

# Archaic cuneiform numbers

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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 script<sup>1</sup> and the proto-cuneiform script<sup>2</sup>. 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”, numerals<sup>3</sup> should however *not* be unified with the already-encoded cuneiform numerals<sup>4</sup>. 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.]

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

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

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

<sup>2</sup>ISO 15924: Pcun, not yet encoded.

<sup>3</sup>Impressed into clay using cylindrical styli, held either perpendicular to the tablet, yielding • (small stylus) or ● (large stylus), or at a shallower angle: ◻, ◻ (small stylus), ◻ (large stylus). Some numerals are composed of multiple such impressions, e.g., ◻◻.

<sup>4</sup>Impressed into clay using a stylus with a trihedral end: ◻ (stylus held horizontally), ◻ (vertically), ◻ (diagonally) ◻ (diagonally with the stylus rotated along its axis), ◻ (stylus pressed deeper, forming a larger wedge), ◻ (combining ◻ and ◻), 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 millennium<sup>5</sup>,  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 lists<sup>6</sup> and dictionaries<sup>7</sup>, and of composite texts<sup>8</sup>. By being compatible with similarly diachronic transliteration practice, *i.e.*, 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]<sup>9</sup>. The diachronic approach is also useful for pedagogic applications<sup>10</sup>.

### 3.2 Arguments for curviform–cuneiform unification


In this context, the argument was made in [L2/04-099], as part of discussion of the cuneiform encoding<sup>11</sup> 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. [L2/04-099, 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:

<sup>5</sup>Merging with U+1224E cuneiform sign ni2.



<sup>6</sup>Notably [OSL] and the online edition of [MZL] in [eBL, Signs].

<sup>7</sup>Notably [ePSD2] and the online edition of [Sch10] in [eBL, Dictionary].

<sup>8</sup>For example, there are Neo-Assyrian and Neo-Babylonian copies parts of the laws of , as well as Old Babylonian copies in both archaizing and cursive styles. Because of damage on the stele [P249253], some sections are known only from those copies. See [Oel22, pp. 110 sqq.].

<sup>9</sup>Attendees may recall the summary given on the third day of UTC #180, as recorded in [L2/24-159]. Other readers may refer to [Svā+24, pp. 242, 148].

<sup>10</sup>For instance, Old Babylonian grammar may be taught in the Neo-Assyrian script, as in [Cap02].

<sup>11</sup>At that time scoped to the repertoire of the Ur III period and later; see [L2/03-162, p. 1], although many disunifications, such as  ≠ , were informed by Early Dynastic distinctions.



- ### 3.3 A primer on classic Ur III and Old Babylonian metrologies











This intertwining of units and numerals explains the large number of already-encoded numeral series:

- $\mathbb{I}$ - $\mathbb{W}$  used in  $S_{\text{Ur III/OB}}$  and the SPVS as well as with overt units;
- $\mathbb{L}$ - $\mathbb{X}$  used in  $G_{\text{Ur III/OB}}$ , of which  $\mathbb{L}$ - $\mathbb{X}$  are also used in  $S_{\text{Ur III/OB}}$  and the SPVS as well as with overt units;
- $\mathbb{I}$ - $\mathbb{W}$  used in  $S_{\text{Ur III/OB}}$ , and sometimes with overt units;
- $\mathbb{L}$ - $\mathbb{X}$  used in  $S_{\text{Ur III/OB}}$ ;
- $\mathbb{L}$ - $\mathbb{X}$  used in  $S_{\text{Ur III/OB}}$  and  $G_{\text{Ur III/OB}}$ ;
- $\mathbb{L}$ - $\mathbb{X}$  used in  $S_{\text{Ur III/OB}}$  and  $G_{\text{Ur III/OB}}$ ;
- $\mathbb{L}$ - $\mathbb{X}$  used in  $C_{\text{Ur III/OB}}$  as well as with overt units of the weight system;
- $\mathbb{L}$ ,  $\mathbb{L}$ ,  $\mathbb{L}$ ,  $\mathbb{L}$ ,  $\mathbb{L}$  used in  $C_{\text{Ur III/OB}}$ ;
- $\mathbb{L}$ ,  $\mathbb{L}$ ,  $\mathbb{L}$ ,  $\mathbb{L}$  used in  $C_{\text{Ur III/OB}}$ —note the overlap with  $\mathbb{L}$ - $\mathbb{W}$ ;
- $\mathbb{L}$  and  $\mathbb{L}$  used in  $G_{\text{Ur III/OB}}$ .

### 3.3.4 The length system

 60 ←  10 ←  12 ←  30 ←  (L<sub>Ur III/Ob</sub>)  
 danna  
berum  
league  
10.8 km  
 US<sup>25</sup>  
cable  
360 m  
 nindan  
nindanum  
rod  
6 m  
 kuš<sub>3</sub>  
ammatum  
cubit  
50 cm  
 šu-si  
ubānum  
finger  
17 mm


( $\bar{l}_{Ur III/OB}$ )

*eš<sub>2</sub>*  
*ašlum*  
 rope  
 60 m

*gi*  
*qānum*  
 reed  
 3 m

<sup>25</sup>TODO

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 Curviform numerals in early metrologies

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]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \text{◐} \xleftarrow{10} \text{◑} \xleftarrow{6} \bullet \xleftarrow{10} \text{◒}. \quad (S)$$

Likewise the area system used in the Early Dynastic IIIb period mirrors system  $G_{Ur III/Ob}$  [LAK, p. 72; NDE93, p. 63; Fri07, p. 378; Lec16]:

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \text{◐} \xleftarrow{10} \bullet \xleftarrow{3} \text{◑} \xleftarrow{6} \text{◒}, \quad (G_{ED IIIb})$$

As noted in [L2/04-099, p. 4] (see section 3.2), the vertical  $\uparrow$  from  $S_{Ur III/Ob}$  becomes a horizontal  $\text{◐}$  in system  $S$ . It is however far from the only case of such a reallocation of function. The earlier form of System  $G$  is [DE87, pp. 141, 165; Fri07, p. 378]:

$$\bullet \xleftarrow{6} \odot \xleftarrow{10} \bullet \xleftarrow{3} \text{◑} \xleftarrow{6} \text{◒}, \quad (G)$$

Observe that, as noted in [DE87, p. 142],  $\odot$  changes meaning from  $10\bullet$  in system  $G$  to  $600\bullet$  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 of the Early Dynastic IIIb 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  $\text{𒌦}$  is generally omitted; in addition, only tens of rods are used; these are equal to one rope, but the sign  $\text{𒌦}$  is not written either. Length shorter than one rope are expressed in half-rope using the  $1/2$  sign  $\text{𒌦}$  (again with no  $\text{𒌦}$ ), and then in reeds, *with* the sign  $\text{𒌦}$ . Effectively, this yields the following factor diagram:



$$\begin{array}{c} \uparrow \xleftarrow{6} \text{◐} \xleftarrow{2} \text{𒌦} \xleftarrow{10} \text{𒌦} \text{ }^{28} \\ \begin{array}{l} 1 \text{ eše}_2 = 10 \text{ nindan} \\ 1 \text{ rope} = 10 \text{ rods} \\ 60 \text{ m} \end{array} \qquad \begin{array}{l} \text{gi} \\ \text{reed} \\ 3 \text{ m} \end{array} \end{array} \quad (L_{ED IIIb})$$

This is the system that was used to express the sides of the field in [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 numerals<sup>29</sup>; in the absence of overt units, such as when dealing with length that

<sup>28</sup>Note that the reeds are counted using *tenû* numerals,  $\text{𒌦}$ ,  $\text{𒌦}$ ,  $\text{𒌦}$ , etc.


<sup>29</sup>TODO(egg): Note the handful of late Urukagina tablets that start to have cuneiform areas.



are integer multiples of a half-rope<sup>30</sup>, the use of curviform or cuneiform numerals 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 , 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.” [TODO(egg): also mention Krebernik 1998 p. 303 n. 686.] Powell does not elaborate on the specifics of this mixed use of numerals, but a cursory search in CDLI finds many occurrences<sup>31</sup>, such as:

- [P221305, obv. 1, 4]<sup>32</sup>                                   

The system of grain<sup>36</sup> capacities in Ebla uses the following units<sup>37</sup>:

$$\begin{array}{c} \text{gu}_2\text{-bar} \xleftarrow{2} \text{ba-ri}_2\text{-zu} \xleftarrow{\frac{5}{2}} \text{nin}_4 \xleftarrow{4} \text{nin}_2\text{-sagšu} \xleftarrow{6} \text{an-zam}_x \end{array}$$

The  $\text{gu}_2\text{-bar}$  and  $\text{ba-ri}_2\text{-zu}$  are generally counted using curviform numerals, and the smaller units using cuneiform  $\text{!}$  numerals. Indeed, a search on [EbDA] for co-occurrences of  $\text{an-zam}_x$  with either of  $\text{gu}_2\text{-bar}$  or  $\text{ba-ri}_2\text{-zu}$  finds the following expressions<sup>38</sup>:

1. [P240532, verso 4, 9]  $\text{gu}_2\text{-bar} \text{ ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$ <sup>40</sup>
2. [P240548, verso 1, 1]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$
3. [P240655, recto 7, 9]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$ <sup>41</sup>
4. [P240579, verso 4, 3]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$
5. [P240675, verso 2, 2]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$
6. [P240609, verso 3, 1]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$
7. [P240533, recto 3, 3]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x \text{ an-zam}_x$
8. [P240697, recto 1, 5]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$ <sup>42</sup>
9. [P240653, recto 6, 2]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x \text{ an-zam}_x$
10. [P240654, recto 2, 6]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x \text{ an-zam}_x$ <sup>43</sup>
11. [P240531, recto 1, 8]  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x \text{ an-zam}_x$ <sup>44</sup>
12. [P241708, recto 1, 1]<sup>45</sup>  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$
13. [P241904, recto 1, 1]<sup>46</sup>  $\text{ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$ <sup>47</sup>

Note that higher numbers of  $\text{gu}_2\text{-bar}$  are expressed in hundreds (*mi-at*  $\text{mi-at}$ ) and then thousands (*li-im*  $\text{li-im}$ ), as is typical in Ebla [Arc15, p. 33], e.g., in [P240532, verso 2, 3],  $\text{mi-at} \text{ li-im} \text{ ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x$  (100 + 60 + 30 + 5 = 195  $\text{gu}_2\text{-bar}$  of grain).

<sup>36</sup>Liquid capacities use a different system [Arc15, p. 229 n. 12]:

$$\text{la-ha} \xleftarrow{30} \text{sil}_3 \xleftarrow{6} \text{an-zam}_x$$

At a glance it seems that  $\text{sil}_3$  are counted with cuneiform numerals and higher units with curviform ones, thus

$$\text{mi-at} \text{ li-im} \text{ ba-ri}_2\text{-zu} \text{ nin}_4 \text{ nin}_2\text{-sagšu} \text{ an-zam}_x \xleftarrow{\frac{5}{2}} \text{sil}_3 \xleftarrow{6} \text{an-zam}_x \xleftarrow{10} \text{an-zam}_x \xleftarrow{3} \text{an-zam}_x \xleftarrow{\frac{10}{3}} \text{an-zam}_x \xleftarrow{6} \text{an-zam}_x$$

but we have not investigated this thoroughly.

<sup>37</sup>TODO mention the other one citing Chambon and the footnote in Archi

<sup>38</sup>We cite here only one attestation per tablet; most tablets contain several expressions mixing curviform  $\text{ba-ri}_2\text{-zu}$  and larger with cuneiform  $\text{nin}_4$  and smaller. In all cases the transcriptions given here are based on the EbDA transliterations, but the shape and orientation of the numerals was checked<sup>39</sup> on a photograph (from EbDA unless noted otherwise).

<sup>39</sup>As we will see in Section 3.7.2, 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.

<sup>40</sup>ba-ri<sub>2</sub>-zu<sub>2</sub>, a variant spelling.

<sup>41</sup>Short for  $\text{gu}_2\text{-bar}$ .

<sup>42</sup>Note the omitted  $\text{gu}_2\text{-bar}$ .

<sup>43</sup>Instead of the expected  $\text{nin}_4 \text{ nin}_2\text{-sagšu}$ .

<sup>44</sup> $\text{an-zam}_x$  not legible on the EbDA photo.

<sup>45</sup>From CDLI photo.

<sup>46</sup>From photo in [Arc89, p. 6].

<sup>47</sup>Laid out as  $\text{an-zam}_x$ ; on stacking patterns see Section 6.2.



TODO figure

Figure 4: TODO [Cha03, p. 6]

formed by only two signs  $\Upsilon$  and  $\text{◀}$ , repeated as many times as necessary; this type of notation is highly standardized. Second, the order of magnitude of the numbers noted in this system is not indicated: 1, 60, 60<sup>2</sup>, 60<sup>3</sup>, 1/60, 1/60<sup>2</sup>, etc. are written in the same way, with the vertical wedge  $\Upsilon$ . The third feature concerns the exact function of

Figure 5: TODO [Cha12, p. 58]

one step. The scribes of the Early Dynastic Period (c. 2600 BC), for instance, represented the number 648,000 with:  $\Upsilon\text{◀}\bullet\bullet\bullet$  but never with the repetition  $\Upsilon\text{◀}\Upsilon\text{◀}\Upsilon\text{◀}\bullet\bullet\bullet$ .

Figure 6: TODO [Cha12, p. 59]<sup>50</sup>

repetition of the same sign refers to both the capacity unit signified—often but not necessarily written immediately afterwards—and its value. The units of measurement are written in descending order from left to right—just as we would write 3 km, 120 m, 50 cm. For example:

$\Upsilon\text{◀}\Upsilon\text{◀}\Upsilon\text{◀}$  še bar  $\text{◀}$  ba-ri-zu  
 ‘3 gubar (capacity units) and 1 parīsu’.

Figure 7: TODO [Cha12, p. 61]

This is particularly true of the signs  $\text{◀}$ ,  $\text{◀}$ ,  $\text{◀}$  and  $\text{◀}$ , whose form explicitly denotes the fractions 1/6, 2/6, 3/6, and 4/6 of the barig capacity measure written  $\text{◀}$  in Mesopotamia—also transcribed by Assyriologists as 1 bán, 2 bán, 3 bán, and 4 bán with reference to the bán measure worth 1/6 of the barig. At Ebla, the sign  $\text{◀}$  is most often associated with the *parīsu* measure, while the signs  $\text{◀}$ ,  $\text{◀}$ ,  $\text{◀}$  and  $\text{◀}$  refer to 1, 2, 3,

Figure 8: TODO [Cha12, p. 64]

shape. The principle of notation is additive: each sign is noted as many times as necessary (e.g.,  $\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}\text{◀}$  transliterated as 2(šar<sub>2</sub>) 1(geš’u) 3(u), means  $2 \times 3600 + 1 \times 600 + 3 \times 10$ ). The system is based on an alternation of factors ten and

Figure 9: TODO

might think of one fabric and a half,<sup>11</sup> but the presence of notations with “2▷2▽”, “3▷3▽”, and “6▷6▽” (Fig. 1) elements excludes that one deals with fractions, as these notations are not consistent with those of Šuruppag’s weight measurement system.<sup>12</sup> The notation “1▷gada” in o. ii 1 and r. vi 1, along with the total of “39



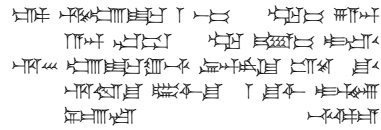
Fig. 1. Combinations of numerals attested in Š. 742.

Figure 10: Discussion of the contrast between ▷ and ▽ numerals in [Gor23, p. 162].

as, for example, in TM.75.G.3125 = ARET III 107 o. iv 1, “4▷ ‘a<sub>3</sub>-da-um<sup>u9</sup>-2 4▽  
aktum 4▷ib<sub>2</sub><sup>u9</sup>×3▽ sa<sub>6</sub> gunu<sub>3</sub>” (Fig. 2).

Figure 11: Transliteration in [Gor23, p. 163] of [P242293, recto 4, 1] incorporating untransliterated numerals.

### 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’<sup>51</sup>. Do you know its reading<sup>52</sup>?

Examenstext A

Many of the cuneiform numerals are used with a logographic or phonetic value. For example, the sign — has, *inter alia*, the values aš, rum, and dili. While the horizontal numerals are most frequently written ▷ in the Early Dynastic period<sup>53</sup>, such non-numeric usage is almost<sup>54</sup> always written —, for instance:

- in personal names in administrative texts, such as the following, which all contain ▷ numerals:
  - — in [P010424; P010458; P010459] from ED IIIa أبو صلايخ,
  - — in [P010960] from ED IIIa Šuruppag,
  - — in [P251641] from ED IIIb Adab,

encoded  $ib_2 \times 3! = \text{𐎶} \times \text{𐎶} = \text{𐎶𐎶}$ .

<sup>49</sup>TODO cite the EbDA one.
















<sup>50</sup>TODO(egg): On the order cite TSS 188, Friberg2007 p. 148 and any of the usual suspects on the haphazard order of signs in early texts; contrast P274845, P241764.





<sup>51</sup>The reader will recall that  $\eta e\dot{s}_2$  is written 𐎶, with a larger wedge than 𐎶; however, these signs have merged by the time Examenstext A is composed.

<sup>52</sup>Besides  $\eta e\dot{s}_2$ , a look at [OSL] shows that the values diš, ge<sub>3</sub>, makkaš, saṇtak<sub>4</sub>, and tal<sub>4</sub> are attested both in [ePSD2] and in lexical lists. The sign is also used for the Akkadian word *ana* in the Neo-Assyrian period.

<sup>53</sup>A CDLI search for “(asz@c)” finds 3296 ED texts, while a search for “(asz)” finds 81 ED texts, of which 46 also contain “(asz@c)”.














<sup>54</sup>Exceptions are discussed in section 3.7.1.





-    in [P252866] from ED IIIb Adab,
-    in [P298637] from ED IIIb Umma;
- in the Sumerian word   $\rightarrow$  u<sub>2</sub>-rum, “property” in ED IIIb Nirsu administrative texts which contain  numerals, such as [P020006; P020008; P020018; P020024; P020030];
- in lexical texts:
  - in the divine name     $\rightarrow$   in the lexical texts [P010570; P010572], where the entries are prefixed with .
  - in the word  $\rightarrow$  dili, “small fish” in [P010578], witness to Early Dynastic Fish,
  - in the same word with a determinative,  $\rightarrow$   dili<sup>ku<sub>6</sub></sup>, in [P010586], witness to Early Dynastic Food, which starts with  numerals.



This is a clear contrast between  $\rightarrow$  and  in this period, and genuine ambiguity can arise if it is lost; for instance, the personal name  $\rightarrow$   occurs on its own line in the aforementioned administrative texts; a line   would instead be read as “one slave”.

### 3.6 Limited benefits of diachronic encoding for numerals

The argument in favour of diachronic encoding is that it facilitates interoperability in a variety of use cases, as we have outlined in section 3.1. While these benefits are real and now visible for cuneiform signs, similar considerations are not generally applicable to curviform numerals.

Diachronic reference works such as sign lists and dictionaries tend to not include numbers, or when they do, they treat them separately, and include signs such as  $\rightarrow$  that have both numeric and non-numeric values in both the main list and the section on numbers. For instance, [KWU, pp. 123 sqq.] lists all of  $\rightarrow$ – together with –, while  $\rightarrow$ , , and , and only those, appear at the beginning of the sign list, since they have non-numeric values<sup>55</sup>. [PTACE, p. 58] has the numeric signs , , , whereas non-numeric  $\rightarrow$  is at the beginning of the sign list, where its values *as* and *rum* are listed. For signs with both non-numeric and numeric usage, [LAK] writes *s. die Zahlz.* throughout the main list; LAK 1  $\rightarrow$  thus reappears at LAK 829 together with , , and . One should note [MZL], which has numbers throughout the sign list; but that sign list does not show glyphs predating the Old Babylonian period, nor does it comprehensively cover the numerals used in the Ur III and Old Babylonian periods, as, for instance, it does not have – used in system *G<sub>Ur III/OB</sub>*.

Composite texts rarely have witnesses both from the Early Dynastic period and later; the kinds of texts that do, chiefly lexical and literary texts, do not contain numbers to the extent that administrative texts do. Further, there tend to be changes<sup>56</sup> to the text between Early Dynastic and later witnesses that prevent a diachronic encoding of such composites. For numerals, the switch from  to  numerals prevents diachronic encoding even if  were unified with  $\rightarrow$ . For instance, the lexical list Early Dynastic Food, already mentioned in section 3.5, contains some numbers, and has a witness from the Old Akkadian period covering these numbers: [P215653, a 1’–6’]; however, they are written with  numerals, whereas they are writ-

<sup>55</sup>Non-numeric values of  $\rightarrow$  were discussed in section 3.5;  has the values *man*<sub>3</sub> and *min*<sub>5</sub>, and is used for the word *didli*, “several, various”;  has the value *eš*<sub>6</sub>.

<sup>56</sup>TODO comment on the ED witnesses to the instructions of Šuruppak

ten with  $\triangleright$  numerals in the Early Dynastic witnesses; since  $\uparrow$  and  $\leftarrow$  are distinct<sup>57</sup> characters, the  $\triangleright \leftarrow$  unification does not help.

More generally, since numbers are so deeply tied to metrology, and since metrological systems change between the Early Dynastic and later periods<sup>58</sup>, there is little opportunity for a diachronic representation of numeric quantities.

In the case of analyses such as [Romach2023], it is interesting to note that numeric expressions are removed prior to the conversion of the corpus to Unicode cuneiform for further analysis.

### 3.7 Compatibility considerations

A disunification twenty years after the fact, affecting all numerals, would ordinarily be a serious compatibility issue. Fortunately, with the exception of one character discussed below, we are not aware of any font using curviform glyphs for the already-encoded numerals. In fact we are not aware of any font designed for a style earlier than Old Babylonian, except for fonts mimicking the representative glyphs from the code charts, which are primarily Ur III, but sometimes earlier or later, as described in [UTR56, §2.4]. The lack of dedicated Ur III fonts may be explainable by the chart-like fonts<sup>59</sup> being good enough for most purposes; the lack of Early Dynastic fonts, by the aforementioned issues with numeral unification making the representation of any text with numerals intractable.

#### 3.7.1 The case of ŠAR<sub>2</sub>

The character U+122B9  $\bullet$  CUNEIFORM SIGN ŠAR2 has a circular reference glyph.

In most texts from the Early Dynastic IIIb and Old Akkadian period<sup>60</sup>, a contrast between non-numeric šar<sub>2</sub> written  $\diamond$  and numeric 1(šar<sub>2</sub>) written  $\bullet$  can be observed, similar to the contrast between  $\leftarrow$  and  $\triangleright$  previously discussed in section 3.5. However, in lexical lists from Šuruppak and Ebla<sup>61</sup>, as well as in the *Stèle des vautours*, non-numeric šar<sub>2</sub> is curviform:

- $\ast \text{𒌦} \text{𒌦} \text{𒌦} \bullet$  and  $\ast \text{𒌦} \bullet \text{𒌦} \text{𒌦}$  in [P010566];
- $\bullet \text{𒌦} \text{𒌦}$  and  $\ast \bullet \text{𒌦} \text{𒌦}$  in [P010576];
- $\bullet \text{𒌦}$  in [P240986]<sup>62</sup>;
- $\bullet \text{𒌦} \text{𒌦}$  in [P222399, obv. 17, 9, 18, 11, 22, 12]<sup>63</sup>.

<sup>57</sup>Besides the contrasts in numeric usage mentioned in section 3.3.3, these characters are clearly not unifiable because of the many contrasts in non-numeric usage between them; several values of  $\leftarrow$  which are not shared with  $\uparrow$  have already been mentioned, but perhaps most striking is the fact that, in the Neo-Assyrian period,  $\leftarrow$  is used for the preposition *ina*, “in”, and  $\uparrow$  for the preposition *ana*, “to”.

<sup>58</sup>TODO cite a few things here.

<sup>59</sup>Most prominently Noto Sans Cuneiform, a system font on both Windows—as part of Segoe UI Historic—and macOS.







<sup>60</sup>For example, in personal names:


- $\text{𒌦} \text{𒌦} \text{𒌦} \diamond \text{𒌦}$  in [P020019] from ED IIIb Nirsu;
- $\text{𒌦} \text{𒌦} \text{𒌦} \diamond \text{𒌦} \text{𒌦}$  in [P020182], also from ED IIIb Nirsu;
- $\text{𒌦} \ast \diamond$  in [P222186] from ED IIIb Umma;
- $\text{𒌦} \ast \text{𒌦} \diamond$  in [P235312] from Old Akkadian Umma.





<sup>61</sup>TODO Mention other ways in which these are archaizing

<sup>62</sup>From copy in [ELLeS, No. 397].






<sup>63</sup>Note however  $\ast \text{𒌦} \diamond \text{𒌦}$  on [P222399, obv. 6, 17]. Curviform non-numeric šar<sub>2</sub> is clearly archaizing in ED IIIb Nirsu; one might suppose that the scribe slipped into their modern ways here. TODO add a photo.














It *would* be disruptive to the diachronic representation of text if non-numeric šar<sub>2</sub> were to have two different representations. The character U+122B9 CUNEIFORM SIGN SHAR2 should therefore be used in those cases, with its curviform glyph , identical to the glyph of the proposed U+12579  CUNEIFORM NUMERIC SIGN ONE N45. Since the archaizing style of texts wherein non-numeric šar<sub>2</sub> is curviform solidly predates the transition from  to  in the relevant metrological systems, there is no need to represent a - contrast, so these characters can have the same glyph in specialist archaizing Early Dynastic fonts.















Since cuneiform U+122B9 CUNEIFORM SIGN SHAR2 effectively merges with U+1212D  CUNEIFORM SIGN HI, the reference glyph should remain as it is, *i.e.*, curviform, so that the contrast between reference glyphs within the Cuneiform block remains clear; see [UTR56, §2.4]. Since system fonts follow the reference glyphs, and since extant specialist fonts target styles where U+122B9 is unambiguously cuneiform, there are no compatibility issues.

Note that in rare cases, such as [P222243] from ED IIIa Adab, non-numeric  (here with the value rum) is written . It is out of scope for this proposal to decide whether such occurrences should be treated as anomalous spellings, encoded as U+12550  cuneiform numeric sign one N01, or as stylistic distinctions, encoded as U+12038 CUNEIFORM SIGN ASH with a curviform glyph. In practice this would often be determined by the transliteration from which the cuneiform text is generated; it is noteworthy that as of this writing, the CDLI transliteration (UR2-1(aš@c)) and the ePSD2 one (uru<sub>8</sub><sup>rum</sup>) of this word disagree on that aspect. Since  has a cuneiform reference glyph, this does not pose any compatibility concerns.

### 3.7.2 Transliteration

An important feature of the encoding is that, in order to support input and bulk conversion of transliterated corpora to Unicode cuneiform, it should not represent distinctions that are finer than those recorded in typical transliterations; thus, while some older forms of BIL<sub>2</sub> can be described as × NE×KASKAL or × NE×PAP<sup>64</sup>, they are typically all transliterated bil<sub>2</sub>, and therefore are all represented by the character U+1224B  CUNEIFORM SIGN NE SHESHIG, its name notwithstanding, as described in [UTR56, §2.5].

The situation is more complicated for numbers. Many transliterations do not represent the type of numeral used, instead interpreting the whole numeric expression and transcribing it with delimiters or units as needed to disambiguate. For instance,    from [P305639] may be transliterated as 95 gur, as in [Feu04, vol. 2, p. 62]. The numerals may also be transliterated separately, but solely by their values in terms of the overt unit, as in EbDA transliterations: the aforementioned         from [P240533, recto 3, 3] is transliterated “20-1-1/2 gu<sub>2</sub>-bar 7 nig<sub>2</sub>-sagšu 2-1/2 an-zam<sub>x</sub><sup>65</sup> za”, reading both  and  as 1/2, but not distinguishing them.

In particular, these transliterations do not differentiate between  and  numerals, nor between  and  numerals. For instance, the aforementioned       from [P242293, recto 4, 1] is transliterated “4 'a<sub>3</sub>-da-um<sup>tug<sub>2</sub></sup>-II 4 aktum<sup>tug<sub>2</sub></sup> 4 ib<sub>2</sub>-III gun<sub>3</sub> sa<sub>6</sub><sup>tug<sub>2</sub></sup>” in EbDA, with no distinction between the  and . Since  and  numerals are separately encoded, the numeric ex-

<sup>64</sup>As on [P249253].

<sup>65</sup>As of this writing, EbDA actually has an-zam<sub>x</sub>, with U+1D6A GREEK SUBSCRIPT SMALL LETTER CHI.



pressions in such transliterations cannot be transformed into Unicode cuneiform without additional context, regardless of curviform–cuneiform unification.

In metrological systems such as systems  $G_{Ur III/OB}$  and  $C_{Ur III/OB}$  where some units are indicated by the type of numeral rather than an overt unit sign, it is common practice to add the unit in parentheses in transliteration; for instance,  $\text{𒀭} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$  from [P386847] is transliterated “1(eše<sub>3</sub>) 5½ iku<sup>66</sup> 7 sar” in [Feu04, vol. 2, p. 176], and  $\text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$  from [P307255] is transliterated “1(n<sup>67</sup>) 2(b) 7 ½ sila<sub>3</sub>” in [Feu04, vol. 2, p. 151].

This practice has been generalized to systematically indicate numeral shape; this is in particular the case in CDLI, where the transliterations of some of the above examples are “1(gešz2) 3(u) 5(asz) gur” for  $\text{𒀭} \text{𒌦} \text{𒌦} \text{𒌦}$ , “1(esze3) 5(iku) 1/2(iku) GAN2 7(disz) sar” for  $\text{𒀭} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$ , and “3(barig) 2(ban2) 7(disz) 1/2(disz) sila3” for  $\text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$ . CDLI and ePSD2 both distinguish curviform from cuneiform numerals in transliteration: the length  $\text{𒀭} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$  from [P020129, rev. 2, 1] is transliterated “6(gešz2@c) 3(u@c) {ninda}nindax(DU) 1/2(asz@c) 4(disz@t) gi” in CDLI, and “6(gešz<sub>2</sub><sup>c</sup>) 3(u<sup>c</sup>)<sup>ninda</sup>ninda<sub>x</sub>(DU) 1/2(aš<sup>c</sup>) 4(diš<sup>t</sup>) gi” in ePSD2. Another example is [Molina2014], which uses *1a* for  $\text{𒀭}$ , *1d* for  $\text{𒌦}$ , *1ac* for  $\text{𒌦}$ , *1dc* or  $\frac{1}{2}dc$  for  $\text{𒌦}$  depending on reading, etc. The literature on the Uruk and Early Dynastic I–II periods uses a different set of transliteration conventions that also disambiguate numeral shapes, as will be discussed in section 4.

While there exist transliterations that distinguish  $\text{𒀭}$  from  $\text{𒌦}$  but not  $\text{𒀭}$  from  $\text{𒀭}$ , such as the ones used in [DCCMT], the trend, especially in more recent works in third millennium studies, seems to be to represent numeral shape; for example, [Maiocchi2024] gave an example of the input syntax used by the new “Urban Economy Begins” project as “10 + 5c(GUR) + 2(BARIGA) + 1(BAN2)” for  $\text{𒀭} \text{𒌦} \text{𒌦} \text{𒌦} \text{𒌦}$ , with a *c* indicating that the GUR numerals are curviform, and the parenthetical GUR indicating that these are  $\text{𒌦}$  rather than  $\text{𒌦}$  numerals.

### 3.8 Conclusions

Co-occurrences of curviform and cuneiform numerals are not anecdotal in the Early Dynastic period, nor are they the result of scribal idiosyncrasy. Instead, they represent systematic contrasts between metrological systems, between individual units within metrological system, and between numeric usage and phonetic or logographic usage. This contrastive usage is reflected in modern publications.

While it would be technically possible to handle this contrast as a stylistic distinction, this approach has no real benefit, and is highly inconvenient, as it would require any treatment of Early Dynastic administrative texts to use multiple cuneiform fonts, often within single numeric expressions. Further, if that contrast is lost in plain-text interchange, the text can be misinterpreted:  $\text{𒀭}$  is a length of three ropes, but  $\text{𒀭}$  is an area of three bur<sub>3</sub>;  $\text{𒌦} \text{𒌦}$  could be read as one  $\text{𒌦} \text{𒌦}$  and one  $\text{𒌦} \text{𒌦}$ , where  $\text{𒌦} \text{𒌦}$  would be one and a half  $\text{𒌦} \text{𒌦}$ ;  $\text{𒀭} \text{𒌦}$  is a personal name, but  $\text{𒌦} \text{𒌦}$  would be “one slave”.

At the same time, contrary to most disunifications, the separate encoding of curviform numerals poses no serious compatibility issues for existing fonts or encoded corpora, nor does it, in general, introduce new issues with transliterated third millennium corpora. The oddity of  $\text{𒀭}$  requires some explanation, but does not

<sup>66</sup>TODO say something about this reading

<sup>67</sup>TODO comment on nigida.

pose any architectural issues, and is not fundamentally different from the other mergers and splits encountered in the cuneiform script.

#### 4 Rationale for ED-Uruk numeral unification

TODO mention the bariga silliness in the CDLI transliteration of Gori's paper.

## 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(ban<sub>7</sub>@c) and 5(ban<sub>7</sub>@c).]

## 6 Characters not included in this proposal

## 6.1 Missing numerals

N<sub>13</sub> not attested in CDLI ( $N_{17}$ ,  $12N_{14}$ , etc.) 7(diš *tenû*)

## 6.2 Stacking patterns

The already-encoded numerals in the Cuneiform Numbers and Punctuation block distinguish some *stacking patterns*; for instance 9I is encoded both as U+12446 𐎶𐎵 and as U+1240E 𐎶𐎵𐎺. This is in part due to contrastive usage of stacking patterns. For instance, besides I and II which are characteristic of bariga measures, four bariga is written IIII even where 4I is written IV, as in [P255010; P292843]. Another contrast is that between the stacking patterns used in scratch calculations in the SPVS, often I II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII XVIII XIX XX XXI XXII XXIII XXIV XXV XXVI XXVII XXVIII XXIX XXX XXXI XXXII XXXIII XXXIV XXXV XXXVI XXXVII XXXVIII XXXIX XL, and results in metrological systems, typically I II III IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII XVIII XIX XX XXI XXII XXIII XXIV XXV XXVI XXVII XXVIII XXIX XXX XXXI XXXII XXXIII XXXIV XXXV XXXVI XXXVII XXXVIII XXXIX XL, occasionally co-occurring as in [P142827; P142357]. This separate encoding is also for compatibility with distinctions made in reference works and in some non-numeric transliterations; for instance, IV is [MZL, No. 860] and has the value limmu, and IIII is [MZL, No. 852] and has the value limmus. Numeric<sup>68</sup> transliterations occasionally distinguish the stacking patterns IV V VI VII VIII IX X XI XII XIII XIV XV XVI XVII XVIII XIX XX XXI XXII XXIII XXIV XXV XXVI XXVII XXVIII XXIX XXX XXXI XXXII XXXIII XXXIV XXXV XXXVI XXXVII XXXVIII XXXIX XL, as in the CDLI transliterations of the aforementioned tablets, although this is rare; often 4(diš) is IIII in Ur III, but IV in the Neo-Assyrian period.

However, the stacking patterns from earlier periods are not separately encoded; for instance, in ED IIIb Nirsu, « 2(u) often has one < atop another. These older stacking patterns do not appear to be contrastive, are not marked in transliteration, and are not listed separately in sign lists nor assigned any different values. There is therefore no evidence of a need to encode them; instead, they should be considered style variants, and an ED IIIb Nirsu font should have an appropriate glyph for U+12399 « CUNEIFORM SIGN U U.

Likewise, many stacking patterns are attested for the curviform numerals proposed in this document, and it is not proposed to separately encode them; these

<sup>68</sup>The Sumerian word limmu means “four”, so limmu and limmu<sub>5</sub> are still numbers. The distinction here is between usage in transliterations of phrases such as 𒌦 𒈪 𒂗 𒀭 𒄩 𒅆 𒊕 𒋼 lugal an-ub-da limmu<sub>5</sub>-ba-ke<sub>4</sub> (king of the four quarters) or of names, and of numeric expressions such as 𒁫 𒉺 4(diš) sila<sub>3</sub>.



Figure 12: The layout of case [P020066]; the numeral ●● is spread across two lines. The text is read in the order ●●▷▷▷▷ 𐎶𐎵𐎶, “twenty-two oxen, one year old”.

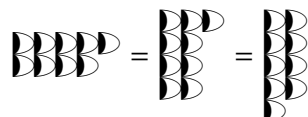


Figure 13: Three stacking patterns for U+12573 CUNEIFORM NUMERIC SIGN NINE N34. The one on the left is the reference glyph, used in Uruk III [P003499; P004430], and widely afterwards, *e.g.*, ED IIIa Šuruppag [P010678], ED IIIb Nirsu [P020057], Old Akkadian Umma [P212464]. The ones in the middle and right are used in two Uruk IV tablets [P001243; P004500]. All three Uruk examples are transliterated 9(N34) in CDLI.

distinctions would be incompatible with the state of the art in numeric transliterations, and are not needed to represent reference works. Idiosyncratic stacking patterns are in fact particularly common in Early Dynastic and earlier tablets, as they are structured in rectangular cases rather than lines, so that numerals may be laid out across the case in whichever way fits the available space; this is illustrated in Figure 12. Note that in that figure, the numerals need to be considerably enlarged in order to reproduce the layout of the tablet: ▷ has the same height as ▷▷. This is impractical when these numerals are set in text that contrasts them with the larger 𐎶, and inconsistent with actual practice when typesetting these numerals, as illustrated in section 3.4.5: reproducing the layout of tablets is not within the scope of plain text.

The reference glyphs use stacking patterns that are common in the Early Dynastic period, but that are also attested in the Uruk period; the Uruk period also frequently features numerals that use a more vertical layout, as illustrated in Figure 13. The later, more horizontal styles were chosen for two reasons: for the numerals used in the third and fourth millenium, usage in third millenium scholarship will be more frequent; and the horizontal layout poses fewer layout difficulties when set in lines of non-cuneiform text, as most modern scholarship is. Indeed, the absolute size of the indents ▷, 𐎶, ●, and ● must remain consistent across the numeral series, lest a 𐎶 numeral be confused with an ▷ numeral. Since the single indents are frequently used in running text, as illustrated in section 3.4.5, they need to be large enough that the vertical stacking patterns are impractical.

Variant stacking patterns, if needed, may be handled at a higher level as stylistic distinctions; Figure 13 uses OpenType stylistic alternates, and Figure 12 rotates the character ●●, in both cases preserving the plain text backing.

## Acknowledgements

TODO(egg): Something about the Vanséveren fonts

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