

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), 𐎷 1-5(u^c = N_{14}), 𐎸 1-9(ḫeš₂^c = N_{34}), 𐎹 1-5(ḫeš^cu^c = N_{48}), etc.

⁴ 𐎶 1-9(aš), 𐎷 1-5(u), 𐎸 1-9(ḫeš₂), 𐎹 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 Šuruppak 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 Dy-

















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                                  



nastic IIIb administrative tablet from Nirsu. The excerpt cited, lines 1–3 of column 1 of the obverse, is as follows:

 ¹²						
1(NEŠ 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 [And04, 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 ([And04] 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, [And04, 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:

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.

- the functions and use of the numerals vary beyond the mere $\text{𐎶}/\text{𐎵}$ switch;
- the contrast between curviform and cuneiform numerals is commonly used to distinguish metrological systems;
- some metrological systems commonly mix curviform and cuneiform in single numerical expressions.

3.3 Metrology

𐎶𐎵 𐎶𐎵𐎶𐎵𐎶𐎵 𐎶𐎵
 𐎶𐎵 𐎶𐎵𐎶𐎵𐎶𐎵 𐎶𐎵𐎶𐎵𐎶𐎵
 𐎶𐎵 𐎶𐎵𐎶𐎵𐎶𐎵 𐎶𐎵𐎶𐎵𐎶𐎵

I want to write tablets: the tablet of 1 gur of barley to 600 gur; the tablet of 1 shekel of silver to 10 minas [...]

Edubba'a D

Before diving into the usage of the curviform numerals in the Early Dynastic period to explain the contrast with cuneiform numerals, it is useful to understand the usage of the already-encoded characters in the Ur III and Old Babylonian periods.

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 [Rob08, 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 𐎶–𐎶𐎶, the multiples of ten (10–50) are 𐎵–𐎶𐎶𐎶, but the other digits 11–59 are sequences 𐎵–𐎶𐎶𐎶; 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* $S_{\text{Ur III/OB}}$, which had different signs for the units 𐎶–𐎶𐎶, tens 𐎵–𐎶𐎶𐎶, sixties 𐎶–𐎶𐎶𐎶𐎶 (with larger wedges than the units), six hundreds 𐎶–𐎶𐎶𐎶, three thousand six hundreds 𐎶–𐎶𐎶𐎶𐎶𐎶𐎶, and thirty-six thousands 𐎶–𐎶𐎶𐎶𐎶𐎶𐎶𐎶.

3.3.1 The discrete counting system

The relations between the values of the signs in the cuneiform discrete counting system may be summarized by the following factor diagram¹⁷, where the number over arrow indicates the multiple of the preceding sign (right of the arrow) corresponding to the following sign (left).

$$\text{𐎶} \xleftarrow{10} \text{𐎵} \xleftarrow{6} \text{𐎶} \xleftarrow{10} \text{𐎶} \xleftarrow{6} \text{𐎶} \xleftarrow{10} \text{𐎶} \quad (S_{\text{Ur III/OB}})$$

For example, the number $1729 = ((2 \times 10 + 8) \times 6 + 4) \times 10 + 9 = 28 \times 60 + 49$ would be written 𐎶𐎶𐎶𐎶𐎶𐎶 in the discrete counting system, and 𐎶𐎶𐎶𐎶𐎶 in the sexagesimal place value system.

¹⁶See, e.g., [Uni16, Section 22.3.3 “Non-Decimal Radix Systems”, sub “Cuneiform Numerals”].

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

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 [Ando4, 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-rope 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:

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

This is the system that was used to express the sides of the field in [Po20054] discussed in section 3.2. In that tablet and others from the same period, such as the ones, 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

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

3.4.2 Dyke lengths in Nirsu

— [P221305] 

— [P221305] 

— [P020129] 

— [P221291] 

— [P221266] 

$$\underbrace{\text{D} \xleftarrow{2} \text{H}}_{\text{D}} \xleftarrow{10} \text{H} \xleftarrow{6} \text{H} \xleftarrow{3} \text{H} \xrightarrow{\text{H}} \text{H} \quad (L'_{\text{ED IIIb}})$$






$$\underbrace{\text{♭} \xleftarrow{10} \text{♮} \xleftarrow{6} \bullet \xleftarrow{2} \text{♯} \xrightarrow{10} \text{♮}}_{\text{♭} \xleftarrow{10} \text{♮}} \quad (L''_{\text{ED IIIb}})$$

3.4.3 Grain in Ebla

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

²⁹TODO(egg): Note that one unit may be omitted if the other is present










The system of grain³⁰ capacities in Ebla uses the following units³¹:

 $\xleftarrow{2}$  $\xleftarrow{\frac{5}{2}}$  $\xleftarrow{4}$  $\xleftarrow{6}$ 




gu₂-bar ba-ri₂-zu ŋin₄ niŋ₂-sagšu an-zam_x

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

- [illegible]

Note that higher numbers of  are expressed in hundreds (*mi-at* ) and then thousands (*li-im* , as is typical in Ebla [Arc15, p. 33], e.g., in [P240532, verso 2, 3],  (100 + 60 + 30 + 5 = 195  of grain).

³⁰Liquid capacities use a different system [Arc15, p. 229 with note 12]:





 $\xleftarrow{30}$

 $\xleftarrow{6}$


At a glance it seems that \triangleright are counted with cuneiform numerals and higher units with curviform ones, thus

$\frac{5}{3}$ 6 10 3 $\frac{10}{2}$ 6 | * > ,

but we have not investigated this thoroughly.

³¹TODO mention the other one citing Chambon and the footnote in Archi

³²We cite here only one attestation per tablet; most tablets contain several expressions mixing cursive   and larger with cuneiform  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 \perp .

³⁶Note the omitted $\square \Diamond \perp$.

³⁷Instead of the expected $\nabla \langle \nabla \mathbf{f} |$.

³⁸  not legible on the EbDA photo.

³⁹From CDLI photo.

⁴⁰From photo in [Arc89, p. 6].

⁴¹Laid out as $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$; on stacking patterns see Section 6.2.

These expressions match the following factor diagram:

[illegible]

3.4.4 Use in modern publications

3.5 Non-numeric usage

The beginning of the scribal art is a single wedge. That one has six pronunciations; it also stands for 'sixty'. Do you know its reading?

Examenstext A

[TODO(egg): In a footnote, comment on the $\mathbb{P} \prec \mathbb{Q}$ situation.]

3.6 Limited benefits of diachronic encoding for numerals

[Composite texts dating back to the period where curved numerals are in use tend to be limited to lexical texts, which do not usually have numbers. When they do, diachronic encoding is prevented by diš-aš distincticons anyway. Administrative texts, which are where numbers are most prominent, are not composite.]

[Diachronic reference works tend to not include numbers, or when they do, to treat them specially (for instance, they are shown at the end of sign lists such as `TODO`).]

[The overarching goal of having consistent representation for equivalent numeric expressions from different periods is quickly foiled by changes in metrology.]

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

(N_{17} , $12N_{14}$, 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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