂗𒂗𒂗 not legible on the EbDA photo.

³⁹From CDLI photo.

⁴⁰From photo in [Arc89, p. 6].

⁴¹Laid out as 𒂗𒂗𒂗 ; on stacking patterns see Section 6.2.

⁴²The untransliterated text would be $\text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗} \text{𒂗𒂗𒂗}$; note the atomically encoded $\text{ib}_2 \times 3$ = $\text{𒂗𒂗} \times \text{𒂗}$ = 𒂗𒂗𒂗 .

Figure 1: Discussion of the contrast between \triangleright and \triangledown numerals in [Gori2023]

Figure 2: Transliteration in [Gori2023] of [P242293] incorporating untransliterated numerals.

3.5 Non-numeric usage

Examenstext A

⁴³TODO cite the EbDA one.

Note that in [Rom24] [TODO(egg): Cite the GitHub repository], as in many other such analyses, numbers are removed as an early step in processing; these therefore would not benefit from diachrony in the encoding of numeric expressions.

3.6.1 Compatibility with transliteration

3.7 Compatibility considerations

3.7.1 The case of ŠAR₂

4 Rationale for ED–Uruk numeral unification

5 Considerations on individual numeral series

[TODO Document to the extent possible the metrological systems in which each sign is used. Note the disunification of N₉ and N₁₀ from 4(ban₂@c) and 5(ban₂@c).]

6 Characters not included in this proposal

6.1 Missing numerals

(N₁₇, 12N₁₄, etc.) 7(diš tenû)

6.2 Stacking patterns

(... are a mess, vary within Uruk, and are not transliterated/documented by Englund, so let's not go there for now.)

6.3 Matters for higher-level protocols

Rotated bits: <https://cdli.mpiwg-berlin.mpg.de/artifacts/101087>

7 Acknowledgements

TODO(egg): Something about the Vanséveren fonts

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