

# Character to Glyph

How Unicode® Text Makes it to Your Screen

Josh Hadley, Adobe Fonts  
Unicode Technology Workshop

November 7, 2023



# Character? Glyph? Aren't they the same?

**NO.** In very general terms, a *glyph* is a specific visual representation (defined in a font) of a *character*.

A *character* is the smallest component of a written language that has semantic value. It refers to the abstract meaning, not a specific shape. It is common to refer to characters by their codepoint(s), for example “U+0041” is the character “A”.

# Got it. So every character has a glyph?

**NO.** Some *characters* are not meant to have a visual representation and will not have a visible *glyph*. In some cases, certain multi-*character* sequences can be represented by a single *glyph*. Furthermore, some single *characters* might be represented by multiple *glyphs*!

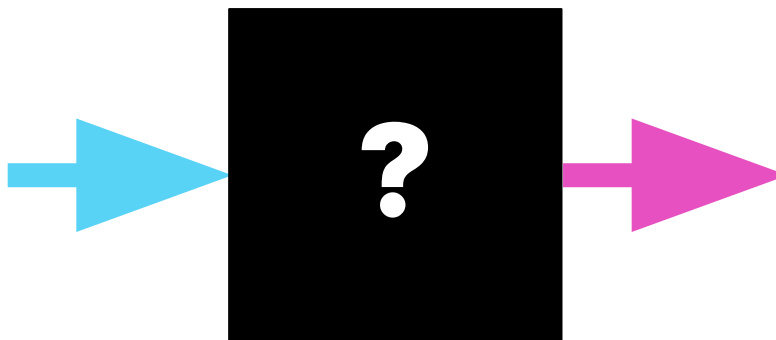
# Main point: relationship is not 1:1

“Many to many” is probably the best generic description.



# So how do we get from character to glyph?

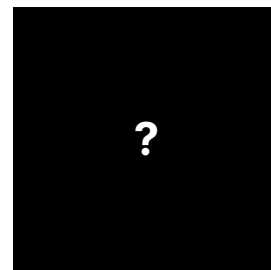
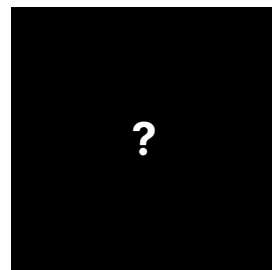
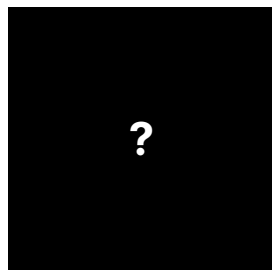
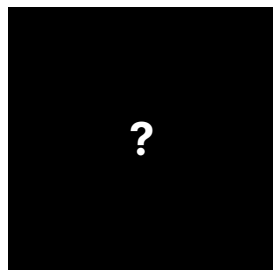
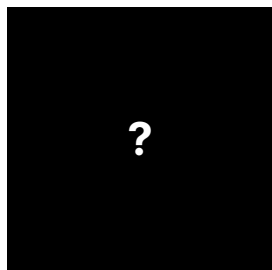
0048 0065 006C 006C  
006F 002C 0020 0077  
006F 0072 006C 0064  
0021 0020 0928 092E  
0938 094D 0924 0947  
0020 0926 0941 0928  
093F 092F 093E 0021



*Hello, World!*  
नमस्ते दुनिया!

*What's inside the box?*

# There are several boxes



**(you've probably heard of this one)**

?

?

?

Font

?



Layout  
Engine

?

?

Font

?





Layout  
Engine

BiDi  
Engine

?

Font

?



Layout  
Engine

BiDi  
Engine

Shaping  
Engine

Font

?



**Layout  
Engine**

**BiDi  
Engine**

**Shaping  
Engine**

**Font**

**Font  
Rasterizer**

# Layout Engine

## Layout Engine

Handles high-level text layout: detecting groups of text belonging to the same script, line-breaking and flowing of text across columns, around images, etc.

[UAX #14](#), [UTR #24](#), [UAX #29](#)

# BiDi (Bidirectional Text) Engine

BiDi  
Engine

Reorders characters so they are in the correct reading order for both right-to-left scripts such as Arabic and Hebrew and left-to-right scripts such as Latin and Greek.

[UAX #9](#)

# Shaping Engine

## Shaping Engine

Gets the correct glyph shapes and glyph positions for the context in which the glyphs occur. Also does some glyph reordering (e.g. for Indic scripts) at the grapheme level.

# Font



Font

A file consisting of several tables for:

- glyph outlines
- mapping Unicode characters to glyphs
- glyph substitutions
- glyph position information
- various metrics
- (and much more)

# Font Rasterizer

Font  
Rasterizer

Draws glyphs from the font onto the screen at the selected size.



# A closer look at fonts

## Example of a font's table directory:

#	tag	checkSum	offset	length	Comment
0	'BASE'	0x651e5dbd	334844	70	<i>Baseline Data Table.</i>
1	'CFF '	0xc49cf28b	24536	162621	<i>Compact Font Format Table.</i>
2	'DSIG'	0x00000001	334916	8	<i>Digital Signature Table.</i>
3	'GDEF'	0x16ef1e45	197072	1514	<i>Glyph Definition Table.</i>
4	'GPOS'	0x02dcec26	238324	96520	<i>Glyph Positioning Table</i>
5	'GSUB'	0x3e1527f2	198588	39734	<i>Glyph Substitution Table.</i>
6	'OS/2'	0x7f175567	336	96	<i>OS/2 and Windows specific metrics table.</i>
7	'cmap'	0xd2d93392	7036	17466	<i>Character To Index Mapping Table.</i>
8	'head'	0x25b632ed	236	54	<i>Font Header Table.</i>
9	'hhea'	0x09f40f3a	292	36	<i>Horizontal Header Table.</i>
10	'hmtx'	0x7c923f4d	187160	9910	<i>Horizontal Metrics Table.</i>
11	'maxp'	0x09ae5000	328	6	<i>Maximum profile table.</i>
12	'name'	0x3355d1e0	432	6602	<i>Naming Table.</i>
13	'post'	0xffd10032	24504	32	<i>PostScript Information Table.</i>

## Excerpt from the 'name' table of a font:

21	3	1	1032	277	Ρέων β	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
22	3	1	1032	278	Εναλλακτικό θ	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
23	3	1	1032	279	Εναλλακτικό φ	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
24	3	1	1032	280	Λατινικό α με πατούρα	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
25	3	1	1032	281	Κεντρικά ογκονεκ [ Α Ξ ς ρ υ ] (Να-Ντενέ)	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
26	3	1	1032	282	ΓράμμαΕνγκ σε σχήμα N [ Ν ] (Σάμη)	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
27	3	1	1032	283	Κεφαλαίοι αριθμοί	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
28	3	1	1032	284	Μηδέν με κεντρική τελεία [ 0 ]	Microsoft; Unicode BMP only; Greek, Greece; font-specific name
29	3	1	1033	0	© 2023 Adobe ( <a href="http://www.adobe.com/">http://www.adobe.com/</a> ), with Reserved Font Name	Microsoft; Unicode BMP only; English, United States; Copyright notice
30	3	1	1033	1	Source Sans 3	Microsoft; Unicode BMP only; English, United States; Font Family name
31	3	1	1033	2	Regular	Microsoft; Unicode BMP only; English, United States; Font Subfamily name
32	3	1	1033	3	3.050;ADBO;SourceSans3-Regular;ADOBE	Microsoft; Unicode BMP only; English, United States; Unique font identifier
33	3	1	1033	4	Source Sans 3	Microsoft; Unicode BMP only; English, United States; Full font name
34	3	1	1033	5	Version 3.050;hotconv 1.1.0;makeotfexe 2.6.0	Microsoft; Unicode BMP only; English, United States; Version string
35	3	1	1033	6	SourceSans3-Regular	Microsoft; Unicode BMP only; English, United States; Postscript name
36	3	1	1033	7	Source is a trademark of Adobe in the United States and/or other countries	Microsoft; Unicode BMP only; English, United States; Trademark
37	3	1	1033	8	Adobe	Microsoft; Unicode BMP only; English, United States; Manufacturer Name
38	3	1	1033	9	Paul D. Hunt	Microsoft; Unicode BMP only; English, United States; Designer
39	3	1	1033	11	<a href="http://www.adobe.com/type">http://www.adobe.com/type</a>	Microsoft; Unicode BMP only; English, United States; URL Vendor
40	3	1	1033	13	This Font Software is licensed under the SIL Open Font License, <a href="http://scripts.sil.org/OFL">http://scripts.sil.org/OFL</a>	Microsoft; Unicode BMP only; English, United States; License Description
41	3	1	1033	14	<a href="http://scripts.sil.org/OFL">http://scripts.sil.org/OFL</a>	Microsoft; Unicode BMP only; English, United States; License Info URL
42	3	1	1033	256	Simple a	Microsoft; Unicode BMP only; English, United States; font-specific name

# Font-wide vertical metrics (various tables):

hhea ascender: 1000  
os/2 typoAscender: 1000  
os/2 winAscent: 1000

cap-height: 660

x-height: 486

baseline: 0

SourceSans3-Regular

hhea descender: -326  
os/2 typoDescender: -326  
os/2 winDescent: 326



## cmap – *character* to *glyph* mapping table:

Type	Name	Value	Comment
struct	Header	+	'cmap' header
list	List	+	'cmap' subtables

#	platformID	encodingID	format	length	languageID	GlyphMapping	Comment
0	0	3	4	4494	0	+	Unicode; 2.0+ semantics, BMP only

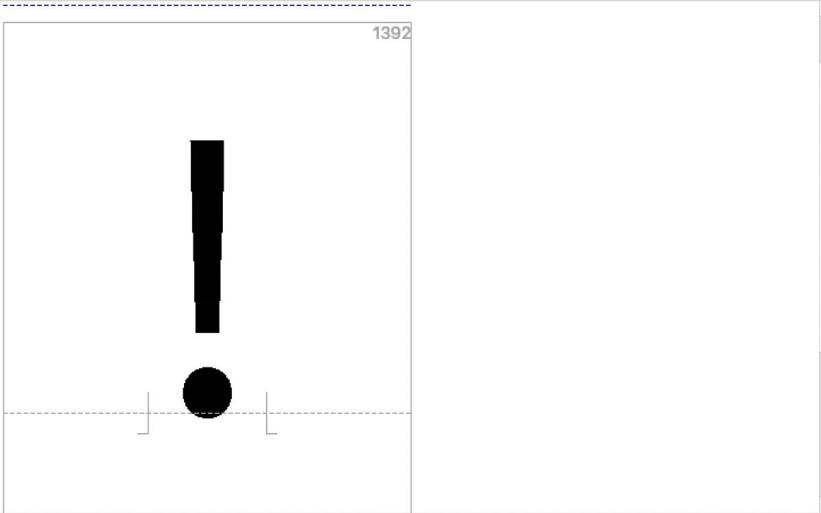
#	Code	GID	Comment
0	0x0020	1	space
1	0x0021	1392	exclam
2	0x0022	1397	quotedbl
3	0x0023	1497	numbersign
4	0x0024	2114	dollar
5	0x0025	2140	percent
6	0x0026	682	ampersand
7	0x0027	1396	quotesingle
8	0x0028	1442	parenleft
9	0x0029	1443	parenright
10	0x002a	1452	asterisk
11	0x002b	2162	plus
12	0x002c	1388	comma
13	0x002d	1415	hyphen
14	0x002e	1387	period
15	0x002f	1448	slash

# Glyph (image)

OTM Glyph Viewer - SourceSans3-Regular.otf - 1392 - exclam

Glyph Set and Code Selector

Glyph Index (GID) 1392



1392

View

- Image
- Outline
- Points
- Indices
- Box
- hhea asc/dsc
- typo asc/dsc
- win asc/dsc
- Hints
- Gridfit
- Grayscale

ppem: 1024

Zoom: 35

Bounding Box

left: 85

bottom: -12

right: 204

top: 670

Glyph Encoding Editor

'CFF' id: exclam

'cmap' subtable codes:

- (0) Unicode; 2.0+ semantics, BMP only
- (1) Unicode; 2.0+ semantics, full repertoire
- (2) Macintosh; Roman
- (3) Microsoft; Unicode BMP only
- (4) Microsoft; Unicode full repertoire

0x0021 del

0x00000021 del

0x0021 del

0x0021 del

0x00000021 del

Metrics Editor

LSB: 85

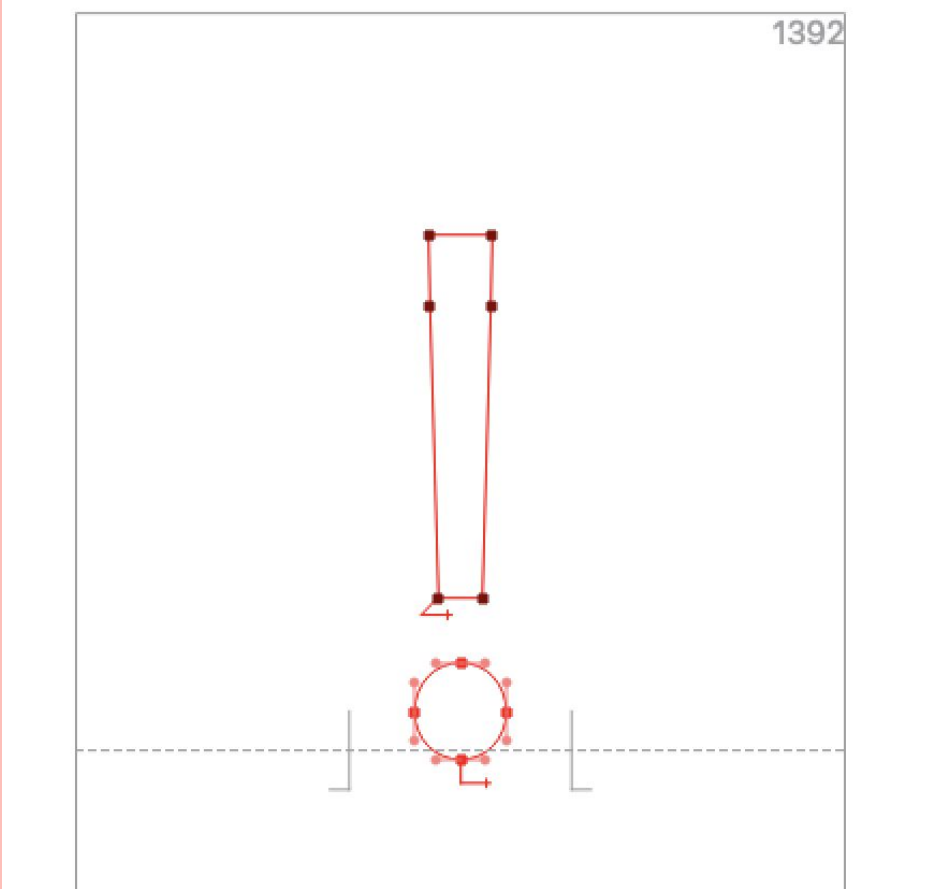
ADW: 289

TSB: none

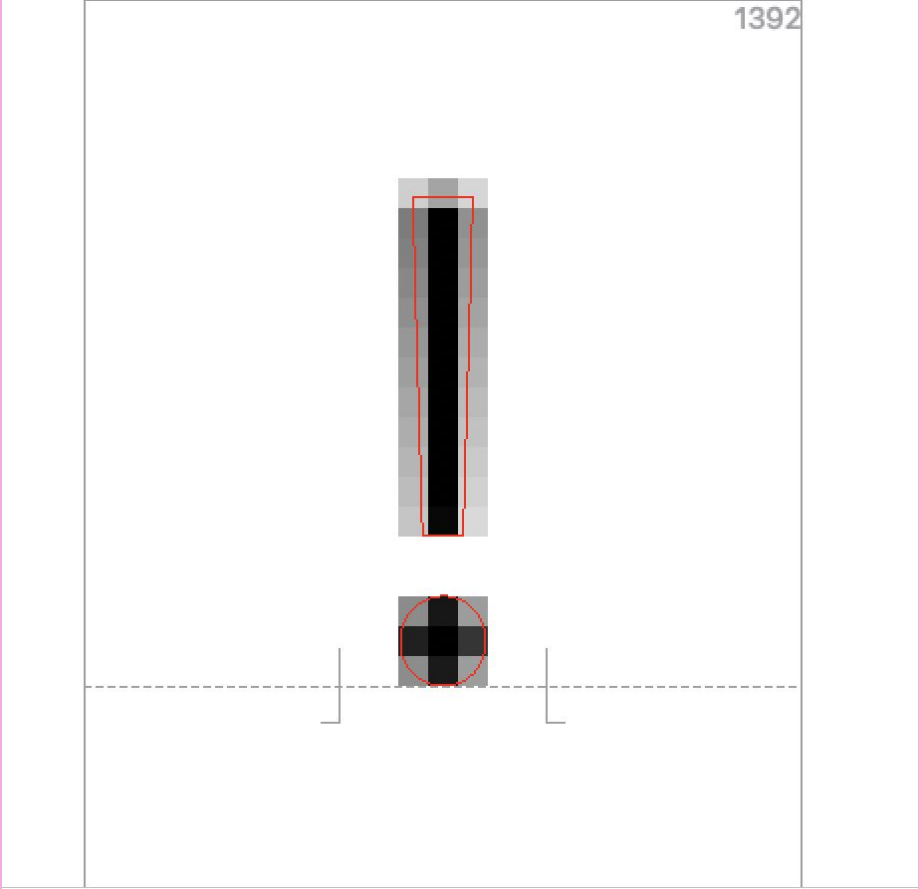
ADH: none

Print ...

Glyph (outline)



**Glyph (rasterized & enlarged)**





## GSUB (Glyph SUBstitution) lookup example ('liga' – ligatures)

69	1	0x0000	1	+	0	<i>single substitution</i>
70	4	0x0000	1	+	0	<i>ligature substitution</i>
#	SubstFormat	Substitution	Comment			
0	1	+	<i>lookup type 4, ligature substitution</i>			
#	LigGlyph	Component	Comment			
0	691	+	<i>f_f_t &lt;- f, f, t</i>			
#	GID	Comment				
0	33	<i>'f_f_t' component 'f'</i>				
1	33	<i>'f_f_t' component 'f'</i>				
2	47	<i>'f_f_t' component 't'</i>				
1	687	+	<i>f_f &lt;- f, f</i>			
2	690	+	<i>f_t &lt;- f, t</i>			
71	4	0x0000	1	+	0	<i>ligature substitution</i>
72	1	0x0000	1	+	0	<i>single substitution</i>

# GPOS (Glyph POSitioning) example ('mark' – mark placement)

OTM GPOS/GSUB Viewer - SourceSans3-Regular.otf

Layout Table: 'GPOS' table | Script: 'DFLT', Default | Language: <default>

Feature: (19) 'mark', Mark Positioning | Lookup: (0) mark to base attachment | Writing Direction: left to right

Subtable View: Data | Report

View

size [ppem] 328

spacing [%] 5

all glyphs one by one

mark glyphs all at once

base glyphs all at once

all glyphs all at once

Filter

Classes

Mark Array #

Base Array #

Mark Glyph (#22,GID=2322,Class=0)

uni0309

X 0

Y 509

Base Glyph (#156,GID=486)

ohorn

X 271

Y 509

# A closer look at the other parts

Layout  
Engine

BiDi  
Engine

Shaping  
Engine

## Layout Engine – script breaks: excerpt from Scripts.txt

```
0000..001F ; Common # Cc [32] <control-0000>..<control-001F>
0020 ; Common # Zs SPACE
0021..0023 ; Common # Po [3] EXCLAMATION MARK..NUMBER SIGN
[...]
0041..005A ; Latin # L& [26] LATIN CAPITAL LETTER A..LATIN CAPITAL LETTER Z
0061..007A ; Latin # L& [26] LATIN SMALL LETTER A..LATIN SMALL LETTER Z
[...]
0370..0373 ; Greek # L& [4] GREEK CAPITAL LETTER HETA..GREEK SMALL LETTER ARCHAIC SAMPI
0375 ; Greek # Sk GREEK LOWER NUMERAL SIGN
0376..0377 ; Greek # L& [2] GREEK CAPITAL LETTER PAMPHYLIAN DIGAMMA..GREEK SMALL LETTER PAMPHYLIAN DIGAMMA
[...]
0400..0481 ; Cyrillic # L& [130] CYRILLIC CAPITAL LETTER IE WITH GRAVE..CYRILLIC SMALL LETTER KOPPA
0482 ; Cyrillic # So CYRILLIC THOUSANDS SIGN
[...]
```

## Layout Engine – word breaks

Text

¡Hola mundo!

Word



¡Hola mundo!

## Layout Engine – line breaks

Text

¡Hola mundo!

Line



¡Hola mundo!

## Layout Engine – sentence breaks

Text

¡Hola mundo!

Sentence



¡Hola mundo!

## Unicode Utilities: BIDI (UBA)

[help](#) | [character](#) | [properties](#) | [confusables](#) | [unicode-set](#) | [compare-sets](#) | [regex](#) | [bnf-regex](#) | [breaks](#) | [transform](#) | [bidi](#) | [bidi-c](#) | [idna](#) | [languageid](#)

Shows processing by the UBA ([Unicode Bidi Algorithm](#)), which is used to display all Unicode Arabic and Hebrew text. For more information, see [bidi info](#).

This Java implementation supports UBA rules and character properties as of [Unicode 6.2](#). To test current UBA rules, or intermediate versions from [Unicode 6.3](#) forward, see the [C Reference](#) demo.

Sample

TAB

LRM

RLM

LRE

RLE

PDF

LRO

RLO

mark 3.1% 2.0 لرك.

Auto ▾

Paragraph Direction

ASCII Hack?

Show Bidi

### Paragraph 1

Base Level 0 = LTR heuristic

#### Source

Memory Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Character	m	a	r	k		3	.	1	%		م	ا	ر	.	ك		2	.	0	.
Bidi Class	L	L	L	L	WS	EN	CS	EN	ET	WS	AL	AL	AL	NSM	AL	WS	EN	CS	EN	CS
Rules Applied					N1→L	W7→L	W4→EN W7→L	W7→L	W5→EN W7→L	N2→L	W3→R	W3→R	W3→R	W1→AL W3→R	W3→R	N1→R	W2→AN	W4→AN	W2→AN	W6→ON N2→L
Resulting Level	L0	L0	L0	L0	L0	L0	L0	L0	L0	L0	L1	L1	L1	L1	L1	L1	L2	L2	L2	L0

#### Reordered

Display Position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Memory Position	0	1	2	3	4	5	6	7	8	9	16	17	18	15	14	13	12	11	10	19
Character	m	a	r	k		3	.	1	%		2	.	0		ك	.	ر	ا	م	.



# BiDi Engine

char	unicode	unicode name	glyph	adv	$\Delta X$	$\Delta Y$
س	U+0633	ARABIC LETTER SEEN	two	722	0	
ل	U+0644	ARABIC LETTER LAM	zero	722	0	
ا	U+0627	ARABIC LETTER ALEF	two	722	0	
م	U+0645	ARABIC LETTER MEEM	three	722	0	
	U+0020	SPACE	space	400	0	
2	U+0032	DIGIT TWO	uni0645	712	0	
0	U+0030	DIGIT ZERO	uni06440627.f	699	-150	
2	U+0032	DIGIT TWO	uni0633.i	905	0	
3	U+0033	DIGIT THREE				

2023 سلام

AdobeArabic-Regular.otf

2023 سلام

AdobeArabic-Regular.otf

# Shaping Engine

- Uses results of Layout & BiDi
- Resolves characters to glyphs using font data
- Applies font rules for glyph substitution & positioning
- Might need to iterate since glyph changes can affect position
- Passes result (glyph array + positioning information) to rasterizer

# Putting it all together – simple Arabic

Layout  
Engine

BiDi  
Engine

Shaping  
Engine

Font

Font  
Rasterizer

## FontGoggles — Untitled

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	uni0645	749	0	0
ر	U+0631	ARABIC LETTER REH	uni0631	471	-180	0
ح	U+062D	ARABIC LETTER HAH	uni062D	983	0	0
ب	U+0628	ARABIC LETTER BEH	uni0628	1,302	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0627	318	0	0
	U+0020	SPACE	space	400	0	0
ب	U+0628	ARABIC LETTER BEH	uni0628	1,302	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0627	318	0	0
ل	U+0644	ARABIC LETTER LAM	uni0644	891	0	0
ع	U+0639	ARABIC LETTER AIN	uni0639	894	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0627	208	-110	0
ل	U+0644	ARABIC LETTER LAM	uni0644	891	0	0
م	U+0645	ARABIC LETTER MEEM	uni0645	749	0	0
!	U+0021	EXCLAMATION MARK	exclam	425	0	0

مرحبا بالعالم!

AdobeArabic-Bold.otf

م ل ا ع ل ا ب ا ب ح ر م !

Direction/orientation:

Left-to-Right

Visual alignment:

Automatic

Script:

Automatic

Language:

dflt – Default

Features

Variations

Options

GSUB

calt Contextual Alternates

ccmp Glyph Composition / Decompos...

dlig Discretionary Ligatures

fina Terminal Forms

frac Fractions

init Initial Forms

isol Isolated Forms

jalt Justification Alternates

liga Standard Ligatures

locl Localized Forms

medi Medial Forms

pnum Proportional Figures

rlig Required Ligatures

salt Stylistic Alternates

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni0645	749	0	0
ح	U+062D	ARABIC LETTER HAH	uni0644	891	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0639	894	0	0
	U+0020	SPACE	uni0644	891	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0628	1,302	0	0
ل	U+0644	ARABIC LETTER LAM	space	400	0	0
ع	U+0639	ARABIC LETTER AIN	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0628	1,302	0	0
ل	U+0644	ARABIC LETTER LAM	uni062D	983	0	0
م	U+0645	ARABIC LETTER MEEM	uni0631	551	-100	0
!	U+0021	EXCLAMATION MARK	uni0645	749	0	0

مرحباً بالعالم!

AdobeArabic-Bold.otf

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Automatic, with BiDi and Segmentation

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## FontGoggles — Untitled

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni0645	749	0	0
ح	U+062D	ARABIC LETTER HAH	uniFEDF	407	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0639	894	0	0
	U+0020	SPACE	uniFEDF	407	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFE91	435	0	0
ل	U+0644	ARABIC LETTER LAM	space	400	0	0
ع	U+0639	ARABIC LETTER AIN	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uni0628	1,302	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEA3	927	0	0
م	U+0645	ARABIC LETTER MEEM	uni0631	531	-120	0
!	U+0021	EXCLAMATION MARK	uniFEE3	688	0	0

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AdobeArabic-Bold.otf

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- ccmp Glyph Composition / Decompos...
- dlig Discretionary Ligatures
- fina Terminal Forms
- frac Fractions
- init Initial Forms
- isol Isolated Forms
- jalt Justification Alternates
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char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni0645	749	0	0
ح	U+062D	ARABIC LETTER HAH	uniFEDF	407	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFECC	752	0	0
	U+0020	SPACE	uniFEDF	407	0	0
ب	U+0628	ARABIC LETTER BEH	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFE91	435	0	0
ل	U+0644	ARABIC LETTER LAM	space	400	0	0
ع	U+0639	ARABIC LETTER AIN	uni0627	318	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFE92	468	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEA3	927	0	0
م	U+0645	ARABIC LETTER MEEM	uni0631	531	-120	0
!	U+0021	EXCLAMATION MARK	uniFEE3	688	0	0

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AdobeArabic-Bold.otf

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## FontGoggles — Untitled

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni06...0645	840	0	0
ح	U+062D	ARABIC LETTER HAH	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFECC	752	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEDF	407	0	0
	U+0020	SPACE	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFE91	435	0	0
ا	U+0627	ARABIC LETTER ALEF	space	400	0	0
ل	U+0644	ARABIC LETTER LAM	uniFE8E	368	0	0
ع	U+0639	ARABIC LETTER AIN	uniFE92	468	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEA3	927	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEAE	496	-160	0
م	U+0645	ARABIC LETTER MEEM	uniFEE3	688	0	0
!	U+0021	EXCLAMATION MARK				

مرحبا بالعالم!

AdobeArabic-Bold.otf

مرحبا بالعالم!

Direction/orientation:

Automatic, with BiDi and Segmentation

Visual alignment:

Automatic

Script:

Automatic

Language:

dflt – Default

Features

Variations

Options

GSUB

calt Contextual Alternates

ccmp Glyph Composition / Decompos...

dlig Discretionary Ligatures

fina Terminal Forms

frac Fractions

init Initial Forms

isol Isolated Forms

jalt Justification Alternates

liga Standard Ligatures

locl Localized Forms

medi Medial Forms

pnum Proportional Figures

rlig Required Ligatures

salt Stylistic Alternates



char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni06...0645	840	0	0
ح	U+062D	ARABIC LETTER HAH	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFECC	752	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEDF	407	0	0
	U+0020	SPACE	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFE91	435	0	0
ا	U+0627	ARABIC LETTER ALEF	space	400	0	0
ل	U+0644	ARABIC LETTER LAM	uniFE8E	368	0	0
ع	U+0639	ARABIC LETTER AIN	uniFE92	468	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEA3	927	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEAE	496	-160	0
م	U+0645	ARABIC LETTER MEEM	uniFEE3	688	0	0
!	U+0021	EXCLAMATION MARK				

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AdobeArabic-Bold.otf

مرحبا بالعالم!

Direction/orientation:

Automatic, with BiDi and Segmentation

Visual alignment:

Automatic

Script:

Automatic

Language:

dflt – Default

Features

Variations

Options

GSUB

- calt** Contextual Alternates
- ccmp** Glyph Composition / Decompos...
- dlig** Discretionary Ligatures
- fina** Terminal Forms
- frac** Fractions
- init** Initial Forms
- isol** Isolated Forms
- jalt** Justification Alternates
- liga** Standard Ligatures
- locl** Localized Forms
- medi** Medial Forms
- pnum** Proportional Figures
- rlig** Required Ligatures
- salt** Stylistic Alternates

## FontGoggles — Untitled

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni06...0645	840	0	0
ح	U+062D	ARABIC LETTER HAH	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFECC	752	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEDF	407	0	0
	U+0020	SPACE	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFE91	435	0	0
ا	U+0627	ARABIC LETTER ALEF	space	400	0	0
ل	U+0644	ARABIC LETTER LAM	uniFE8E	368	0	0
ع	U+0639	ARABIC LETTER AIN	uniFE92	468	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEA3	927	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEAE	496	-160	0
م	U+0645	ARABIC LETTER MEEM	uniFEE3	688	0	0
!	U+0021	EXCLAMATION MARK				

مرحبا بالعالم!

AdobeArabic-Bold.otf

مرحبا بالعالم!

Direction/orientation:

Automatic, with BiDi and Segmentation

Visual alignment:

Automatic

Script:

Automatic

Language:

dflt – Default

Features

Variations

Options

GSUB

- calt** Contextual Alternates
- ccmp** Glyph Composition / Decompos...
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- jalt** Justification Alternates
- liga** Standard Ligatures
- locl** Localized Forms
- medi** Medial Forms
- pnum** Proportional Figures
- rlig** Required Ligatures
- salt** Stylistic Alternates

char	unicode	unicode name	glyph	adv	ΔX	ΔY
م	U+0645	ARABIC LETTER MEEM	exclam	425	0	0
ر	U+0631	ARABIC LETTER REH	uni06...0645	840	0	0
ح	U+062D	ARABIC LETTER HAH	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFECC	752	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEDF	407	0	0
	U+0020	SPACE	uniFE8E	368	0	0
ب	U+0628	ARABIC LETTER BEH	uniFE91	435	0	0
ا	U+0627	ARABIC LETTER ALEF	space	400	0	0
ل	U+0644	ARABIC LETTER LAM	uniFE8E	368	0	0
ع	U+0639	ARABIC LETTER AIN	uniFE92	468	0	0
ا	U+0627	ARABIC LETTER ALEF	uniFEA3	927	0	0
ل	U+0644	ARABIC LETTER LAM	uniFEAE	496	-160	0
م	U+0645	ARABIC LETTER MEEM	uniFEE3	688	0	0
!	U+0021	EXCLAMATION MARK				

مرحبا بالعالم!

AdobeArabic-Bold.otf

مرحبا بالعالم!

SalfordSansArabic.ttf

مرحبا بالعالم!

KigeliaArabic-Bold.otf

مرحبا بالعالم!

EskorteArabic-Sb.otf

مرحبا بالعالم!

Direction/orientation:

Automatic, with BiDi and Segmentation

Visual alignment:

Automatic

Script:

Automatic

Language:

dflt – Default

Features

Variations

Options

GSUB

aalt Access All Alternates

calt Contextual Alternates

case Case-Sensitive Forms

ccmp Glyph Composition / Decompos...

dlig Discretionary Ligatures

dnom Denominators

fina Terminal Forms

frac Fractions

init Initial Forms

isol Isolated Forms

jalt Justification Alternates

liga Standard Ligatures

locl Localized Forms

medi Medial Forms

# Putting it all together – Indic shaping

Layout  
Engine

BiDi  
Engine

Shaping  
Engine

Font

Font  
Rasterizer

FontGoggles — Untitled

char	unicode	unicode name	glyph
न	U+0928	DEVANAGARI LETTER NA	uni0928
म	U+092E	DEVANAGARI LETTER MA	uni092E
स	U+0938	DEVANAGARI LETTER SA	uni0938
्	U+094D	DEVANAGARI SIGN VIRAMA	uni094D
त	U+0924	DEVANAGARI LETTER TA	uni0924
े	U+0947	DEVANAGARI VOWEL SIGN E	uni0947
	U+0020	SPACE	space
द	U+0926	DEVANAGARI LETTER DA	uni0926
ु	U+0941	DEVANAGARI VOWEL SIGN U	uni0941
न	U+0928	DEVANAGARI LETTER NA	uni0928
ि	U+093F	DEVANAGARI VOWEL SIGN I	uni093F
य	U+092F	DEVANAGARI LETTER YA	uni092F
ा	U+093E	DEVANAGARI VOWEL SIGN AA	uni093E
!	U+0021	EXCLAMATION MARK	exclam.latn

नमस्ते दुनिया!

AdobeDevanagari-Regular.otf

~~नमस्ते दुनिया!~~

**WRONG**

Direction/orientation:  
Automatic, with BiDi and Segmentation

Visual alignment:  
Automatic

Script:  
latn – Latin

Language:  
dfit – Default

Features Variations Options

Relative Size  
90.0

Baseline  
24.6

Margin  
20.4

Enable Color (COLR/CPAL)

FontGoggles — Untitled

char	unicode	unicode name	glyph
न	U+0928	DEVANAGARI LETTER NA	uni0928
म	U+092E	DEVANAGARI LETTER MA	uni092E
स	U+0938	DEVANAGARI LETTER SA	uni09...0924
्	U+094D	DEVANAGARI SIGN VIRAMA	uni0947
त	U+0924	DEVANAGARI LETTER TA	space
े	U+0947	DEVANAGARI VOWEL SIGN E	uni0926
	U+0020	SPACE	uni0941.calt
द	U+0926	DEVANAGARI LETTER DA	uni093F.710
ु	U+0941	DEVANAGARI VOWEL SIGN U	uni0928
न	U+0928	DEVANAGARI LETTER NA	uni092F
ि	U+093F	DEVANAGARI VOWEL SIGN I	uni093E
य	U+092F	DEVANAGARI LETTER YA	exclam
ा	U+093E	DEVANAGARI VOWEL SIGN AA	
!	U+0021	EXCLAMATION MARK	

नमस्ते दुनिया!

AdobeDevanagari-Regular.otf

नमस्ते दुनिया!

Direction/orientation: Automatic, with BiDi and Segmentation

Visual alignment: Automatic

Script: dev2 – Devanagari v.2

Language: dflt – Default

Features Variations Options

Relative Size 90.0

Baseline 24.6

Margin 20.4

Enable Color (COLR/CPAL)

# Putting it all together – mark positioning

Layout  
Engine

BiDi  
Engine

Shaping  
Engine

Font

Font  
Rasterizer

FontGoggles — Untitled

IBMPlexSansThaiLooped-SemiBold.otf

เหล่านี้ยังขัดแย้งซึ่งกันและกัน

char	unicode	unicode name	glyph	adv	ΔX	ΔY
เ	U+0E40	THAI CHARACTER SARA E	uni0E40	329	0	0
ห	U+0E2B	THAI CHARACTER HO HIP	uni0E2B	734	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	626	0	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48	0	0	0
า	U+0E32	THAI CHARACTER SARA AA	uni0E32	519	0	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
ี	U+0E35	THAI CHARACTER SARA II	uni0E35	0	0	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49.small	0	0	0
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	0	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ช	U+0E02	THAI CHARACTER KHO KHAI	uni0E02	659	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	0	0
ด	U+0E14	THAI CHARACTER DO DEK	uni0E14	726	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49	0	0	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ซ	U+0E0B	THAI CHARACTER SO SO	uni0E0B	671	0	0
ี	U+0E36	THAI CHARACTER SARA UE	uni0E36	0	0	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48.small	0	0	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	0	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	636	0	0
ะ	U+0E30	THAI CHARACTER SARA A	uni0E30	553	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	0	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0

Direction/orientation: Automatic, with BIDI and Segmentation

Visual alignment: Automatic

Script: Automatic

Language: dflt - Default

Features Variations Options

- ccmp Glyph Composition / Decompos...
- dnom Denominators
- frac Fractions
- liga Standard Ligatures
- numr Numerators
- ordn Ordinals
- salt Stylistic Alternates
- sinf Scientific Inferiors
- ss01 simple lowercase a
- ss02 simple lowercase g
- ss03 slashed number zero
- ss04 dotted number zero
- ss05 alternate lowercase eszett
- subs Subscript
- supr Superscript
- zero Slashed Zero

GPOS

- kern Kerning
- mark Mark Positioning
- mkmk Mark to Mark Positioning



FontGoggles — Untitled

IBMPlexSansThaiLooped-SemiBold.otf

เหล่านี้ยังขัดแย้งซึ่งกันและกัน

เหล่านี้ยังขัดแย้งซึ่งกันและกัน

char	unicode	unicode name	glyph	adv	ΔX	ΔY
เ	U+0E40	THAI CHARACTER SARA E	uni0E40	329	0	0
ห	U+0E2B	THAI CHARACTER HO HIP	uni0E2B	734	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	626	0	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48	0	-51	0
า	U+0E32	THAI CHARACTER SARA AA	uni0E32	519	0	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
ี	U+0E35	THAI CHARACTER SARA II	uni0E35	0	-89	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49.small	0	79	-200
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	115	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ช	U+0E02	THAI CHARACTER KHO KHAI	uni0E02	659	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	102	0
ด	U+0E14	THAI CHARACTER DO DEK	uni0E14	726	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49	0	124	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ซ	U+0E0B	THAI CHARACTER SO SO	uni0E0B	671	0	0
ี	U+0E36	THAI CHARACTER SARA UE	uni0E36	0	33	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48.small	0	-48	-200
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	104	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	636	0	0
ะ	U+0E30	THAI CHARACTER SARA A	uni0E30	553	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	104	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0

Direction/orientation: Automatic, with BIDI and Segmentation

Visual alignment: Automatic

Script: Automatic

Language: dflt - Default

Features Variations Options

- ccmp Glyph Composition / Decompos...
- dnom Denominators
- frac Fractions
- liga Standard Ligatures
- numr Numerators
- ordn Ordinals
- salt Stylistic Alternates
- sinf Scientific Inferiors
- ss01 simple lowercase a
- ss02 simple lowercase g
- ss03 slashed number zero
- ss04 dotted number zero
- ss05 alternate lowercase eszett
- subs Subscript
- supr Superscript
- zero Slashed Zero

GPOS

- kern Kerning
- mark Mark Positioning
- mkmk Mark to Mark Positioning

FontGoggles — Untitled

เหล่านี้ยังขัดแย้งซึ่งกันและกัน

IBMPlexSansThaiLooped-SemiBold.otf

เหล่านี้ยังขัดแย้งซึ่งกันและกัน

char	unicode	unicode name	glyph	adv	ΔX	ΔY
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ห	U+0E2B	THAI CHARACTER HO HIP	uni0E2B	734	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	626	0	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48	0	-51	0
า	U+0E32	THAI CHARACTER SARA AA	uni0E32	519	0	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
ี	U+0E35	THAI CHARACTER SARA II	uni0E35	0	-89	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49.small	0	79	101
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	115	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ช	U+0E02	THAI CHARACTER KHO KHAI	uni0E02	659	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	102	0
ด	U+0E14	THAI CHARACTER DO DEK	uni0E14	726	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ย	U+0E22	THAI CHARACTER YO YAK	uni0E22	625	0	0
๕	U+0E49	THAI CHARACTER MAI THO	uni0E49	0	124	0
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ซ	U+0E0B	THAI CHARACTER SO SO	uni0E0B	671	0	0
๕	U+0E36	THAI CHARACTER SARA UE	uni0E36	0	33	0
เ	U+0E48	THAI CHARACTER MAI EK	uni0E48.small	0	-48	80
ง	U+0E07	THAI CHARACTER NGO NGU	uni0E07	574	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	104	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0
แ	U+0E41	THAI CHARACTER SARA AE	uni0E41	666	0	0
ล	U+0E25	THAI CHARACTER LO LING	uni0E25	636	0	0
ะ	U+0E30	THAI CHARACTER SARA A	uni0E30	553	0	0
ก	U+0E01	THAI CHARACTER KO KAI	uni0E01	689	0	0
๕	U+0E31	THAI CHARACTER MAI HAN-AKAT	uni0E31	0	104	0
น	U+0E19	THAI CHARACTER NO NU	uni0E19	709	0	0

Direction/orientation: Automatic, with BIDI and Segmentation

Visual alignment: Automatic

Script: Automatic

Language: dflt - Default

Features Variations Options

- ccmp Glyph Composition / Decompos...
- dnom Denominators
- frac Fractions
- liga Standard Ligatures
- numr Numerators
- ordn Ordinals
- salt Stylistic Alternates
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- ss04 dotted number zero
- ss05 alternate lowercase eszett
- subs Subscript
- supr Superscript
- zero Slashed Zero

GPOS

- kern Kerning
- mark Mark Positioning
- mkmk Mark to Mark Positioning

Character **≠** glyph

