

Proposed Draft: Unicode Technical Report #53
UNICODE ARABIC MARK ORDERING ALGORITHM

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Note to reviewers: This proposed draft UTR makes no change to Unicode normalization forms, and does not propose a new normalization form. Instead, this is similar to the processing used in <https://www.microsoft.com/typography/OpenTypeDev/USE/intro.htm>: a transient process which is used to reorder text for display in an internal rendering pipeline. This reordering is not intended for modifying original text, nor for open interchange. Subsequent versions of this document will include this clarification.

Summary

The Unicode Arabic Mark Ordering Algorithm (UAOA) describes an algorithm for determining correct rendering of Arabic combining mark sequences.

Status

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Please submit corrigenda and other comments with the online reporting form [[Feedback](#)]. Related information that is useful in understanding this document is found in the [References](#). For the latest version of the Unicode Standard see [[Unicode](#)]. For a list of current Unicode Technical Reports see [[Reports](#)]. For more information about versions of the Unicode Standard, see [[Versions](#)].

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1. OVERVIEW

The combining classes of Arabic combining characters in Unicode are different than combining classes in most other scripts. They are a mixture of special classes for specific marks plus two more generalized classes for all the other marks. This has resulted in problems for sequences with multiple combining marks since Unicode 2.0.

UAOA, described herein, is the proposed implementation to deal with the problems of special combining classes. This algorithm is the simplest algorithm that matches user expectations, stays within the stability requirements of Unicode, correctly renders data in normalized forms, and renders all canonically equivalent sequences the same way.

2. BACKGROUND

Rules and recommendations for the correct display of combining marks are discussed in a number of places in the Unicode Standard, including sections 5.13, 7.9, and 9.2 [[Unicode](#)]. Some general principles include:

- Canonically equivalent sequences should display the same.
- Combining marks from the same combining class are normally displayed using the *inside-out rule*, i.e., from the base outward.

- Combining marks from different combining classes (other than `ccc=0`) may be re-ordered with respect to each other if that helps to achieve the desired display.

In Unicode, the Arabic script combining marks include eleven different non-zero canonical combining class values, as shown in Table 1. When a combining character sequence includes marks from more than one of these classes, the rendering system has to determine a display order in which to position these marks on the base character.

While it might be tempting to just use NFC or NFD, neither of these normalization forms will yield what Arabic readers expect. For one example that will be easily understood by all readers of Arabic script, given a combining character sequence including a *shadda* (`ccc=33`) and *damma* (`ccc=31`), NFC and NFD will move the *damma* before the *shadda* – at which point the default inside-out rendering rule would place the *shadda* above the *damma*, which is incorrect.

Some cases are obvious to readers of languages written with Arabic script, and thus will likely get the same display from various rendering implementations. However, many of the combining marks, especially those with `ccc=220` and `ccc=230`, are not commonly understood. Different rendering implementations have made different decisions regarding display order, resulting in inconsistent behavior between one system and another.

UAOA defines a method to reorder Arabic combining marks in order to accomplish the following goals:

- The inside-out rendering rule will display combining marks in the expected visual order.
- Ensure identical display of canonically equivalent sequences.
- Provide a mechanism for overriding the display order in exceptional cases.

Table 1: Canonical combining class values for marks used in Arabic script

Canonical Combining Class (ccc) value	Combining marks in this class
0	Combining grapheme joiner
27	fathatan, open fathatan
28	dammatan, open dammatan
29	kasratan, open kasratan
30	fatha, small fatha
31	damma, small damma
32	kasra, small kasra
33	shadda
34	sukun
35	Superscript alef
220	All other below combining marks
230	All other above combining marks

3. UAOA DETAILS

The algorithm starts by reordering combining marks according to one of the Unicode Normalization forms, and then makes adjustments by moving certain marks closer to the base.

3.1 Modifier Combining Marks (MCM)

For use by this algorithm, we define a group of combining marks called “Modifier Combining Marks” (MCM). MCM are combining characters that are normally used to modify the base character before them, and should normally be rendered closer to the base character than *tashkil* (supplementary diacritics, including vowels). The MCM characters are not formally classified as *ijam* (consonant pointing/nukta, etc) in the Unicode Standard, but they are usually perceived by users as *ijam*.

The complete list of MCM characters is:

U+0654 ARABIC HAMZA ABOVE
U+0655 ARABIC HAMZA BELOW
U+0658 ARABIC MARK NOON GHUNNA
U+06DC ARABIC SMALL HIGH SEEN
U+06E3 ARABIC SMALL LOW SEEN
U+06E7 ARABIC SMALL HIGH YEH
U+06E8 ARABIC SMALL HIGH NOON
U+08F3 ARABIC SMALL HIGH WAW

Review note: After an appropriate review period, the list of characters included in the MCM will be considered “fixed.” Adding an existing Unicode character to the list of MCM could change the rendering of data that assumes the implementation of UAOA. If new characters are encoded in Unicode, those new characters could be added to the MCM at the time of encoding if needed.

For stability reasons, existing Unicode characters will not be added to the list of MCM.

3.2 UAOA

In the following specification, parenthetical definitions, for example (*D56*), refer to definitions in the Unicode core specification.

Input: A Combining Character Sequence (*D56*) containing one or more Arabic combining marks.

Output: A canonically equivalent Combining Character Sequence reordered for rendering using inside-out stacking.

Steps:

1. Normalize the input to NFD
2. Within the result, for each maximal-length substring, *S*, of non-Starter (*D107*) characters, re-order as follows:
 - a. Move any shadda characters (ccc=33) to the beginning of *S*.
 - b. If a sequence of ccc=230 characters begins with any MCM characters, move those MCM to the beginning of *S* (before any characters with ccc=33).
 - c. If a sequence of ccc=220 characters begins with any MCM characters, move those MCM to the beginning of *S* (before any MCM with ccc=230).

4. DEMONSTRATING UAOA

4.1 Artificial Test Case

The following figure demonstrates the algorithm using an artificial sequence of characters:



4.2 Override Mechanism for Exceptions

The default display order implemented by the UAOA will be correct for most uses. However there are situations where a different mark order is desired. In these cases, U+034F COMBINING GRAPHEME JOINER (CGJ) can be used to achieve the desired display order.

4.3 Examples

The following examples demonstrate why each of the respective characters is included in the MCM.

U+0654 ARABIC HAMZA ABOVE and U+0655 ARABIC HAMZA BELOW

The use of combining hamza above and below is discussed in [Unicode, Chapter 9].

Example 1 [Quran1, page 9, end of line 5]

In Example 1, UAOA puts a *damma* over a *hamza above*. If an orthography needs to put the *hamza above* over the *damma*, the text should be encoded as <damma, CGJ, hamza above>.

UAOA puts the *kasra* below a *hamza below*. If an orthography needs to put the *hamza below* under the *fatha*, the text should be encoded as <fatha, CGJ, hamza below>.

U+0658 ARABIC MARK NOON GHUNNA

Regarding inclusion of this mark in the MCM, Kew says “The ARABIC NASALIZATION MARK is considered equivalent to a ‘nukta’, *as it is a modifier that binds tightly to the underlying letter*,” (italics added for emphasis) [Kew]. The character referred to by Kew as “ARABIC NASALIZATION MARK” is the character encoded as U+0658 ARABIC MARK NOON GHUNNA.

U+06DC ARABIC SMALL HIGH SEEN and U+06E3 ARABIC SMALL LOW SEEN

SMALL HIGH SEEN is included in MCM because most Quranic orthographies use the character as an MCM only. Orthographies that place the *small seen* differently will need to use a CGJ.

Example 2a [Al-Hilâlî]

Example 2b [Al-Hilâlî]

In Example 2a, the *small high seen* is rendered below the *sukun*, while in Example 2b, it is rendered over it. The examples are indeed from the same document (Al-Hilâlî and Khân 1996), just two pages away. The *small high seen* has different roles: in Example 2a it is a hint

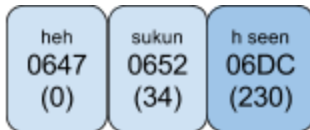
that the base letter, *sad*, should be pronounced as if it was a *seen*; in Example 2b, it is a pause-related hint.

Example 2a (characters and properties):



Running UAOA on this string does not result in any changes.

Example 2b (characters and properties):

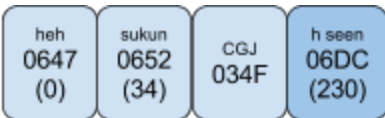


Input

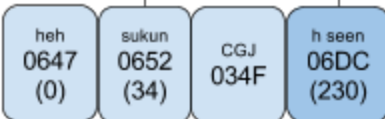


After running UAOA (MCM denoted in dark blue)

Running UAOA on the string in Example 2b resulted in an undesired change. It puts a *sukun* over a *seen* above. If an orthography needs to put the *seen* above over the *sukun*, the text should be encoded as <sukun, CGJ, seen above>.



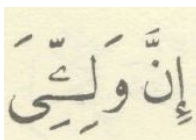
Input



After running UAOA - final result using CGJ

U+06E7 ARABIC SMALL HIGH YEH

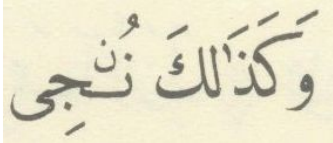
Example 3 [Milo, page 9, line 11]



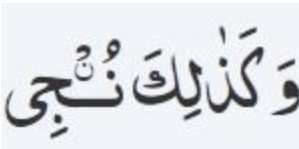
In Example 3, UAOA puts a *shadda* over a *small high yeh*. If an orthography needs to put the *small high yeh* over the *shadda*, the text should be encoded as <shadda, CGJ, small high yeh>.

U+06E8 ARABIC SMALL HIGH NOON

Example 4a [[Milo](#), page 10, (21.88)]

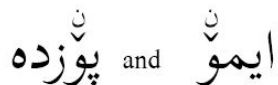


Example 4b [[Quran2](#)]



Example 4a demonstrates a common reading with just a small high noon. However some readings, such as in Example 4b, have a *sukun* over a *small high noon*. UAOA puts a *sukun* over a *small high noon*. If an orthography needs to put *small high noon* over *sukun*, the text should be encoded as <sukun, CGJ, small high noon>.

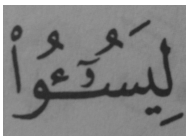
Example 4c



Example 4c shows a practical orthography that uses *small high noon* for nasalization. It is theoretically possible for a vowel to appear above the small high noon in this practical orthography.

U+08F3 ARABIC SMALL HIGH WAW

Example 5 [[Pournader](#), page 4]



In Example 5, UAOA puts a *maddah* over a *small high waw*. This indicates the *small high waw* should stay closer to the base than *maddah*.

5. SUPPLEMENTAL INFORMATION

5.1 Use of NFD and not NFC

NFD assures that sequences such as <superscript alef, madda> always result in the same ordering, independent of the base letter. If the algorithm were to use NFC instead, the sequence <alef, superscript alef, madda> would have resulted in a different order than <lam, superscript alef, madda>, because NFC composes <alef, madda> to <alef-with-madda-above>.

5.2 Shadda

The combining class for shadda is higher than most vowels (ccc=33); however, it should be displayed closer to the base than the vowels.

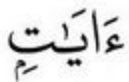
5.3 Kasra and kasra-like characters

UAOA is able to handle the special ligation of *kasra* and *kasra-like* characters which are ligated with a *shadda* or *hamza* in some styles and appear just below them instead of below the base letter; they still logically follow the *shadda* or *hamza*.

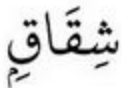
5.4 Rationale for exclusion of some marks

Why are *meem above* (ccc=230) and *meem below* (ccc=220), and other similar characters, not in the MCM? Examples 6a-6c show that the *meem* is normally kept after *fatha*, *kasra* or *damma*. The canonical combining class of these marks is 230 or 220, so their ordering in the presence of other combining marks is not affected by UAOA.

Example 6a [[Quran1](#), page 11]



Example 6b [[Quran1](#), page 21]



Example 6c [Quran1, page 19]

Sukun alternate forms

There are three *sukun-like* marks encoded at U+06DF..U+06E1 that are used in some Quranic orthographies to denote different entities – they may not always represent a *sukun*. The canonical combining class of these marks is 230, so their ordering in the presence of other combining marks is not affected by UAOA. However, since the combining class for the *sukun* is 34, these *sukun-like* marks will *not* be treated like a normal *sukun* in all cases. Users who create data using these alternate *sukun* characters will have more flexibility than when using the normal *sukun*. UAOA does not make them equivalent to U+0652 ARABIC SUKUN, as that would make the algorithm unnecessarily complex and make the usage of CGJ more frequent.

Maddah

Neither U+0653 ARABIC MADDAH ABOVE (ccc=230) nor U+06E4 ARABIC SMALL HIGH MADDA (ccc=230) are MCM because they are normally displayed above vowel marks.

5.5 Dotted circles

Some rendering engines will insert a dotted circle for what it understands to be an invalid sequence. This is a problem in Arabic script because something that appears invalid may actually be valid text in some lesser known orthography of a minority language or in the Quran. For example, the Microsoft Windows text rendering engine, described in [Microsoft], inserts a dotted circle in combinations of certain Quranic marks that are known to appear with each other in the Quran.

Such spell-checking processes are best implemented at a higher level than a rendering engine. Also, a dotted circle insertion algorithm that displays all canonically equivalent sequences identically is hard to design and the result may be counter-intuitive for its users.

Implementations of the algorithm may be adapted to insert dotted circles by applying the algorithm first and then inserting the dotted circles.

5.6 Other uses for UAOA

UAOA is very useful in implementations of backspacing in cases where there is no external information available about the original order in which the text was entered.

5.7 Best combining classes for yet-to-be-encoded combining marks in Arabic

When new combining marks are encoded, 220 should be used for below marks and 230 for above marks. In the special cases where an alternative version of the basic *tashkil* is encoded, the same combining class as the *tashkil* could be used, but extreme care should be taken.

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