

Archaic cuneiform numbers

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1 Summary

This document proposes encoding, at U+12550–U+12585, 310 numerals used in the fourth millennium (Uruk IV and Uruk III periods) and Early Dynastic period in conjunction with the Sumero-Akkadian cuneiform script¹ and the proto-cuneiform script². The proposed characters are listed in §2. Most of them were listed in [L2/23-190]. The present document provides a more detailed rationale for their encoding and additional information about their identity and usage, both as part of the rationale and in §5. Some characters have been removed, in some cases because they are non-encodable variants, in others because their encodability should be considered as part of the proto-cuneiform proposal; these are discussed in §6. The glyphs have also been reworked, and additional characters used in the Early Dynastic period have been added.

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 requires that the language of a text be understood 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 §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 §3, including compatibility considerations in §3.7.

The overall picture of unifications and disunifications over time is illustrated in table 1. The Script_Extensions property assignments in §2.3 reflect the overlap. Many of these numerals are also used in proto-Elamite⁵ texts, where they are treated as identical characters in scholarship on proto-Elamite, so that they should

¹[ISO15924]: Xsux, Script property value long name: Cuneiform; encoded since Unicode Version 5.0.

²[ISO15924]: Ppun, not yet encoded.

³Impressed 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., ◁▷. The terms “curved”, “curviform”, “curvilinear”, and “round” can be found in the literature. We avoid the term “round” here as it has other meanings in the context of numbers. We use “curviform” in this document as, being the least common term, it is least likely to lead to confusion, and “CURVED” in the character names for consistency with documentation about the modifier @c used in machine readable ATF transliterations [inlineATF].

⁴Impressed into clay using a stylus with a trihedral end: — (stylus held horizontally), † (vertically), ‡ (diagonally) ‹ (with the head of the stylus), † (stylus pressed deeper, forming a larger wedge), ‡ (combining † and ‹), etc.

⁵[ISO15924]: Pelm, not yet encoded.

be unified with the ones proposed in [L2/23-196]. However, in the interest of time, we do not provide a detailed rationale for this unification in this document, and we are not proposing that the numerals be given the corresponding Script_Extensions property value for now. Neither do we propose encoding any numerals that are solely attested in proto-Elamite texts, or well-attested in proto-Elamite texts but insufficiently attested in Uruk—those are discussed in §2.

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

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

2 Proposed changes to the Standard

2.1 Core specification text

Amend [Uni16, §11.1.2, sub “Cuneiform Numerals”], as follows:

Cuneiform Numerals. In general, numerals that also have a phonetic, logographic, or determinative value are encoded in the main Cuneiform block; as a result, some series of numerals, such as 𐎶–𐎶𐎵 1(diš)–9(diš) or 𐎶–𐎶𐎵 1(u)–9(u), are split across the two blocks. Numerals have been encoded separately from signs that are visually identical but ~~semantically different~~ etymologically unrelated (for example, U+1244F 𐎶 CUNEIFORM NUMERIC SIGN ONE BAN2, U+12450 𐎶 CUNEIFORM NUMERIC SIGN TWO BAN2, and so on, versus U+12226 𐎶 CUNEIFORM SIGN MASH, U+1227A 𐎶 CUNEIFORM SIGN PA, and so on).

The relation between series of numerals depends on the metrological system; for instance, when counting talents, written 𐎶𐎵 (a unit of weight, approximately 30 kg), 𐎶𐎵 is used for “one talent”, and 𐎶𐎵𐎶 for “ten talents”. However, when measuring areas, the area 𐎶𐎵 (one *būrum*) is eighteen times 𐎶𐎵 (one *ikūm*, approximately 3600 m²). The Numeric_Value property assignment of a cuneiform numeral therefore reflects only its relation to the first numeral in its series, rather than the absolute numeric value that it might represent. For instance, the number “fifty” is written 𐎶𐎵, but U+12410 𐎶 CUNEIFORM NUMERIC SIGN FIVE U has Numeric_Value=5, as it is 5 × 𐎶.

In the third millennium, and especially in the Early Dynastic period, some numerals are written using a cylindrical tool, rather than the cuneiform stylus, forming curved rather than cuneiform numerals (𐎶 rather than 𐎶). The cuneiform numerals are descended from these curved numerals. However, in the Early Dynastic period, the curved numerals contrast with the cuneiform ones, and are used together with them in several metrological systems; they are therefore separately encoded. Most curved numerals are encoded in the Archaic Cuneiform

Numerals block, with the exception of two fractions in the Cuneiform Numbers and Punctuation block: U+1245D 𐎧 CUNEIFORM NUMERIC SIGN ONE THIRD VARIANT FORM A and U+1245E 𐎨 CUNEIFORM NUMERIC SIGN TWO THIRDS VARIANT FORM A, the curved counterparts of U+1245A 𐎡 CUNEIFORM NUMERIC SIGN ONE THIRD DISH and U+1245B 𐎢 CUNEIFORM NUMERIC SIGN TWO THIRDS DISH.

Add after [Uni16, §11.1.3]:

11.1.4 Archaic Cuneiform Numerals: U+12550–U+1268F

TODO something about consistent size

The sign ŠAR₂.

































































































































































Amend [Uni16, §24.1.2, sub “Dashed Box Convention”], third paragraph, as follows:























































































































































In a few cases of very wide ~~punctuation~~ characters that do not naturally fit into a code chart cell, the representative glyph may be shown with an artificially narrow shape, displayed inside the dashed box, with or without additional annotation, to indicate this adjustment of shape.

2.2 Code charts

The code charts for the proposed block, including the character names list with proposed informative aliases, cross references, and informative notes, are shown on the following pages.

This space for rent.

	1255	1256	1257	1258	1259	125A	125B	125C	125D	125E
0	 12550	 12560	 12570	 12580	 12590	 125A0	 125B0	 125C0	 125D0	 125E0
1	 12551	 12561	 12571	 12581	 12591	 125A1	 125B1	 125C1	 125D1	 125E1
2	 12552	 12562	 12572	 12582	 12592	 125A2	 125B2	 125C2	 125D2	 125E2
3	 12553	 12563	 12573	 12583	 12593	 125A3	 125B3	 125C3	 125D3	 125E3
4	 12554	 12564	 12574	 12584	 12594	 125A4	 125B4	 125C4	 125D4	 125E4
5	 12555	 12565	 12575	 12585	 12595	 125A5	 125B5	 125C5	 125D5	 125E5
6	 12556	 12566	 12576	 12586	 12596	 125A6	 125B6	 125C6	 125D6	 125E6
7	 12557	 12567	 12577	 12587	 12597	 125A7	 125B7	 125C7	 125D7	 125E7
8	 12558	 12568	 12578	 12588	 12598	 125A8	 125B8	 125C8	 125D8	 125E8
9	 12559	 12569	 12579	 12589	 12599	 125A9	 125B9	 125C9	 125D9	 125E9
A	 1255A	 1256A	 1257A	 1258A	 1259A	 125AA	 125BA	 125CA	 125DA	 125EA
B	 1255B	 1256B	 1257B	 1258B	 1259B	 125AB	 125BB	 125CB	 125DB	 125EB
C	 1255C	 1256C	 1257C	 1258C	 1259C	 125AC	 125BC	 125CC	 125DC	 125EC
D	 1255D	 1256D	 1257D	 1258D	 1259D	 125AD	 125BD	 125CD	 125DD	 125ED
E	 1255E	 1256E	 1257E	 1258E	 1259E	 125AE	 125BE	 125CE	 125DE	 125EE
F	 1255F	 1256F	 1257F	 1258F	 1259F	 125AF	 125BF	 125CF	 125DF	 125EF

	125F	1260	1261	1262	1263	1264	1265	1266	1267	1268
0	 125F0	 12600	 12610	 12620	 12630	 12640	 12650	 12660	 12670	 12680
1	 125F1	 12601	 12611	 12621	 12631	 12641	 12651	 12661	 12671	 12681
2	 125F2	 12602	 12612	 12622	 12632	 12642	 12652	 12662	 12672	 12682
3	 125F3	 12603	 12613	 12623	 12633	 12643	 12653	 12663	 12673	 12683
4	 125F4	 12604	 12614	 12624	 12634	 12644	 12654	 12664	 12674	 12684
5	 125F5	 12605	 12615	 12625	 12635	 12645	 12655	 12665	 12675	 12685
6	 125F6	 12606	 12616	 12626	 12636	 12646	 12656	 12666	 12676	
7	 125F7	 12607	 12617	 12627	 12637	 12647	 12657	 12667	 12677	
8	 125F8	 12608	 12618	 12628	 12638	 12648	 12658	 12668	 12678	
9	 125F9	 12609	 12619	 12629	 12639	 12649	 12659	 12669	 12679	
A	 125FA	 1260A	 1261A	 1262A	 1263A	 1264A	 1265A	 1266A	 1267A	
B	 125FB	 1260B	 1261B	 1262B	 1263B	 1264B	 1265B	 1266B	 1267B	
C	 125FC	 1260C	 1261C	 1262C	 1263C	 1264C	 1265C	 1266C	 1267C	
D	 125FD	 1260D	 1261D	 1262D	 1263D	 1264D	 1265D	 1266D	 1267D	
E	 125FE	 1260E	 1261E	 1262E	 1263E	 1264E	 1265E	 1266E	 1267E	
F	 125FF	 1260F	 1261F	 1262F	 1263F	 1264F	 1265F	 1266F	 1267F	

Common Numerals

Used in the sexagesimal discrete counting system and other metrological systems

12550	𐎶	CUNEIFORM NUMERIC SIGN ONE N01 = 1 aš curved → 12038 𐎶 cuneiform sign ash • often used instead of diš in Early Dynastic counterparts of cuneiform metrological systems → 12079 𐎶 cuneiform sign dish
12551	𐎷	CUNEIFORM NUMERIC SIGN TWO N01 → 12400 𐎷 cuneiform numeric sign two ash
12552	𐎸	CUNEIFORM NUMERIC SIGN THREE N01
12553	𐎹	CUNEIFORM NUMERIC SIGN FOUR N01
12554	𐎺	CUNEIFORM NUMERIC SIGN FIVE N01
12555	𐎻	CUNEIFORM NUMERIC SIGN SIX N01
12556	𐎼	CUNEIFORM NUMERIC SIGN SEVEN N01
12557	𐎽	CUNEIFORM NUMERIC SIGN EIGHT N01
12558	𐎾	CUNEIFORM NUMERIC SIGN NINE N01
12559	𐎿	CUNEIFORM NUMERIC SIGN ONE N08 = 1 diš curved → 12079 𐎶 cuneiform sign dish = 1/2 iku curved • used for one half in multiple metrological systems → 12039 𐎶 cuneiform sign ash zida tenu → 12226 𐎶 cuneiform sign mash = 1 bariga curved • used in Early Dynastic capacity systems
1255A	𐎿	CUNEIFORM NUMERIC SIGN TWO N08 → 1222B 𐎿 cuneiform sign min = 2 bariga curved → 12456 𐎶 cuneiform numeric sign nigidamin
1255B	𐎿	CUNEIFORM NUMERIC SIGN THREE N08 → 12408 𐎶 cuneiform numeric sign three dish • used in Early Dynastic capacity systems = 3 bariga curved → 12457 𐎶 cuneiform numeric sign nigidaesh
1255C	𐎿	CUNEIFORM NUMERIC SIGN FOUR N08
1255D	𐎿	CUNEIFORM NUMERIC SIGN FIVE N08
1255E	𐎿	CUNEIFORM NUMERIC SIGN SIX N08
1255F	𐎿	CUNEIFORM NUMERIC SIGN SEVEN N08
12560	𐎿	CUNEIFORM NUMERIC SIGN EIGHT N08
12561	𐎿	CUNEIFORM NUMERIC SIGN NINE N08
12562	•	CUNEIFORM NUMERIC SIGN ONE N14 = 1 u curved = 1 bur ₃ curved → 1230B 𐎶 cuneiform sign u → 12399 𐎶 cuneiform sign u u
12563	𐎿	CUNEIFORM NUMERIC SIGN TWO N14 → 12399 𐎶 cuneiform sign u u
12564	𐎿	CUNEIFORM NUMERIC SIGN THREE N14 → 1230D 𐎶 cuneiform sign u u u
12565	𐎿	CUNEIFORM NUMERIC SIGN FOUR N14 → 1240F 𐎶 cuneiform numeric sign four u
12566	𐎿	CUNEIFORM NUMERIC SIGN FIVE N14
12567	𐎿	CUNEIFORM NUMERIC SIGN SIX N14
12568	𐎿	CUNEIFORM NUMERIC SIGN SEVEN N14
12569	𐎿	CUNEIFORM NUMERIC SIGN EIGHT N14
1256A	𐎿	CUNEIFORM NUMERIC SIGN NINE N14
1256B	𐎿	CUNEIFORM NUMERIC SIGN ONE N34 = 1 ḡeš ₂ curved → 12415 𐎶 cuneiform numeric sign one gesh ₂
1256C	𐎿	CUNEIFORM NUMERIC SIGN TWO N34
1256D	𐎿	CUNEIFORM NUMERIC SIGN THREE N34
1256E	𐎿	CUNEIFORM NUMERIC SIGN FOUR N34
1256F	𐎿	CUNEIFORM NUMERIC SIGN FIVE N34














12570	𐎿	CUNEIFORM NUMERIC SIGN SIX N34
12571	𐎿	CUNEIFORM NUMERIC SIGN SEVEN N34
12572	𐎿	CUNEIFORM NUMERIC SIGN EIGHT N34
12573	𐎿	CUNEIFORM NUMERIC SIGN NINE N34
12574	𐎿	CUNEIFORM NUMERIC SIGN ONE N48 = 1 ḡeš ₃ u curved → 1241E 𐎶 cuneiform numeric sign one geshu
12575	𐎿	CUNEIFORM NUMERIC SIGN TWO N48
12576	𐎿	CUNEIFORM NUMERIC SIGN THREE N48
12577	𐎿	CUNEIFORM NUMERIC SIGN FOUR N48
12578	𐎿	CUNEIFORM NUMERIC SIGN FIVE N48
12579	•	CUNEIFORM NUMERIC SIGN ONE N45 = 1 šar ₂ curved • 122B9 • should be used for cuneiform 1 šar ₂ • 122B9 • should be used for logographic šar ₂ , even when curved → 122B9 • cuneiform sign shar ₂
1257A	•	CUNEIFORM NUMERIC SIGN TWO N45
1257B	•	CUNEIFORM NUMERIC SIGN THREE N45
1257C	•	CUNEIFORM NUMERIC SIGN FOUR N45
1257D	•	CUNEIFORM NUMERIC SIGN FIVE N45
1257E	•	CUNEIFORM NUMERIC SIGN SIX N45
1257F	•	CUNEIFORM NUMERIC SIGN SEVEN N45
12580	•	CUNEIFORM NUMERIC SIGN EIGHT N45
12581	•	CUNEIFORM NUMERIC SIGN NINE N45
12582	•	CUNEIFORM NUMERIC SIGN ONE N50 = 1 šar ₃ u curved → 1242C 𐎶 cuneiform numeric sign one sharu • used instead of 1258E • in fourth millennium land area systems → 12434 𐎶 cuneiform numeric sign one buru
12583	•	CUNEIFORM NUMERIC SIGN TWO N50
12584	•	CUNEIFORM NUMERIC SIGN THREE N50
12585	•	CUNEIFORM NUMERIC SIGN FOUR N50
12586	•	CUNEIFORM NUMERIC SIGN FIVE N50

Numerals used for land areas

Together with N08, N01, N14, N45, and N50

















12587	𐎿	CUNEIFORM NUMERIC SIGN ONE EIGHTH IKU CURVED → 1245F 𐎶 cuneiform numeric sign one eighth ash
12588	𐎿	CUNEIFORM NUMERIC SIGN ONE EIGHTH IKU CURVED VARIANT FORM
12589	𐎿	CUNEIFORM NUMERIC SIGN ONE N01 REVERSED = 1/4 iku curved → 12460 𐎶 cuneiform numeric sign one quarter ash
1258A	𐎿	CUNEIFORM NUMERIC SIGN ONE QUARTER IKU CURVED VARIANT FORM
1258B	𐎿	CUNEIFORM NUMERIC SIGN ONE HALF IKU CURVED VARIANT FORM → 12039 𐎶 cuneiform sign ash zida tenu
1258C	𐎿	CUNEIFORM NUMERIC SIGN ONE N22 = 1 eše ₃ curved → 12458 𐎶 cuneiform numeric sign one eshe ₃
1258D	𐎿	CUNEIFORM NUMERIC SIGN TWO N22
1258E	•	CUNEIFORM NUMERIC SIGN ONE BURU CURVED → 12434 𐎶 cuneiform numeric sign one buru
1258F	•	CUNEIFORM NUMERIC SIGN TWO BURU CURVED
12590	•	CUNEIFORM NUMERIC SIGN THREE BURU CURVED
12591	•	CUNEIFORM NUMERIC SIGN FOUR BURU CURVED
12592	•	CUNEIFORM NUMERIC SIGN FIVE BURU CURVED

Early Dynastic capacity measures





















- 12593  CUNEIFORM NUMERIC SIGN ONE BAN2 CURVED
 • 1244F  cuneiform numeric sign one ban2
 = 1/2 aš curved
 • used for one half in multiple metrological systems
 → 12226  cuneiform sign mash
- 12594  CUNEIFORM NUMERIC SIGN TWO BAN2 CURVED
- 12595  CUNEIFORM NUMERIC SIGN THREE BAN2 CURVED
- 12596  CUNEIFORM NUMERIC SIGN FOUR BAN2 CURVED
- 12597  CUNEIFORM NUMERIC SIGN FIVE BAN2 CURVED
- 12598  CUNEIFORM NUMERIC SIGN NINDA2 TIMES SHE PLUS ONE ASH CURVED
 = 1/3 aš curved variant form
 → 1245D  cuneiform numeric sign one third dish variant form a
 → 1245A  cuneiform numeric sign one third dish
- 12599  CUNEIFORM NUMERIC SIGN NINDA2 TIMES SHE PLUS TWO ASH CURVED
 = 2/3 aš curved variant form
 → 1245E  cuneiform numeric sign two thirds dish variant form a
 → 1245B  cuneiform numeric sign two thirds dish

Numerals used in the bisexagesimal system

Together with N08, N01, N14, and N34




















- 1259A  CUNEIFORM NUMERIC SIGN ONE N51
 = 1 ɢeš₂ curved doubled, 1 ɢešmin curved
- 1259B  CUNEIFORM NUMERIC SIGN TWO N51
- 1259C  CUNEIFORM NUMERIC SIGN THREE N51
- 1259D  CUNEIFORM NUMERIC SIGN FOUR N51
- 1259E  CUNEIFORM NUMERIC SIGN FIVE N51
- 1259F  CUNEIFORM NUMERIC SIGN SIX N51
- 125A0  CUNEIFORM NUMERIC SIGN SEVEN N51
- 125A1  CUNEIFORM NUMERIC SIGN EIGHT N51
- 125A2  CUNEIFORM NUMERIC SIGN NINE N51
- 125A3  CUNEIFORM NUMERIC SIGN ONE N54
 = 1 ɢeš' u curved doubled, 1 ɢešmin' u curved
- 125A4  CUNEIFORM NUMERIC SIGN TWO N54
- 125A5  CUNEIFORM NUMERIC SIGN THREE N54
- 125A6  CUNEIFORM NUMERIC SIGN FOUR N54
- 125A7  CUNEIFORM NUMERIC SIGN FIVE N54
- 125A8  CUNEIFORM NUMERIC SIGN ONE N56
- 125A9  CUNEIFORM NUMERIC SIGN TWO N56

Fourth millennium capacity measures

- 125AA  CUNEIFORM NUMERIC SIGN ONE N24
- 125AB  CUNEIFORM NUMERIC SIGN ONE N26
- 125AC  CUNEIFORM NUMERIC SIGN ONE N28
- 125AD  CUNEIFORM NUMERIC SIGN ONE N29A
- 125AE  CUNEIFORM NUMERIC SIGN ONE N29B
- 125AF  CUNEIFORM NUMERIC SIGN ONE N30A
- 125B0  CUNEIFORM NUMERIC SIGN ONE N30C
- 125B1  CUNEIFORM NUMERIC SIGN ONE N30D
- 125B2  CUNEIFORM NUMERIC SIGN ONE N30E
- 125B3  CUNEIFORM NUMERIC SIGN ONE N31
- 125B4  CUNEIFORM NUMERIC SIGN ONE N32
- 125B5  CUNEIFORM NUMERIC SIGN ONE N33
- 125B6  CUNEIFORM NUMERIC SIGN ONE N39A
- 125B7  CUNEIFORM NUMERIC SIGN TWO N39A
- 125B8  CUNEIFORM NUMERIC SIGN THREE N39A
- 125B9  CUNEIFORM NUMERIC SIGN FOUR N39A
- 125BA  CUNEIFORM NUMERIC SIGN ONE N39B
- 125BB  CUNEIFORM NUMERIC SIGN TWO N39B
- 125BC  CUNEIFORM NUMERIC SIGN THREE N39B
- 125BD  CUNEIFORM NUMERIC SIGN FOUR N39B


























Numerals of sexagesimal system S'

Used to count dead animals and jars of certain types of liquids

- 125BE  CUNEIFORM NUMERIC SIGN ONE N02
- 125BF  CUNEIFORM NUMERIC SIGN TWO N02
- 125C0  CUNEIFORM NUMERIC SIGN THREE N02
- 125C1  CUNEIFORM NUMERIC SIGN FOUR N02
- 125C2  CUNEIFORM NUMERIC SIGN FIVE N02
- 125C3  CUNEIFORM NUMERIC SIGN SIX N02
- 125C4  CUNEIFORM NUMERIC SIGN SEVEN N02
- 125C5  CUNEIFORM NUMERIC SIGN EIGHT N02
- 125C6  CUNEIFORM NUMERIC SIGN NINE N02
- 125C7  CUNEIFORM NUMERIC SIGN ONE N15
- 125C8  CUNEIFORM NUMERIC SIGN TWO N15
- 125C9  CUNEIFORM NUMERIC SIGN THREE N15
- 125CA  CUNEIFORM NUMERIC SIGN FOUR N15
- 125CB  CUNEIFORM NUMERIC SIGN FIVE N15
- 125CC  CUNEIFORM NUMERIC SIGN ONE N35
- 125CD  CUNEIFORM NUMERIC SIGN TWO N35
- 125CE  CUNEIFORM NUMERIC SIGN THREE N35
- 125CF  CUNEIFORM NUMERIC SIGN FOUR N35
- 125D0  CUNEIFORM NUMERIC SIGN FIVE N35

















Numerals of bisexagesimal system B*

Used in the fourth millennium to count rations of an unclear nature

- 125D1  CUNEIFORM NUMERIC SIGN ONE N06
- 125D2  CUNEIFORM NUMERIC SIGN TWO N06
- 125D3  CUNEIFORM NUMERIC SIGN THREE N06
- 125D4  CUNEIFORM NUMERIC SIGN FOUR N06
- 125D5  CUNEIFORM NUMERIC SIGN FIVE N06
- 125D6  CUNEIFORM NUMERIC SIGN SIX N06
- 125D7  CUNEIFORM NUMERIC SIGN SEVEN N06
- 125D8  CUNEIFORM NUMERIC SIGN EIGHT N06
- 125D9  CUNEIFORM NUMERIC SIGN NINE N06
- 125DA  CUNEIFORM NUMERIC SIGN ONE N21
- 125DB  CUNEIFORM NUMERIC SIGN TWO N21
- 125DC  CUNEIFORM NUMERIC SIGN THREE N21
- 125DD  CUNEIFORM NUMERIC SIGN FOUR N21
- 125DE  CUNEIFORM NUMERIC SIGN FIVE N21
- 125DF  CUNEIFORM NUMERIC SIGN ONE N38
- 125E0  CUNEIFORM NUMERIC SIGN ONE N52
- 125E1  CUNEIFORM NUMERIC SIGN TWO N52
- 125E2  CUNEIFORM NUMERIC SIGN THREE N52
- 125E3  CUNEIFORM NUMERIC SIGN FOUR N52
- 125E4  CUNEIFORM NUMERIC SIGN FIVE N52
- 125E5  CUNEIFORM NUMERIC SIGN SIX N52
- 125E6  CUNEIFORM NUMERIC SIGN SEVEN N52
- 125E7  CUNEIFORM NUMERIC SIGN EIGHT N52
- 125E8  CUNEIFORM NUMERIC SIGN NINE N52
- 125E9  CUNEIFORM NUMERIC SIGN ONE N60

Numerals of capacity system Š'

Used in the fourth millennium to measure malted barley

- 125EA  CUNEIFORM NUMERIC SIGN ONE N24A
- 125EB  CUNEIFORM NUMERIC SIGN ONE N40
- 125EC  CUNEIFORM NUMERIC SIGN TWO N40
- 125ED  CUNEIFORM NUMERIC SIGN THREE N40
- 125EE  CUNEIFORM NUMERIC SIGN FOUR N40
- 125EF  CUNEIFORM NUMERIC SIGN ONE N03
- 125F0  CUNEIFORM NUMERIC SIGN TWO N03
- 125F1  CUNEIFORM NUMERIC SIGN THREE N03
- 125F2  CUNEIFORM NUMERIC SIGN FOUR N03
- 125F3  CUNEIFORM NUMERIC SIGN FIVE N03
- 125F4  CUNEIFORM NUMERIC SIGN ONE N18
- 125F5  CUNEIFORM NUMERIC SIGN TWO N18
- 125F6  CUNEIFORM NUMERIC SIGN THREE N18
- 125F7  CUNEIFORM NUMERIC SIGN FOUR N18
- 125F8  CUNEIFORM NUMERIC SIGN FIVE N18
- 125F9  CUNEIFORM NUMERIC SIGN SIX N18

125FA		CUNEIFORM NUMERIC SIGN SEVEN N18
125FB		CUNEIFORM NUMERIC SIGN EIGHT N18
125FC		CUNEIFORM NUMERIC SIGN NINE N18

Numerals of capacity system Š"

Used in the fourth millennium to measure various kinds of emmer

125FD		CUNEIFORM NUMERIC SIGN ONE N24B
125FE		CUNEIFORM NUMERIC SIGN ONE N26B
125FF		CUNEIFORM NUMERIC SIGN ONE N28B
12600		CUNEIFORM NUMERIC SIGN ONE N29AB
12601		CUNEIFORM NUMERIC SIGN ONE N41
12602		CUNEIFORM NUMERIC SIGN TWO N41
12603		CUNEIFORM NUMERIC SIGN THREE N41
12604		CUNEIFORM NUMERIC SIGN FOUR N41
12605		CUNEIFORM NUMERIC SIGN ONE N04
12606		CUNEIFORM NUMERIC SIGN TWO N04
12607		CUNEIFORM NUMERIC SIGN THREE N04
12608		CUNEIFORM NUMERIC SIGN FOUR N04
12609		CUNEIFORM NUMERIC SIGN FIVE N04
1260A		CUNEIFORM NUMERIC SIGN ONE N19
1260B		CUNEIFORM NUMERIC SIGN TWO N19
1260C		CUNEIFORM NUMERIC SIGN THREE N19
1260D		CUNEIFORM NUMERIC SIGN FOUR N19
1260E		CUNEIFORM NUMERIC SIGN FIVE N19
1260F		CUNEIFORM NUMERIC SIGN SIX N19
12610		CUNEIFORM NUMERIC SIGN SEVEN N19
12611		CUNEIFORM NUMERIC SIGN EIGHT N19
12612		CUNEIFORM NUMERIC SIGN NINE N19
12613		CUNEIFORM NUMERIC SIGN ONE N46
12614		CUNEIFORM NUMERIC SIGN TWO N46
12615		CUNEIFORM NUMERIC SIGN ONE N36
12616		CUNEIFORM NUMERIC SIGN TWO N36
12617		CUNEIFORM NUMERIC SIGN THREE N36
12618		CUNEIFORM NUMERIC SIGN FOUR N36
12619		CUNEIFORM NUMERIC SIGN FIVE N36
1261A		CUNEIFORM NUMERIC SIGN SIX N36
1261B		CUNEIFORM NUMERIC SIGN SEVEN N36
1261C		CUNEIFORM NUMERIC SIGN EIGHT N36
1261D		CUNEIFORM NUMERIC SIGN NINE N36
1261E		CUNEIFORM NUMERIC SIGN ONE N49
1261F		CUNEIFORM NUMERIC SIGN TWO N49
12620		CUNEIFORM NUMERIC SIGN THREE N49
12621		CUNEIFORM NUMERIC SIGN FOUR N49

Numerals of capacity system Š*

Used in the fourth millennium to measure barley groats

12622		CUNEIFORM NUMERIC SIGN ONE N25
12623		CUNEIFORM NUMERIC SIGN ONE N27
12624		CUNEIFORM NUMERIC SIGN ONE N28C
12625		CUNEIFORM NUMERIC SIGN ONE N29AC
12626		CUNEIFORM NUMERIC SIGN ONE N30AC
12627		CUNEIFORM NUMERIC SIGN ONE N30CC
12628		CUNEIFORM NUMERIC SIGN ONE N42A
12629		CUNEIFORM NUMERIC SIGN TWO N42A
1262A		CUNEIFORM NUMERIC SIGN THREE N42A
1262B		CUNEIFORM NUMERIC SIGN FOUR N42A
1262C		CUNEIFORM NUMERIC SIGN ONE N42B
1262D		CUNEIFORM NUMERIC SIGN TWO N42B
1262E		CUNEIFORM NUMERIC SIGN THREE N42B
1262F		CUNEIFORM NUMERIC SIGN FOUR N42B
12630		CUNEIFORM NUMERIC SIGN ONE N05
12631		CUNEIFORM NUMERIC SIGN TWO N05
12632		CUNEIFORM NUMERIC SIGN THREE N05
12633		CUNEIFORM NUMERIC SIGN FOUR N05
12634		CUNEIFORM NUMERIC SIGN FIVE N05
12635		CUNEIFORM NUMERIC SIGN ONE N20
12636		CUNEIFORM NUMERIC SIGN TWO N20
12637		CUNEIFORM NUMERIC SIGN THREE N20
12638		CUNEIFORM NUMERIC SIGN FOUR N20

12639		CUNEIFORM NUMERIC SIGN FIVE N20
1263A		CUNEIFORM NUMERIC SIGN SIX N20
1263B		CUNEIFORM NUMERIC SIGN SEVEN N20
1263C		CUNEIFORM NUMERIC SIGN EIGHT N20
1263D		CUNEIFORM NUMERIC SIGN NINE N20
1263E		CUNEIFORM NUMERIC SIGN ONE N47
1263F		CUNEIFORM NUMERIC SIGN TWO N47
12640		CUNEIFORM NUMERIC SIGN ONE N37
12641		CUNEIFORM NUMERIC SIGN TWO N37

Numerals of system EN




















Only attested in the Uruk IV period

12642		CUNEIFORM NUMERIC SIGN ONE N09
12643		CUNEIFORM NUMERIC SIGN ONE N11
12644		CUNEIFORM NUMERIC SIGN ONE N12
12645		CUNEIFORM NUMERIC SIGN ONE N07A
12646		CUNEIFORM NUMERIC SIGN TWO N07A
12647		CUNEIFORM NUMERIC SIGN THREE N07A
12648		CUNEIFORM NUMERIC SIGN ONE N07B
12649		CUNEIFORM NUMERIC SIGN TWO N07B
1264A		CUNEIFORM NUMERIC SIGN THREE N07B

Flat numerals

Rectangular numerals impressed with a flat tool, used in Ur in the Early Dynastic I–II period

1264B		CUNEIFORM NUMERIC SIGN ONE N01 FLAT = 1 aš flat → 12038 ← cuneiform sign ash
1264C		CUNEIFORM NUMERIC SIGN TWO N01 FLAT
1264D		CUNEIFORM NUMERIC SIGN THREE N01 FLAT
1264E		CUNEIFORM NUMERIC SIGN FOUR N01 FLAT
1264F		CUNEIFORM NUMERIC SIGN FIVE N01 FLAT
12650		CUNEIFORM NUMERIC SIGN SIX N01 FLAT
12651		CUNEIFORM NUMERIC SIGN SEVEN N01 FLAT
12652		CUNEIFORM NUMERIC SIGN EIGHT N01 FLAT
12653		CUNEIFORM NUMERIC SIGN NINE N01 FLAT
12654		CUNEIFORM NUMERIC SIGN ONE N08 FLAT
12655		CUNEIFORM NUMERIC SIGN ONE N14 FLAT = 1 u flat → 1230B ← cuneiform sign u
12656		CUNEIFORM NUMERIC SIGN TWO N14 FLAT
12657		CUNEIFORM NUMERIC SIGN THREE N14 FLAT
12658		CUNEIFORM NUMERIC SIGN FOUR N14 FLAT
12659		CUNEIFORM NUMERIC SIGN FIVE N14 FLAT
1265A		CUNEIFORM NUMERIC SIGN SIX N14 FLAT
1265B		CUNEIFORM NUMERIC SIGN SEVEN N14 FLAT
1265C		CUNEIFORM NUMERIC SIGN EIGHT N14 FLAT
1265D		CUNEIFORM NUMERIC SIGN NINE N14 FLAT
1265E		CUNEIFORM NUMERIC SIGN ONE N34 FLAT
1265F		CUNEIFORM NUMERIC SIGN TWO N34 FLAT
12660		CUNEIFORM NUMERIC SIGN THREE N34 FLAT
12661		CUNEIFORM NUMERIC SIGN FOUR N34 FLAT
12662		CUNEIFORM NUMERIC SIGN FIVE N34 FLAT
12663		CUNEIFORM NUMERIC SIGN SIX N34 FLAT
12664		CUNEIFORM NUMERIC SIGN SEVEN N34 FLAT
12665		CUNEIFORM NUMERIC SIGN EIGHT N34 FLAT
12666		CUNEIFORM NUMERIC SIGN NINE N34 FLAT
12667		CUNEIFORM NUMERIC SIGN ONE N45 FLAT
12668		CUNEIFORM NUMERIC SIGN TWO N45 FLAT
12669		CUNEIFORM NUMERIC SIGN ONE N22 FLAT
1266A		CUNEIFORM NUMERIC SIGN TWO N22 FLAT
1266B		CUNEIFORM NUMERIC SIGN ONE N51 FLAT
1266C		CUNEIFORM NUMERIC SIGN TWO N51 FLAT
1266D		CUNEIFORM NUMERIC SIGN THREE N51 FLAT
1266E		CUNEIFORM NUMERIC SIGN FOUR N51 FLAT
1266F		CUNEIFORM NUMERIC SIGN FIVE N51 FLAT
12670		CUNEIFORM NUMERIC SIGN SIX N51 FLAT
12671		CUNEIFORM NUMERIC SIGN SEVEN N51 FLAT
12672		CUNEIFORM NUMERIC SIGN EIGHT N51 FLAT





12673		CUNEIFORM NUMERIC SIGN NINE N51 FLAT
12674		CUNEIFORM NUMERIC SIGN ONE N34 FLAT TENU = 1 n39a flat
12675		CUNEIFORM NUMERIC SIGN ONE N04 FLAT
12676		CUNEIFORM NUMERIC SIGN TWO N04 FLAT
12677		CUNEIFORM NUMERIC SIGN THREE N04 FLAT
12678		CUNEIFORM NUMERIC SIGN FOUR N04 FLAT
12679		CUNEIFORM NUMERIC SIGN FIVE N04 FLAT
1267A		CUNEIFORM NUMERIC SIGN ONE N19 FLAT
1267B		CUNEIFORM NUMERIC SIGN TWO N19 FLAT
1267C		CUNEIFORM NUMERIC SIGN THREE N19 FLAT
1267D		CUNEIFORM NUMERIC SIGN FOUR N19 FLAT
1267E		CUNEIFORM NUMERIC SIGN FIVE N19 FLAT
1267F		CUNEIFORM NUMERIC SIGN SIX N19 FLAT
12680		CUNEIFORM NUMERIC SIGN SEVEN N19 FLAT
12681		CUNEIFORM NUMERIC SIGN EIGHT N19 FLAT
12682		CUNEIFORM NUMERIC SIGN NINE N19 FLAT
12683		CUNEIFORM NUMERIC SIGN ONE N46 FLAT
12684		CUNEIFORM NUMERIC SIGN TWO N46 FLAT
12685		CUNEIFORM NUMERIC SIGN ONE N36 FLAT

2.3 Properties

3 Rationale for curviform–cuneiform disunification

The numbering systems that use cuneiform numerals are descended from the ones that use curviform numerals, and many of the cuneiform signs have clear curviform counterparts across this transition. Co-occurrences are sometimes described by analogy to distinctions that are not the realm of plain text, as in [Pow72, p. 215] “in the same fashion as we use black and red ink”; however, we must bear in mind that such analogies are not made in the context of character encoding discussions. In 2004, the curviform numerals were deemed unencodable for the time being; however, closer inspection reveals that the distinction functions less like markup than was argued at the time, and that the unification is problematic.

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 millennium⁶,  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 lists⁷ and dictionaries⁸, and of composite texts⁹. 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]¹⁰. The diachronic approach is also useful for pedagogic applications¹¹.

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 encoding¹² 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

⁶Merging with U+1224E CUNEIFORM SIGN NI2.

⁷Notably [OSL] and the online edition of [Bor10] in [eBL, Signs].

⁸Notably [ePSD2] and the online edition of [Sch10] in [eBL, Dictionary].

⁹For example, there are Neo-Assyrian and Neo-Babylonian copies parts of the laws of                                                         

                                                          

                                                          

                                                          

                                                          

                                                          

                            

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

𐎶 ¹³	𐎠	𐎶	𐎶	𐎶	𐎶	𐎶
1(ḫeš ₂)	1(u)	1/2(diš)	5(diš <i>tenû</i>)	gi	us ₂	sa ₂
	7.5 (ropes)		5	reed	side	equal
𐎶 ¹⁴	𐎶	𐎶	𐎶	𐎶	𐎶	𐎶
3(u)	6(diš <i>tenû</i>)	gi	saṇ	sa ₂		
3 (ropes)	6	reed	front	equal		
𐎶𐎶𐎶	•	𐎶	𐎶	𐎶	𐎶	𐎶
ašag-bi	1(bur ₃ ^c)	1(eše ₃ ^c)	1(iku ^c)	1/2(iku ^c)		
ašag=bi						
field=DEM ¹⁵						

𐎶𐎶𐎶𐎶𐎶
tug_x(LAK 483)-si-ga-kam
tugsiga =ak =am -Ø
ploughed=GEN=COP-3.SG.S

The argument made in [L2/04-099, p. 4] is that this is comparable to a stylistic distinction such as¹⁶

465 metres, equal lengths
198 metres, equal widths
this field is 9, 18 hectares of ploughed land

where the numerals have the same structure ([L2/04-099] 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, [L2/04-099, 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 𐎶 to 𐎶 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 §3.1.

Although they had been part of the preliminary proposal [L2/03-393R], the curviform numerals were therefore removed from [L2/04-036] and [L2/04-189], which both state that “The distinction between curved numerals and their cuneiform

¹³As 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 𐎶 in copies. The photos in [CDLI] clearly show that this is in fact a vertical wedge.

¹⁴Note that ED IIIb 𐎶 numerals have a somewhat different appearance from those of the Ur III period used in this transcription; the sign 𐎶 in [P020054] looks more like Ur III 𐎶.

¹⁵Alternatively: area=POSS.3.SG.NH, “its area”.

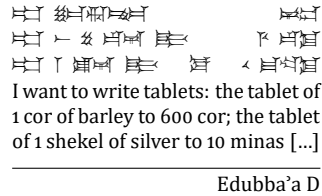
¹⁶We have taken the liberty of adjusting the analogy to use measures approximately equal to those in [P020054], instead of a field of five by twenty-five metres.

descendants is treated as glyphic for the purposes of the present proposal; this issue will need to be revisited in subsequent encoding phases¹⁷.”

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

- the functions and use of the numerals vary beyond the mere \triangleright /I 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 A primer on classic Ur III and Old Babylonian metrologies



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 known¹⁸ 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 I – IX , the multiples of ten (10–50) are X – XL , but the other digits 11–59 are sequences X – IX – I – IX ; 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 I – IX , tens X – XL , sixties I – IX (with larger wedges than the units), multiples of six hundred K – KL , multiples of three thousand six hundred D – DL , and multiples of thirty-six thousand D – DL .

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 diagram¹⁹, where the num-



¹⁷The cuneiform encoding process was planned in *stages* in [L2/03-162]. One might expect the second stage of encoding, which led to the creation of the Early Dynastic Cuneiform block, to incorporate the numerals needed for the representation and discussion of Early Dynastic texts; however, the proposal [L2/12-208] stated that “numerals have been omitted due to the complexity of numeral signs from this period. An expert in the metrology of this period must be consulted before these can be properly included.”

¹⁸See, *e.g.*, [Uni16, §22.3.3, sub “Cuneiform Numerals”].

¹⁹These diagrams, which have become standard in discussions of Mesopotamian metrology, originate with [Fri78, p. 10], where they are called *step-diagrams*, see Figure 3.

ber over arrow indicates the multiple of the preceding sign (right of the arrow) corresponding to the following sign (left).






























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







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

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]:

(G_{UR III/OB})

Note that for the range of areas given above, 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 punctuation²⁰, but the numerals are tied to the metrology; thus a surface of 5 *bûr* 1 *ebel* 4 *ikû* (100 *ikû*, 36 ha) would be written²¹                         . 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” or 五頃八畝五分九厘. Note also that the same signs are shared between multiple systems, with different relations; the sign  is equal to sixty times  in the area system, but to three hundred and sixty times  in the discrete counting system.

For areas smaller than a quarter *ikûm*, an overt unit is used, with one  (*sar*, *mûšarum*), approximately 36 m², written , equal to one hundredth of an *ikûm*, then sexagesimally subdivided in 60  (*gin*₄, *šiqlum*, “shekel”). For areas greater than 3600 *bûr*, the  and  numerals are reused with a suffix  (*gal*, “big”), as follows [Robo8, p. 295 nn. b, c; Fri07, p. 378; Rob19]:

$$\underbrace{\langle \diamond \xleftarrow{10} \diamond \rangle \xleftarrow{6} \langle \diamond \xleftarrow{10} \diamond \rangle \xleftarrow{6} \langle \diamond \xleftarrow{10} \diamond \rangle \xleftarrow{3} \langle \diamond \xleftarrow{6} \diamond \rangle \xleftarrow{2} \langle \diamond \xleftarrow{2} \diamond \rangle \xleftarrow{2,5} \langle \diamond \xleftarrow{10} \diamond \rangle \xleftarrow{2} \langle \diamond \xleftarrow{3} \diamond \rangle \xleftarrow{3} \langle \diamond \xleftarrow{10} \diamond \rangle}_{\text{Diagram 1}}, \quad (G_{\text{Ur III/OB}})$$

e.g.,  for $(2 \times 3600 + 20 \times 60 + 49)$ *būr* 5 *ikū* $(5 + \frac{1}{2})$ *mūšar* 19 *šiqil*. Factor diagrams in this document will use bottom curly brackets in this fashion to separate numerals from units and other suffixes.

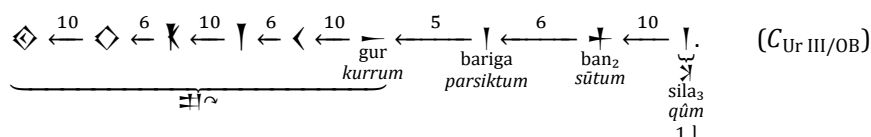
²⁰This sign is sometimes interpreted as a measurement unit, and transliterated *iku*, see, e.g., [Pro20, pp. 385 sqq.], or transliterations in [Feu04] discussed in §3.7.2. Even with this interpretation, the sequence of numerals used, and the interpretation of numerals shared with other metrological systems, is specific to system $G_{\text{IIR-III/OB}}$.

²¹As in the surface of the field of (the city of Apisal) reported on [P102305, r. 1]


²²From [P213162], which has an additional 𐤀𐤁𐤏, two thirds (of a shekel), see §3.3.5.

3.3.3 The capacity system

Another such system of note is the one for capacities²³ [Fri07, p. 376; Rob19],



In the above diagram, the numerals for ban₂ are 𐤁𐤍, 𐤁𐤍𐤁, 𐤁𐤍𐤁𐤁, 𐤁𐤍𐤁𐤁𐤁, and 𐤁𐤍𐤁𐤁𐤁𐤁, and those for bariga are 𐤁𐤍, 𐤁𐤍𐤁, 𐤁𐤍𐤁𐤁, and 𐤁𐤍𐤁𐤁𐤁 (contrast ordinary 𐤁𐤍 and 𐤁𐤍𐤁 otherwise used with 𐤁 numerals). Further, we have used the symbol \sim to express that, as described in [Hue11, p. 585 nn. (b), (f)], the sign 𐤁𐤍 GUR, while it is used only with volumes in excess of one gur, is written after the whole expression, after the overt unit sign 𐤁𐤍 if present, and after the word for “grain” if present, as in

 3554 gur
  3 ban₂
  6
  sila₃
  of grain.

Observe that while large numbers of gur follow²⁵ system $S_{\text{Ur III/OB}}$, the use of horizontal (AŠ) numerals for the gur disambiguates from the vertical bariga, as $\langle \text{I} \text{—} \text{II} \rangle$ would be 10 gur 1 bariga, and $\langle \text{—} \text{II} \rangle$ would be 11 gur; again even with some overt units, most of the numerals that participate in a metrological system have an interpretation dependent on that system.

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

- \mathbb{I} - \mathbb{W} used in $\mathcal{S}_{\text{Ur III/OB}}$ and the SPVS as well as with overt units;
- \mathbb{L} - \mathbb{X} used in $\mathcal{G}_{\text{Ur III/OB}}$, of which \mathbb{L} - \mathbb{X} are also used in $\mathcal{S}_{\text{Ur III/OB}}$ and the SPVS as well as with overt units;
- \mathbb{I} - \mathbb{W} used in $\mathcal{S}_{\text{Ur III/OB}}$, and sometimes with overt units;
- \mathbb{K} - \mathbb{W} used in $\mathcal{S}_{\text{Ur III/OB}}$;
- \mathbb{O} - \mathbb{X} used in $\mathcal{S}_{\text{Ur III/OB}}$ and $\mathcal{G}_{\text{Ur III/OB}}$;
- \mathbb{O} - \mathbb{X} used in $\mathcal{S}_{\text{Ur III/OB}}$ and $\mathcal{G}_{\text{Ur III/OB}}$;
- \mathbb{L} - \mathbb{X} used in $\mathcal{C}_{\text{Ur III/OB}}$ as well as with overt units of the weight system;
- \mathbb{L} , \mathbb{L} , \mathbb{L} , \mathbb{L} , \mathbb{L} used in $\mathcal{C}_{\text{Ur III/OB}}$;
- \mathbb{L} , \mathbb{L} , \mathbb{L} , \mathbb{L} used in $\mathcal{C}_{\text{Ur III/OB}}$ —note the overlap with \mathbb{I} - \mathbb{W} ;
- \mathbb{L} and \mathbb{L} used in $\mathcal{G}_{\text{Ur III/OB}}$.

Only in the SPVS did numerals exist truly independently of metrology; to quote [Robo8, p. 78]: “The SPVS temporarily changed the status of numbers from properties of real-world objects to independent entities that could be manipulated without regard to [...] metrological system. [...] Once the calculation was done, the result was expressed in the most appropriate metrological units and thus re-entered the natural world as a concrete quantity.”

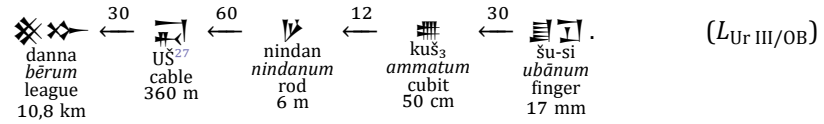
²³Used for volumes of grain, but also oil, dairy products, beer, etc., as well as to express the capacity of boats; volumes of earthworks instead use system $G_{Ur III/OB}$ based on a height of one cubit, see[[Pow87](#), p. 488; [Robo8](#), p. 294; [Rob19](#)].

²⁴From [P309594, obv. 11].

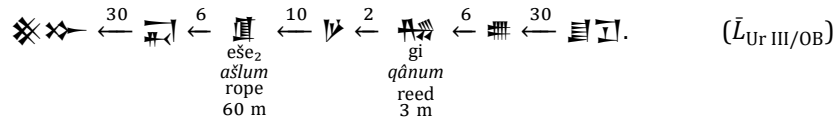
²⁵A larger unit, the *guru*₇ (*karûm*, grain heap), is sometimes used instead, with 𐎠𐎡𐎢𐎣𐎤𐎥𐎦𐎧𐎨𐎩𐎪𐎫𐎬𐎭𐎮𐎯𐎰𐎱𐎲𐎳𐎴𐎵𐎶𐎷𐎸𐎹𐎺𐎻𐎼𐎽𐎾𐎿𐏀𐏁𐏂𐏃𐏄𐏅𐏆𐏇𐏈𐏉𐏊𐏋𐏌𐏍𐏎𐏏𐏐𐏑𐏒𐏓𐏔𐏕𐏖𐏗𐏘𐏙𐏚𐏛𐏜𐏝𐏞𐏟𐏠𐏡𐏢𐏣𐏤𐏥𐏦𐏧𐏨𐏩𐏪𐏫𐏬𐏭𐏮𐏯𐏰𐏱𐏲𐏳𐏴𐏵𐏶𐏷𐏸𐏹𐏺𐏻𐏼𐏽𐏾𐏿𐐀𐐁𐐂𐐃𐐄𐐅𐐆𐐇𐐈𐐉𐐊𐐋𐐌𐐍𐐎𐐏𐐐𐐑𐐒𐐓𐐔𐐕𐐖𐐗𐐘𐐙𐐚𐐛𐐜𐐝𐐞𐐟𐐠𐐡𐐢𐐣𐐤𐐥𐐦𐐧𐐨𐐩𐐪𐐫𐐬𐐭𐐮𐐯𐐰𐐱𐐲𐐳𐐴𐐵𐐶𐐷𐐸𐐹𐐺𐐻𐐼𐐽𐐾𐐿𐑀𐑁𐑂𐑃𐑄𐑅𐑆𐑇𐑈𐑉𐑊𐑋𐑌𐑍𐑎𐑏𐑐𐑑𐑒𐑓𐑔𐑕𐑖𐑗𐑘𐑙𐑚𐑛𐑜𐑝𐑞𐑟𐑠𐑡𐑢𐑣𐑤𐑥𐑦𐑧𐑨𐑩𐑪𐑫𐑬𐑭𐑮𐑯𐑰𐑱𐑲𐑳𐑴𐑵𐑶𐑷𐑸𐑹𐑺𐑻𐑼𐑽𐑾𐑿𐒀𐒁𐒂𐒃𐒄𐒅𐒆𐒇𐒈𐒉𐒊𐒋𐒌𐒍𐒎𐒏𐒐𐒑𐒒𐒓𐒔𐒕𐒖𐒗𐒘𐒙𐒚𐒛𐒜𐒝𐒞𐒟𐒠𐒡𐒢𐒣𐒤𐒥𐒦𐒧𐒨𐒩𐒪𐒫𐒬𐒭𐒮𐒯𐒰𐒱𐒲𐒳𐒴𐒵𐒶𐒷𐒸𐒹𐒺𐒻𐒼𐒽𐒾𐒿𐓀𐓁𐓂𐓃𐓄𐓅𐓆𐓇𐓈𐓉𐓊𐓋𐓌𐓍𐓎𐓏𐓐𐓑𐓒𐓓𐓔𐓕𐓖𐓗𐓘𐓙𐓚𐓛𐓜𐓝𐓞𐓟𐓠𐓡𐓢𐓣𐓤𐓥𐓦𐓧𐓨𐓩𐓪𐓫𐓬𐓭𐓮𐓯𐓰𐓱𐓲𐓳𐓴𐓵𐓶𐓷𐓸𐓹𐓺𐓻𐓼𐓽𐓾𐓿𐔀𐔁𐔂𐔃𐔄𐔅𐔆𐔇𐔈𐔉𐔊𐔋𐔌𐔍𐔎𐔏𐔐𐔑𐔒𐔓𐔔𐔕𐔖𐔗𐔘𐔙𐔚𐔛𐔜𐔝𐔞𐔟𐔠𐔡𐔢𐔣𐔤𐔥𐔦𐔧𐔨𐔩𐔪𐔫𐔬𐔭𐔮𐔯𐔰𐔱𐔲𐔳𐔴𐔵𐔶𐔷𐔸𐔹𐔺𐔻𐔼𐔽𐔾𐔿𐕀𐕁𐕂𐕃𐕄𐕅𐕆𐕇𐕈𐕉𐕊𐕋𐕌𐕍𐕎𐕏𐕐𐕑𐕒𐕓𐕔𐕕𐕖𐕗𐕘𐕙𐕚𐕛𐕜𐕝𐕞𐕟𐕠𐕡𐕢𐕣𐕤𐕥𐕦𐕧𐕨𐕩𐕪𐕫𐕬𐕭𐕮𐕯𐕰𐕱𐕲𐕳𐕴𐕵𐕶𐕷𐕸𐕹𐕺𐕻𐕼𐕽𐕾𐕿𐖀𐖁𐖂𐖃𐖄𐖅𐖆𐖇𐖈𐖉𐖊𐖋𐖌𐖍𐖎𐖏𐖐𐖑𐖒𐖓𐖔𐖕𐖖𐖗𐖘𐖙𐖚𐖛𐖜𐖝𐖞𐖟𐖠𐖡𐖢𐖣𐖤𐖥𐖦𐖧𐖨𐖩𐖪𐖫𐖬𐖭𐖮𐖯𐖰𐖱𐖲𐖳𐖴𐖵𐖶𐖷𐖸𐖹𐖺𐖻𐖼𐖽𐖾𐖿𐗀𐗁𐗂𐗃𐗄𐗅𐗆𐗇𐗈𐗉𐗊𐗋𐗌𐗍𐗎𐗏𐗐𐗑𐗒𐗓𐗔𐗕𐗖𐗗𐗘𐗙𐗚𐗛𐗜𐗝𐗞𐗟𐗠𐗡𐗢𐗣𐗤𐗥𐗦𐗧𐗨𐗩𐗪𐗫𐗬𐗭𐗮𐗯𐗰𐗱𐗲𐗳𐗴𐗵𐗶𐗷𐗸𐗹𐗺𐗻𐗼𐗽𐗾𐗿𐘀𐘁𐘂𐘃𐘄𐘅𐘆𐘇𐘈𐘉𐘊𐘋𐘌𐘍𐘎𐘏𐘐𐘑𐘒𐘓𐘔𐘕𐘖𐘗𐘘𐘙𐘚𐘛𐘜𐘝𐘞𐘟𐘠𐘡𐘢𐘣𐘤𐘥𐘦𐘧𐘨𐘩𐘪𐘫𐘬𐘭𐘮𐘯𐘰𐘱𐘲𐘳𐘴𐘵𐘶𐘷𐘸𐘹𐘺𐘻𐘼𐘽𐘾𐘿𐙀𐙁𐙂𐙃𐙄𐙅𐙆𐙇𐙈𐙉𐙊𐙋𐙌𐙍𐙎𐙏𐙐𐙑𐙒𐙓𐙔𐙕𐙖𐙗𐙘𐙙𐙚𐙛𐙜𐙝𐙞𐙟𐙠𐙡𐙢𐙣𐙤𐙥𐙦𐙧𐙨𐙩𐙪𐙫𐙬𐙭𐙮𐙯𐙰𐙱𐙲𐙳𐙴𐙵𐙶𐙷𐙸𐙹𐙺𐙻𐙼𐙽𐙾𐙿𐚀𐚁𐚂𐚃𐚄𐚅𐚆𐚇𐚈𐚉𐚊𐚋𐚌𐚍𐚎𐚏𐚐𐚑𐚒𐚓𐚔𐚕𐚖𐚗𐚘𐚙𐚚𐚛𐚜𐚝𐚞𐚟𐚠𐚡𐚢𐚣𐚤𐚥𐚦𐚧𐚨𐚩𐚪𐚫𐚬𐚭𐚮𐚯𐚰𐚱𐚲𐚳𐚴𐚵𐚶𐚷𐚸𐚹𐚺𐚻𐚼𐚽𐚾𐚿𐛀𐛁𐛂𐛃𐛄𐛅𐛆𐛇𐛈𐛉𐛊𐛋𐛌𐛍𐛎𐛏𐛐𐛑𐛒𐛓𐛔𐛕𐛖𐛗𐛘𐛙𐛚𐛛𐛜𐛝𐛞𐛟𐛠𐛡𐛢𐛣𐛤𐛥𐛦𐛧𐛨𐛩𐛪𐛫𐛬𐛭𐛮𐛯𐛰𐛱𐛲𐛳𐛴𐛵𐛶𐛷𐛸𐛹𐛺𐛻𐛼𐛽𐛾𐛿𐜀𐜁𐜂𐜃𐜄𐜅𐜆𐜇𐜈𐜉𐜊𐜋𐜌𐜍𐜎𐜏𐜐𐜑𐜒𐜓𐜔𐜕𐜖𐜗𐜘𐜙𐜚𐜛𐜜𐜝𐜞𐜟𐜠𐜡𐜢𐜣𐜤𐜥𐜦𐜧𐜨𐜩𐜪𐜫𐜬𐜭𐜮𐜯𐜰𐜱𐜲𐜳𐜴𐜵𐜶𐜷𐜸𐜹𐜺𐜻𐜼𐜽𐜾𐜿𐝀𐝁𐝂𐝃𐝄𐝅𐝆𐝇𐝈𐝉𐝊𐝋𐝌𐝍𐝎𐝏𐝐𐝑𐝒𐝓𐝔𐝕𐝖𐝗𐝘𐝙𐝚𐝛𐝜𐝝𐝞𐝟𐝠𐝡𐝢𐝣𐝤𐝥𐝦𐝧𐝨𐝩𐝪𐝫𐝬𐝭𐝮𐝯𐝰𐝱𐝲𐝳𐝴𐝵𐝶𐝷𐝸𐝹𐝺𐝻𐝼𐝽𐝾𐝿𐞀𐞁𐞂𐞃𐞄𐞅𐞆𐞇𐞈𐞉𐞊𐞋𐞌𐞍𐞎𐞏𐞐𐞑𐞒𐞓

3.3.4 The length system

In the Ur III and Old Babylonian periods, lengths are expressed using overt units counted with 1 and < numerals with their system $S_{\text{Ur III/OB}}$ values. Since it does not have any unusual numerals, this system would not in itself be of much relevance to character encoding, but we present it here as background for its Early Dynastic counterpart presented in §3.4. Metrological tables use the following units²⁶ [Fri07, p. 118; Rob19]:



Two more units appear occasionally [Pow87, p. 459; Fri07, p. 118; Rob19]:



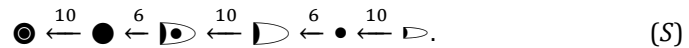
In addition, there are Akkadian names for the half-rope and half-reed, see [Pow87, pp. 463 sq.].

3.3.5 Fractions

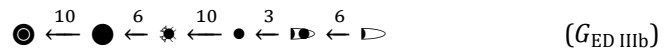
Fractions of the *ikīm*, $\frac{1}{2}$ and $\frac{1}{4}$, have already been encountered. In other contexts, the fraction $\frac{1}{2}$ is written $\frac{1}{2}$, as in $\frac{1}{2}$. The fractions $\frac{1}{3}$ and $\frac{2}{3}$ are written $\frac{1}{3}$ and $\frac{2}{3}$. The latter two signs are derived from curviform signs $\frac{1}{3}$ and $\frac{2}{3}$, which are already separately encoded; these are in turn derived from the sign $\frac{1}{3}$ ($\bar{S}U_2$), whose Early dynastic form resembles $\frac{1}{3}$, and $\frac{2}{3}$ numerals; see [Pow71, pp. 113, 134]. The $\frac{1}{3}$ is sometimes omitted, as in [P240545, verso 6 9; P221530; P221531; P271238; P274845].

3.4 Curviform numerals in early metrologies

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



Likewise the area system used in the Early Dynastic IIIb period for areas of one iku and greater [Dei22, p. 72; NDE93, p. 63; Fri07, p. 378; Lec16],



²⁶In this factor diagram and the next, we do not include the numerals. The units are no more than a factor of 60 apart, so higher numerals such as $\frac{1}{2}$ or $\frac{1}{4}$ are not used.

²⁷As indicated by the capitalization, the reading of this sign is unknown; see [Pow87, pp. 465 sqq.] for a discussion of various hypotheses.

mirrors system $G_{Ur III/OB}$, with consistent use of the numerals: \bullet corresponds to \leftarrow , \bullet to \diamond , and \odot to \diamond . An exception to this correspondence, noted in [L2/04-099, p. 4] (see §3.2), is that the vertical \uparrow from $S_{Ur III/OB}$ corresponds to a horizontal \triangleright in system S . This is however far from the only case of such a reallocation of function. The earlier form of the area system is [DE87, pp. 141, 165; Fri07, p. 378]:

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

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 fourth millennium, 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).

Another example of nontrivial correspondence between cuneiform and curviform numerals may be found by comparing the fractions the Early Dynastic IIIb area system²⁸,

$$\odot \xleftarrow{10} \bullet \xleftarrow{6} \star \xleftarrow{10} \bullet \xleftarrow{3} \triangleright \xleftarrow{6} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright, \quad (G_{ED IIIb})$$

with the numerals of a contemporaneous capacity system:

$$\underbrace{\triangleright \xleftarrow{10} \triangleright \xleftarrow{6} \bullet \xleftarrow{10} \triangleright \xleftarrow{4} \triangleright \xleftarrow{6} \triangleright}_{\text{gur san ḡal}_2} \quad (C_{\text{ED IIIb}})$$

both described in [Lec16]. While the size of the gur san ḡal_2 in bariga is different from that of the Old Babylonian gur , the basic structure of the capacity system is recognizable, with \triangleright corresponding to \uparrow for bariga, \triangleright – \triangleright corresponding to \uparrow – \uparrow for ban₂, and the gur counted with \triangleright rather than \leftarrow numerals. However, the half-iku is counted with the same \triangleright as the bariga, whereas it uses a different sign, \searrow , in the Old Babylonian system. As we will see, this cannot be handled as a split, by giving \searrow the glyph \triangleright in an Early Dynastic IIIb font, as the \searrow numeral series is also in use in that period.

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 \uparrow is generally omitted; in addition, only tens of rods are used; these are equal to one rope, but the sign gur is not written either. Lengths shorter than one rope are expressed in half-rope using the $\frac{1}{2}$ sign \uparrow (again with no gur), and then in reeds, *with* the sign gi , as follows:

$$\uparrow \xleftarrow{6} \leftarrow \xleftarrow{2} \uparrow \xleftarrow{10} \searrow. \quad (L_{ED IIIb})$$

$\begin{array}{l} 1 \text{ eše}_2 = 10 \text{ nindan} \\ 1 \text{ rope} = 10 \text{ rods} \\ 60 \text{ m} \end{array} \quad \begin{array}{l} \text{gi} \\ \text{reed} \\ 3 \text{ m} \end{array}$


This is the system that was used to express the sides of the field in [P020054] discussed in §3.2. In that tablet and most others from the same period, such as the

²⁸A variant is $\odot \xleftarrow{10} \bullet \xleftarrow{6} \star \xleftarrow{10} \bullet \xleftarrow{3} \triangleright \xleftarrow{6} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright \xleftarrow{2} \triangleright$, see [Pow72, p. 218].

²⁹The (fairly rare) cuneiform counterpart is \downarrow .

³²The reeds are counted using *tenû* numerals, \searrow , \swarrow , \nwarrow , etc.

numerals for \aleph [Fri78, p. 43; Lec16]:


(C 出 出 出)

as in [P020016, rev. 1 4; P020065; P020090, obv. 1 3, rev. 2 1; P020092, rev. 3, 1; P020137, obv. 1 2] and others, where ban_2 counted with ∇ numerals are followed by sil_3 counted with \searrow numerals. Curviform numerals are also used to count sil_3 , but not⁴⁰ as part of the \boxplus systems. This contrast can be seen in [P220927], which measures butter (∇ , i_3) with a different capacity system, using the \boxplus (dug, “pot”) of 20 \searrow , with \triangleright and \bullet numerals⁴¹ for both the \boxplus and the \searrow , thus [Pow87, pp. 504 sq.]

$$\bullet \xleftarrow{10} \text{D} \xleftarrow{2} \bullet \xleftarrow{10} \text{D} \xleftarrow{\frac{3}{2}} \text{D} \xleftarrow{2} \text{D}, \quad (C_{\text{D}})$$

but counts cheese (𐤒𐤍𐤏𐤍, ga'ar) using the 𐤁𐤏𐤍𐤏𐤍 capacity system, with 𐤏 numerals for the 𐤍.

Another capacity system in ED IIIb Nirsu is the $\text{𒀠} \text{𒀡} \text{𒀢}$, the gur of two ul [Lec16]:






$$\bullet \xleftarrow{10} \underbrace{\triangleright \xleftarrow{2} \triangleright \xleftarrow{6} \triangleright \xleftarrow{6}}_{\mathbb{H} \times \langle \triangleright \rangle} \xleftarrow{\mathbb{K}}. \quad (C_{\mathbb{H} \times \langle \triangleright \rangle})$$

Here the $\triangleright-\searrow-\sqcup$ contrast occurs not only within the numerals of the system, but with its units; this is perhaps best illustrated by the expressions $\text{𐤀} \text{𐤁} \text{𐤂}$ $\text{𐤃} \text{𐤄} \text{𐤅}$ $\text{𐤆} \text{𐤇} \text{𐤈}$ $\text{𐤉} \text{𐤊} \text{𐤋}$ in [P221746, rev. 2 2] and $\text{𐤌} \text{𐤍} \text{𐤎}$ $\text{𐤏} \text{𐤐} \text{𐤑}$ $\text{𐤒} \text{𐤓} \text{𐤔}$ in [P221814, rev. 15].






3.4.4 Grain in Ebla








The mixing of curviform and cuneiform numerals within a metrological system is not specific to Nirsu.

⁴⁰As of this writing, the single occurrence of {ban2@c} followed by curviform numerals and sila3 in ED IIIb Nirsu transliterations on [CDL], 4{ban2@c} 3{asz@c} sila3 in [P221815, obv. 4 7], is incorrect: it should be 4{ban2@c} 3{disz@t} sila3.

⁴¹This tablet also uses subtractive notation:  “two pots minus two thirds (silā₃)”,  “ten minus one pots, six silā₃”. Such subtractive notation is common in most of the metrological systems discussed here; it appears in the ED IIIa period [Rob08, p. 77]. It presents no complexity for character encoding, but it is noteworthy that the sign  (‘al, ‘minus’) is often ligated with the following numerals, with the subtrahend placed under a sometimes considerably enlarged , similar to the layout of the radical in modern mathematical notation, see, e.g., [P020092, rev. 3, 1, 2]. A good font could handle the very common -1 case, perhaps even -2 and -3 ; setting arbitrary numeric expressions under the , or more generally replicating the layout of Early Dynastic tablets, is outside the realm of plain text; see also §6.2.

The system of grain⁴² capacities in Ebla uses the following units⁴³:

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

The  and  are generally counted using curviform numerals, and the smaller units using cuneiform  numerals⁴⁴ Indeed, a search on [EbDA] for co-occurrences of either  or  with either of  or  finds the following expressions⁴⁵:

- [illegible]

⁴²Liquid capacities use a different system [Arc15, p. 229 n. 12]:







←³⁰ ←⁶

A glance it seems that 𐤀 are counted with cuneiform numerals and higher units with curviform ones, thus



[illegible]

but we have not investigated this thoroughly.

⁴³Another system uses different values for the \mathbb{I} and \mathbb{J} , see [Cha12, p. 62; Arc15, p. 229 n. 12]:

⁴⁴As mentioned in [Cha12, p. 63], the 𐤠 is also counted using the 𐤡–𐤢 numeral series. Some instances of that usage are found transliterated *n/6* in [EbdA]; in some cases the 𐤠 sign is omitted, and the 𐤡 numeral is then written before the 𐤠 unit, as in 𐤡𐤠𐤢𐤠 from [P240545, verso 13].

⁴⁵We 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 checked⁴⁶ on a photograph (from [EbDA] unless noted otherwise).


⁴⁶As we will see in §3.7.2, [CDL] 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.

⁴⁷ba-ri₂-zu₂, a variant spelling.

⁴⁸Short for $\Box \perp$.

⁴⁹Note the omitted $\square \Diamond \perp$.

⁵⁰Instead of the expected $\mathbb{R}^2 \times \mathbb{R}^2$.

⁵¹  not legible on the EbDA photo.

⁵²From [CDLI] photo.

⁵³From photo in [Arc89, p. 6].

⁵⁴Laid out as $\begin{smallmatrix} | & | & | \\ | & | & | \end{smallmatrix}$; on stacking patterns see §6.2.

Thus, for instance, the original set of fractions $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{8}$ of an iku) in the Sumerian GANA system, was after a time augmented through the addition of the new sub-unit SAR: $\frac{1}{100}$ of an iku ($\frac{1}{20}$). Similarly, the Sumerian weight unit "na-na" which originally may have had only the sub-units $\frac{1}{3}$ sa-na (= 1/3 mana) and $\frac{2}{3}$ sa-na-bi (= 2/3 mana), and perhaps also gin: $\frac{1}{60}$ (= 1/60 mana), seems to have acquired, at some time or other, also the smaller sub-units $\frac{1}{3}$ gin, and $\frac{1}{3} \times \frac{1}{60}$ gin).

Figure 5: Discussion of proposed fractions $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{1}{100}$, as well as already-encoded $\frac{1}{3}$ and $\frac{2}{3}$ in [Fri78, p. 49].

stein publizierten Zeichenliste enthalten ist³, bis vor kurzem unentdeckt bleiben konnte. Erst 1978 machte der schwedische Mathematiker J. Friberg, ERM I, 9-11, darauf aufmerksam, daß die Zeichen für die Zahlen Eins (∇) und Zehn (\bullet) in Verbindung mit dem Zeichen ŠE nicht im Verhältnis 1 zu 10 sondern im Verhältnis 1 zu 6 stehen. Bis dahin hatte man, obwohl die Andersartigkeit des in Verbindung mit dem Zeichen ŠE verwendeten Zahlzeichensystems bekannt war, für diese beiden häufigsten Zahlzeichen einheitlich ein Verhältnis 1 zu 10 unterstellt, obwohl es mehrere eindeutige Gegenbelege gab, von denen zumindest diejenigen der Archaischen Texte aus Gendet Nasr bereits früh publiziert und jedermann zugänglich waren⁴. Als Folge

Figure 6: Discussion in [DE87, p. 117] of the discovery in [Fri78, pp. 9–11] (see Figure 3) of the different relations between ∇ and \bullet in systems G and ??.

there is in any case an important qualitative difference between IX for Latin novem and \bullet for Sumerian niš. niš seems to be a primary numberword requiring, in a system depicting Sumerian numeration, a differentiated representation comparable

Figure 7: The sign \bullet used in a parallel with IX in [Eng88, pp. 131–133 n. 9], discussing an argument from [Pow72, p. 172] on the question of the language of the Uruk III texts.

the derivation in [Fri78, p. 15] is based on proto-Elamite artefacts. There is a typo in the equation for C 27: the right-hand side should have 10X (rather than 1X), otherwise nothing could be deduced about X . Note that in Friberg's early works [Fri78; Fri79; Fri86; Fri87], copies of fourth millennium and sometimes third millennium tablets are shown as vertical text (which they were for the scribes), and their numerals are written within horizontal text in the same orientation that they have if the tablet is taken as vertical text; in [UAX50] parlance, as if they had Vertical_Orientation=Upright. In addition, they are listed in these equations in the horizontal order in which they appear as vertical text (thus the rightmost numeral is the most significant, read first). Cuneiform is correctly Vertical_Orientation=Rotated, consistently both with modern practice and with the rotation between earlier vertical and later horizontal monumental inscriptions. Friberg's early conventions are not followed in later scholarship, and are abandoned in his own more recent works, such as [Fri07]; a more typical way to express the first equations might be

$$\begin{aligned} 5\bullet + 4\text{D} &= 3\bullet + 24\text{D} & (\text{C } 234) \\ 1\text{D} + 1\bullet + 5\text{D} &= 7\bullet + 5\text{D} & (\text{C } 314) \\ 1\text{X} + 1\text{X} + 1\text{D} &= 10\text{X} + 2\text{D} + 6\bullet. & (\text{C } 27) \end{aligned}$$

A diplomatic edition of [Fri78] could rotate the numerals using a higher-level protocol:

$$\begin{aligned} 4\text{D} 5\bullet &= 24\text{D} 3\bullet & (\text{C } 234) \\ 5\text{D} 1\bullet 1\text{D} &= 5\text{D} 7\bullet & (\text{C } 314) \\ 1\text{D} 1\text{X} 1\text{X} &= 6\bullet 2\text{D} 1\text{X} & (\text{C } 27). \end{aligned}$$

of decreasing fractions $1/n$ of this measure, whereby "n" was determined by the number of oblique impressions made by the rounded end of a thin stylus around a central point in a specific sign. Thus $\Xi = 1/2 N_{39}$, $\tilde{\nabla} = 1/3 N_{39}$, and so on. The first sign of the latter units, N_{34} ,

Figure 8: Description of the fractions Ξ and $\tilde{\nabla}$ in [Eng98, p. 113]⁶¹.

For instance, the first line contains the notations $1N_{34} 1N_{39} ; 2N_{20}$, which can be translated "60 of the (grain rations containing) (of grain); (grain involved): 2 • (of ground barley)". This calculation contradicts the assumed numerical relationship $10N_1 = 1N_{14}$, since as was well known the measure represented by the sign N_{39} was $1/5$ of that represented by N_1 , so that $60 \times 1/5 = 12$ and not 20, as $2N_{14}$ would imply. Instead of relying on complicated

Figure 9: The sign \ominus used as a capacity measure within otherwise translated text in [Eng98, p. 116].

Die halbkreisförmigen Griffleindrücke gehen manchmal in mehr oder weniger eckige Formen über (∇)⁶⁸⁵. Es gibt aber auch Einer in Form von regelrechten – meist mehr oder weniger schräggestellten – Keilen (\searrow), die öfters neben halbrunden Einern vorkommen und mit diesen kontrastieren⁶⁸⁶. Selten treten mit ∇ gebildete Zahlen auf⁶⁸⁷ (sie entsprechen den biga-Zahlen im Hohlmaßsystem, s.u. 7.4).

Figure 10: Discussion of co-occurrences and contrasts between \lrcorner , \searrow , and ∇ in [Kre98, p. 303].

The calculations:									
Obv. i	1	$60 \times 1/5 \nabla$	(\ominus)	=	$12 \times \nabla$	=	$2 \times \bullet$		
	2	$120 \times 1/10 \nabla$	(Ξ)	=	$12 \times \nabla$	=	$2 \times \bullet$		
	3	$120 \times 1/15 \nabla$	($\tilde{\nabla}$)	=	$8 \times \nabla$	=	$1 \times \bullet$	$2 \times \nabla$	
	4	$300 \times 1/20 \nabla$	($\tilde{\Xi}$)	=	$15 \times \nabla$	=	$2 \times \bullet$	$3 \times \nabla$	
	5	$600 \times 1/25 \nabla$	($\tilde{\Xi}$)	=	$24 \times \nabla$	=	$4 \times \bullet$		
Rev. i	1	1200			$1 \times \bullet$	$1 \times \bullet$	$5 \times \nabla$		
Obv. i	6	$6000 \times 1/30 \nabla$	(GAR+6N ₅₇)	=	$200 \times \nabla$	=	$1 \times \nabla$	$3 \times \bullet$	$2 \times \nabla$
ii	1	$120 \times \approx 1/4 \nabla$	(DUG _a +U _{2a})	\approx	$30 \times \nabla$	=	$5 \times \bullet$	$1 \times \nabla$	$1 \times \nabla$
	2	$180 \times 1/5 \nabla$	(DUG+AS ₁)	=	$36 \times \nabla$	=	$6 \times \bullet$		
	3	$300 \times 1/15 \nabla$	(KAŠ _a)	=	$20 \times \nabla$	=	$3 \times \bullet$	$2 \times \nabla$	
Rev. i	3	600			$1 \times \bullet$	$4 \times \bullet$	$3 \times \nabla$		$1 \times \nabla$
					$1 \times \bullet$	$1 \times \bullet$	$5 \times \nabla$		
					$1 \times \nabla$	$3 \times \bullet$	$2 \times \nabla$		
					$1 \times \bullet$	$4 \times \bullet$	$3 \times \nabla$		$1 \times \nabla$
Grand total of groats used:					$1 \times \nabla$	$2 \times \bullet$	$9 \times \bullet$	$4 \times \nabla$	$1 \times \nabla$
Grand total of malt used: $1N_{47} 4N_{20} 3N_5 1N_{42a}$ (rev. i 3) $\times 1/5 \approx$					$8 \times \bullet$	$4 \times \nabla$	$1 \times \nabla$		

Figure 6. Transliteration and calculations of MSVO 4, 66.

Figure 11: Calculations from [P005468] transcribed in [Eng01, p. 132] using modern mathematical notation combined with some of the proposed characters.

⁶¹The text erroneously has N_{34} instead of N_{24} .









strong similarities between “area” 1 and “area” 3 systems, the sign with two concentric discs (, notated N₅₀²⁷) remains problematic. It never appears in any numerical combination with the sign with a single disc (,

Figure 12: Discussion of  and  ⁶² in [Cha03, p. 6].

¹/₁₅, etc., of gur, we would expect the metrogram gur to appear in sub-column ii. In a certain way, it does for larger measures: the notation   could be understood as 1 ¹/₅ gur.²⁷ However, the metrogram gur does not appear for lower measures. It would not be consistent to attribute different functions to the same grapheme, according to the relative importance (be it great or small) of the quantity, so the signs  and  cannot be considered klasmatograms.

Metrological tablets from the end of the 4th millennium (Nissen, Damerow and Englund 1993, 55-59, to *MSVO* 1, nos. 2-3) contain a discrete set of numerical signs with specific surface area reference:

 1(iku) represents a surface of 3600m²
 1(eše₃) represents a surface of 21,600m²
 etc.

The signs iku and eše₃ constitute by themselves measures of surface areas. These measures are usually followed by the sign GAN₂, which means either surface or field and

Figure 13: Discussion of Old Babylonian⁶⁴ capacity and fourth millennium area measures in [Pro09, p. 9].




formed by only two signs  and , 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, 60², 60³, 1/60, 1/60², etc. are written in the same way, with the vertical wedge . The third feature concerns the exact function of

Figure 14: Description of the SPVS in [Cha12, p. 58], using the already-encoded signs  and .
















one step. The scribes of the Early Dynastic Period (c. 2600 BC), for instance, represented the number 648,000 with:    but never with the repetition   .

Figure 15: Discussion of large numbers illustrated by    ⁶⁵ in [Cha12, p. 59]

⁶²The statement that these do not co-occur refers to the texts from ED I-II Ur; these signs co-occur both earlier and later in areas, with different relations as previously discussed.

⁶⁴The cuneiform text is Unicode-encoded.

⁶⁵Compare   in system G_{Ur III/0B}. Sign order can be variable in early texts, see [Fox16, p. 8]. See [P010773], also discussed in [Fri07, p. 148], for an example of  , and [P274845; P241764] for examples of  .

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:







 še bar  ba-rí-zu
'3 *gubar* (capacity units) and 1 *parisu*'.

Figure 16: Partial transliteration of [P240597, recto 5 3]      in [Cha12, p. 61].














This is particularly true of the signs , ,  and , whose form explicitly denotes the fractions 1/6, 2/6, 3/6, and 4/6 of the barig capacity measure written  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  is most often associated with the *parisu* measure, while the signs , ,  and  refer to 1, 2, 3,

Figure 17: Discussion in [Cha12, p. 64] of the relation between – and  in Mesopotamia and in Ebla.







shape. The principle of notation is additive: each sign is noted as many times as necessary (e.g.,    transliterated as 2(*šar*₂) 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 18: Explanation of the structure of the number    in [Pro20, p. 350].





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



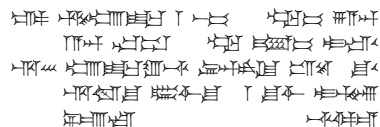
Fig. 1. Combinations of numerals attested in Š. 742.

Figure 19: 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  ‘a₃-da-um^{tu}-2 ”,
aktum 4      sa₆ gunu₃” (Fig. 2).

Figure 20: 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’⁶⁶. Do you know its reading⁶⁷?

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 period⁶⁸, such non-numeric usage is almost⁶⁹ always written , for instance:

- in personal names in administrative texts, such as the following, which all contain numerals:
 - in [P010424, rev. 1 5; P010458, obv. 1 5; P010459, obv. 2 5'] from ED IIIa *أبو صلابيخ*,
 - in [P010960, obv. 2 5] from ED IIIa Šuruppag,
 - in [P251641, obv. 4 3] from ED IIIb Adab,
 - in [P252866, rev. 2 3] from ED IIIb Adab,
 - in [P298637, rev. 2 4] from ED IIIb Umma;
- in the Sumerian word *u₂-rum*, “property” in ED IIIb Nirsu administrative texts which contain numerals, such as [P020006, obv. 2 3; P020008, rev. 1 2; P020018, rev. 1 2; P020024, obv. 1 4; P020030, obv. 3 1];
- in lexical texts:
 - in the divine name in the lexical texts [P010570, rev. 2 4; P010572, obv. 3 6], where the entries are prefixed with .
 - in the word *dili*, “small fish” in [P010578, obv. 2 5], witness to Early Dynastic Fish,
 - in the same word with a determinative, *dili*^{ku₆}, in [P010586, obv. 4 4, 6], witness to Early Dynastic Food, which starts with numerals.

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

3.6 The 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 §3.1. While these benefits are real and

⁶⁶The reader will recall that *neš₂* is written , with a larger wedge than ; however, these signs have merged by the time Examenstext A is composed.

⁶⁷Besides *neš₂*, a look at [OSL] shows that the values *diš*, *ge₃*, *makkaš*, *saṅtak₄*, and *tal₄* are attested both in [ePSD2] and in lexical lists. The sign is also used for the Akkadian word *ana* in the Neo-Assyrian period.

⁶⁸A [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)”.

⁶⁹Exceptions are discussed in §3.7.1.

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 — that have both numeric and non-numeric values in both the main list and the section on numbers. For instance, [Sch35, pp. 123 sqq.] lists all of — – — together with — – — , while — , — , and — , and only those, appear at the beginning of the sign list, since they have non-numeric values⁷⁰. [Cat13, p. 58] has the numeric signs — , — , — , whereas non-numeric — is at the beginning of the sign list, where its values *aš* and *rum* are listed. For signs with both non-numeric and numeric usage, [Dei22] writes *s. die Zahlz.* throughout the main list; LAK 1 — thus reappears at LAK 829 together with — , — , and — . One should note [Bor10], 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 $G_{\text{Ur III/OB}}$.

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 changes⁷¹ to the text between Early Dynastic and later witnesses that prevent a diachronic encoding of such composites. For numerals, the switch from \triangleright to \intercal numerals prevents diachronic encoding even if \triangleright were unified with \blacktriangleleft . For instance, the lexical list Early Dynastic Food, already mentioned in §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 \intercal numerals, whereas they are written with \triangleright numerals in the Early Dynastic witnesses; since \intercal and \blacktriangleleft are distinct⁷² characters, the \triangleright - \blacktriangleleft 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 periods⁷³, there is little opportunity for a diachronic representation of numeric quantities.

In the case of analyses such as [Rom23, sub “Adding Corpora”], it is interesting to note that numeric expressions are removed prior to the conversion of the corpus to Unicode cuneiform for further analysis.

⁷⁰Non-numeric values of \multimap were discussed in §3.5; \multimap has the values man_3 and min_5 , and is used for the word *didli*, “several, various”; $\multimap\multimap$ has the value es_6 .

⁷¹Compare, e.g., in the *Instructions of Šuruppak*, 𒊩𒈾𒀭𒂗𒍪 / 𒊩𒈾𒀭𒂗𒍪 in the ED IIIa witness [P222243, obv. 2 7], also discussed in §3.7.1, and 𒊩𒈾𒀭𒂗𒍪 𒉈𒁺𒃶𒄣 in the OB composite [Q000782, 6] (translated “Šuruppak gave instructions to his son” in [ETCSL, t.5.6.1, 1–13]). It does not matter for the construction of a composite text whether this is encoded 𒊩𒈾𒀭𒂗𒍪 or 𒉈𒁺𒃶𒄣, since that word is absent from other witnesses, and since the surrounding words differ.

⁷²Besides the contrasts in numeric usage mentioned in §3.3.3, these (already-encoded) characters were clearly not unifiable because of the many contrasts in non-numeric usage between them; several values of — which are not shared with † have already been mentioned, but perhaps most striking is the fact that, in the Neo-Assyrian period, — is used for the preposition *ina*, ‘in’, and † for the preposition *ana*, ‘to’.

⁷³See, e.g., [Pow87, p. 493; Robo8, p. 55] on the unification of metrologies in the Old Akkadian period, resulting in the systems described in §3.3.

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 fonts⁷⁴ 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 ŠAR₂

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

In most texts from the Early Dynastic IIIb and Old Akkadian period⁷⁵, a contrast between non-numeric šar₂ written ◊ and numeric 1(šar₂) written ● can be observed, similar to the contrast between — and ▷ previously discussed in §3.5. However, in lexical lists from Šuruppak and Ebla⁷⁶, as well as in the *Stèle des vautours*, non-numeric šar₂ is curviform:

- * 𒌦 ◊ and * 𒌦 ● in [P010566, obv. 10 10, 11];
- ● 𒌦 and * 𒌦 in [P010576, rev. 3 16, 17];
- ● 𒌦 in [P240986, recto 3 3]⁷⁷;
- ● 𒌦 in [P222399, obv. 17 9, 18 11, 22 12]⁷⁸.

It *would* be disruptive to the diachronic representation of text if non-numeric šar₂ were to have two different representations. The character U+122B9 CUNEIFORM SIGN ŠAR₂ 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 šar₂ 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 ŠAR₂ 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.

⁷⁴Most prominently Noto Sans Cuneiform, a system font on both Windows—as part of Segoe UI Historic—and macOS.

⁷⁵For example, in personal names:

- 𒌦 ◊ 𒌦 in [P020019, rev. 1 2] from ED IIIb Nirsu;
- 𒌦 ◊ 𒌦 in [P020182, obv. 2 9], also from ED IIIb Nirsu;
- 𒌦 ◊ in [P222186, obv. 3 3] from ED IIIb Umma;
- 𒌦 ◊ in [P235312, obv. 16] from Old Akkadian Umma.

⁷⁶These are archaizing in other ways, *e.g.*, they have a 𒌦-𒌦 (NAM₂-TUG₂) split.

⁷⁷From copy in [Man81, ELLeS 397].

⁷⁸Note however * 𒌦 ◊ 𒌦 on [P222399, obv. 6 17], see Figure 21. Curviform non-numeric šar₂ is clearly archaizing in ED IIIb Nirsu; one might suppose that the scribe slipped into their modern ways here.



Figure 21: [P222399, obv. 6 16–17] 𒍪𒍪𒍪𒍪 / 𒍪𒍪𒍪𒍪.

Note that in rare cases, such as [P222243, obv. 2 7] from ED IIIa Adab, non-numeric 𒍪 (here with the value rum) is written 𒍪. It is out of scope for this proposal to decide whether such occurrences should be treated as anomalous spellings, encoded as U+12550 𒍪 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 (uru₈^{rum}) of this word disagree on that aspect. Since 𒍪 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 BIL₂ can be described as 𒍪𒍪𒍪𒍪 NE×KASKAL or 𒍪𒍪𒍪𒍪 NE×PAP⁷⁹, they are typically all transliterated bil₂, and therefore are all represented by the character U+1224B 𒍪 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, 𒍪𒍪𒍪𒍪 from [P305639, rev. 21] 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 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 𒍪𒍪𒍪𒍪 from [P240533, recto 3 3] is transliterated “20-1-1/2 gu₂-bar 7 nig₂-sagšu 2-1/2 an-zam_x⁸⁰ za”, reading both 𒍪 and 𒍪 as 1/2, but not distinguishing them.

⁷⁹As on [P249253].

⁸⁰As of this writing, [EbDA] actually has an-zam_x, with U+1D6A GREEK SUBSCRIPT SMALL LETTER CHI.

cuneiform fonts, often within single numeric expressions. Further, if that contrast is lost in plain-text interchange, the text can be misinterpreted: \llcorner is a length of three ropes, but $\bullet\bullet$ is an area of three bur₃; $\triangleright\updownarrow$ could be read as one \llcorner and one \updownarrow , where $\triangleright\varnothing$ would be one and a half \llcorner ; $\neg\llcorner$ is a personal name, but $\triangleright\llcorner$ would be “one slave”.

In addition, there would be a risk of confusion about character identity should fontmakers attempt to treat the curviform and cuneiform numerals as unified. A designer concerned about the numeric-syllabic $\triangleright\neg$ contrast, and wishing to support diachronic encoding between systems $S_{\text{Ur III/OB}}$ and S , might give the \updownarrow numeral series (which is typically only used numerically in the Early Dynastic period) the glyphs of the \triangleright numeral series, since the clear $\updownarrow\triangleright$ identification involves the same rotation; this would however make it impossible to represent capacity measures that use \varnothing . Similarly, in an effort to support diachronic encoding for 1/2(iku), one might be tempted to give \neg the glyph of \varnothing , thereby rendering the font unusable for quantities measured using the \neg numeral series; an ED I–II Ur font designer could decide to give 𒌦 the same glyph as \llcorner (that of the proposed \bullet), according to the older area system, making it impossible to represent the newer system.

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 \bullet requires some explanation, but does not 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

A complete rationale for disunification between the non-numeric signs used in the fourth millennium and the already-encoded cuneiform signs will be given in the forthcoming proto-cuneiform encoding proposal. The core issue with extending the cuneiform script further back in time is that, since 1987, fourth millennium studies have used a different model of character identity and associated transliteration conventions, with names being given to structurally different glyphs, and no attempt being made at assigning phonetic values to them.

This is not a mere classification of glyph variants, as contrastive meanings of these systematic variants can often be reconstructed, with, *e.g.*, signs $\text{KA}\check{S}_a$, $\text{KA}\check{S}_b$, and $\text{KA}\check{S}_c$, depicting filled jars with a spout (a), a handle (c), or neither (b), being understood as referring to containers of different substances, see [Eng01, pp. 34 sq.]. However, not all identified systematic variants are understood, and the general approach to character identity is closer to that used for undeciphered or partially deciphered scripts.






As part of the development of these conventions, a classification of fourth millennium numeric signs was developed; see [DE87]. This classification assigns to each unit numerals an identifier formed by the letter N with a numeric subscript (sometimes with an additional alphabetic subscript): N_1 is \triangleright , N_{14} is \bullet , N_{34} is \triangleright , etc. Transliterations of numeric expression then use those to identify the type of number used, thus $5N_1$ is 𒌦 , and $5N_{14}$ is $\bullet\bullet\bullet$.

In contrast with the use of parenthetical unit names, this approach does not require interpreting the quantity being counted. This is valuable in contexts where

numerals are being used atypically, as conventional transliterations can otherwise force a dubious interpretation. For instance, the [CDLI] transliteration of   or   in [P283802, rev. 1 6, 2 2] currently uses (barig@c) for the vertical numerals, since  numerals are typically capacity measures; but [Gor23] interprets these instead as counting linen textiles. As a result, the fourth millennium conventions for numeral transliteration are used in Early Dynastic texts, especially those from the ED I–II period, even though the Sumerian text uses classical assyriological transliteration conventions; see [Cha03, p. 6 n. 27].

While the non-numeric signs are treated as undeciphered, the metrological systems used in the fourth millennium are well understood, as can be seen in [DE87, p. 165]. As a result, contrary to the non-numeric proto-cuneiform conventions, these numeric transliteration conventions are compatible with the classical ones described in §3.7.2; they are indeed used interchangeably, as in [P011104] which uses the notation u@f in [ePSD2], but N14@f in [CDLI]. Indeed, the numerals are used similarly in Early Dynastic metrological systems, and are visually identical.

A disunification of numerals between the third and fourth millennium would therefore induce confusion as to which numerals should be used in third millennium studies, and would needlessly duplicate the encoding of at least seventy characters; by splitting the attestations, these separate encoding proposals would run into additional difficulties to supply evidence for encoding.

Note that the structural variants designated by letters in fourth millennium notation have systematically been encoded, as they have occasionally be found to carry distinct numeric meaning. For instance,  N_{30c} is listed as a variant of  N_{30a} in [DE87, p. 166], where the numeric value of either in relation to  N_{39a} is still unknown, but their values are found in [Eng04, p. 33] to be $\frac{1}{10}$ , whereas $\frac{1}{6}$ .

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

TODO “Ten of the sixty numerical signs contained in the list in figure 27, moreover, do not belong to any of the identified systems. Three of them were apparently scribbled by an awkward pupil. As to four of those remaining, we are not sure whether they constitute derivations of other, as yet unknown numerical signs or whether they are in fact numerical signs at all. For at least two of the ten signs, txi and we can affirm that each formed part of two additional systems, about which we know nothing due to the fact that no informative texts have been unearthed with notations in these systems.” [NDE93, p. 27] TODO N10 described as coming from P001319 which does not have it anymore. TODO N13 not attested in CDLI TODO (N_{17} not usefully numeric, $12N_{14}$ not encodable, etc.). Cite [DE87, p. 147] N_{30C6} not attested 7 and 8(diš *tenû*) encodable, but not today; want to go into the Cuneiform Numbers and Punctuation block for sanity.



Figure 23: The layout of case [P020066, obv. 1 1]; the numeral 𐎶 is spread across two lines. The text is read in the order 𐎶𐎵𐎶𐎶𐎶𐎶, “twenty-two oxen, one year old”.

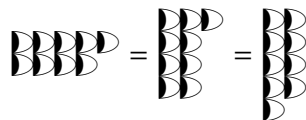


Figure 24: Three stacking patterns for U+12573 CUNEIFORM NUMERIC SIGN NINE N34. The one on the left is the reference glyph, used in Uruk III [P003499, obv. 1 1b; P004430, rev. 1 2], and widely afterwards, *e.g.*, ED IIIa Šuruppag [P010678, obv. 2], ED IIIb Nirsu [P020057, obv. 1 3], Old Akkadian Umma [P212464, obv. 11]. The ones in the middle and right are used in two Uruk IV tablets [P001243, rev. P004500, rev. 2]. All three Uruk examples are transliterated 9(N34) in [CDLI].

astic period, but that are also attested in the fourth millennium in the Uruk III period; the fourth millennium, especially the Uruk IV period, also frequently features numerals that use a more vertical layout, as illustrated in Figure 24. The later, more horizontal styles were chosen for two reasons: for the numerals used in the third and fourth millennium, usage in third millennium 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, 𐎵, 𐎶, and 𐎶 must remain consistent across the numeral series, lest a 𐎵 numeral be confused with an 𐎶 numeral. Since the single indents are frequently used in running text, as illustrated in §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 24 uses OpenType stylistic alternates, and Figure 22 rotates the character 𐎶, in both cases preserving the plain text backing.

6.3 Other glyph variants not reflected in transliteration

TODO Comment on the nameless variant glyphs from L2/23-190 and note that they are illustrating an even wider glyphic range as shown in [Eng01].

Acknowledgements

TODO(egg): Something about the Vanséveren fonts

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CDLI: [P240548](#).
EbDA: [1350](#).
- [P240579] Excavation number TM.75.G.00341.
CDLI: [P240579](#).
EbDA: [1364](#).
- [P240597] Excavation number TM.75.G.00407.
CDLI: [P240597](#).
- [P240609] Excavation number TM.75.G.00440.
CDLI: [P240609](#).
EbDA: [1378](#).
- [P240653] Excavation number TM.75.G.00535.
CDLI: [P240653](#).
EbDA: [1382](#).
- [P240654] Excavation number TM.75.G.00536.
CDLI: [P240654](#).
EbDA: [1383](#).
- [P240655] Excavation number TM.75.G.00537.
CDLI: [P240655](#).
EbDA: [1358](#).
- [P240675] Excavation number TM.75.G.00557.
CDLI: [P240675](#).
EbDA: [1371](#).
- [P240697] Excavation number TM.75.G.00579.
CDLI: [P240697](#).
EbDA: [1381](#).
- [P240964] Excavation number TM.75.G.01392.
CDLI: [P240964](#).
ORACC: [dccmt/P240964](#).
EbDA: [3184](#).

- [P240986] Excavation number TM.75.G.01415.
CDLI: [P240986](#).
ORACC: [dcclt/P240986](#).
- [P241708] Excavation number TM.75.G.02143.
CDLI: [P241708](#).
EbDA: [3173](#).
- [P241764] Excavation number TM.75.G.02200.
CDLI: [P241764](#).
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CDLI: [P241904](#).
EbDA: [3183](#).
ORACC: [dccmt/P241904](#).
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CDLI: [P242293](#).
EbDA: [217](#).
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CDLI: [P249253](#).
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CDLI: [P251641](#).
ORACC: [epsd2/P251641](#).
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CDLI: [P252866](#).
ORACC: [epsd2/P252866](#).
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CDLI: [P255010](#).
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CDLI: [P271238](#).
ORACC: [epsd2/P271238](#).
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CDLI: [P274845](#).
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CDLI: [P283802](#).
ORACC: [epsd2/P283802](#).
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CDLI: [P292843](#).
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CDLI: [P298637](#).
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