

Font Metrics and a Design Pipeline for Type Design

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Contents

Okay, so you decided to design your own font?	1
The gold standard.....	1
The difference between design measures and typesetting measures.....	2
Determining width and height of characters and line.....	2
A design pipeline for font design	4
Conclusion	7
Recommended literature	8

Okay, So You Decided To Design Your Own Font?

Awesome. Designing a font is a challenging task, because you need to keep a lot in mind. Ascenders, descender, x-height, SMALL-CAPS, CAPITALS, minuscules, special characters, ligatures, and so forth.

What you need to understand is this: I’m an artist. What you also need to understand is this: you’re probably also an artist, because you’re doing something that a lot of people in art don’t do, namely look up solid rules of craftsmanship. That doesn’t mean that when I say I’m an artist I mean to be cocky, it just so happens to be a learned trade.

A lot has already been written, maybe this also, but it’s the last piece of advise that I ended up needing. Font metrics may not always seem to be that important, because you feel that with modern day computers people can resize your font anyway, but they are.

This short essay illustrates how to use font metrics, how to determine the size of your type, and a couple of things to consider in determining the size of your type. It also means to help you come up with a proper design process, using atomization to create more room to focus on your creativity.

The Gold Standard

The gold standard isn’t that complicated. It’s simply a measure that people use to determine size of type in regular printing.

The gold standard is 72 DPI, but that isn’t what you want to hear, right? What you really want to discuss is *resolution* in general. In general for printing photos and such, what people recommend is actually a *minimum* of 300 DPI. But the gold standard is important for some forms of typesetting, so don’t forget it.

What we’re discussing here is dots per inch. The number of dots a printer prints on a line, horizontally and vertically, uses this measure to determine its resolution. The size of one dot then equals 1 inch divided by the resolution.

The Difference Between Design Measures and Typesetting Measures

Design measures make use of something that's called Units Per Em. This name actually caused most of the confusion I had, because I assumed that my "M" or "m" character (note how they both have a different width to them) would have to have this width. Units Per Em or UPM represents more of a hypothetical measure, that's still called an *em square*.

What the UPM size basically says, is that if you employ the full number of units, and then choose a font size in dots (dots equal points), the full number of units represents the full width of this number in the specified number of dots. To illustrate this, let's assume that the UPM size is set to 1000 UPM. If I then apply a 10 pts. size to the typesetting, then these 1000 *units* will be equally divided over 10 *printed dots*, giving 1 dot $1000 / 10 = 100$ units.

The same goes for any other font size. When you select the font size in points, you get the UPM size in number of units per the number of points set by the font size.

Determining Width and Height of Characters and Line

As you may now understand, not every character that's set to 12 pts. will actually equal these full 12 pts. in width. Only characters that employ the full UPM size in width, meaning that with for instance a 1000 UPM size, they are 1000 units wide, will also actually be 12 pts. wide. When you employ a 12 pts. font size with a 72 DPI resolution, you get 12 points / 72 inches, meaning that the width of the full em square equals 1/6 of an inch.

To determine the width and the height of your characters, you need to consider how many characters you want per inch. A typical example is the Courier font, because it's monospaced. In terms of line-height, not every Courier design sticks to the proper metrics. Here are the proper metrics.

Courier, when set to a 12 pts. font size, should have 6 lines per inch, including spacing between the lines, with a fixed width of 10 characters per inch, as such 1/10 inch that every character occupies, including spacing between the characters.

The line-height isn't so much determined by the capital height, because the capital height isn't uniform. Characters with a pointy top or a round top, to match our visual perception of maintaining the line, somewhat ironically need to stick out a little above the CAP-height. The ascender height also needs to leave room for accents.

Something you might want to consider, to keep the printed line-height uniform, is to lower the height of capitals that have accents to them. This makes sure that when you use particular characters, the accents don't clash with descenders of characters, or markings placed under characters of characters in the line above.

The line-height is really defined by the measures for the ascenders and descenders in UPM. If you add up the ascender height to the descender depth, you get the full line height.

In case of Courier, when you apply a font size of 12 pts., you want 1/6 inch per line, which as was previously determined, means that the line height needs to occupy the full 12 pts. This doesn't mean that your characters physically occupy and use a 12 point height. It only means that when you add up the ascender height to the descender depth, together they make up for the entire em square in UPM.

I've noticed that some Courier fonts don't stick to this metric, in that if you add up the ascender height to the descender depth, they tend to have more units than what was specified as the em square size in terms of UPM. As such the line is actually higher than one

em square. If you want to design a proper Courier-like monospaced font, you do need to keep this in mind.

When you set the em square to 1000 UPM, this means that to get six lines per inch, you could use an ascender of 700 units and a descender of -300 units.

Font design software developers, due to the byte-organization of computers, recommend you always use a power of two to determine the size of your em square, like 1024 UPM, 2048 UPM, 4096 UPM, etc. Supposedly, due to increased computing speed, nowadays this isn't as important. The em square dimensions will somewhat alter the division of units per point a little bit, but these are things you need to consider for yourself, as we'll later see.

The width of a character can then be determined, considering that you want for instance for a character, including spacing to take up such a width.

In case of Courier, you would have to determine this so you get 10 characters per inch, when set to 12 pts. This means that when you set the resolution to 72 DPI, you get ten characters per 72 dots on an inch. If you were to employ the full em square for a character, you would get 6 characters per inch, but you want 10.

Name	Formula	Measure
Resolution	Printed dots / Inch	Dots Per Inch (DPI)
Font size	Dots / Em square	Points (<i>pts.</i>)
Em square	Number of units in font software	Units Per Em (UPM)
Em square dimensions	Font size / Resolution	Inches (I)
Type size	Characters / Inch	Characters Per Inch (CPI)
Em count	Resolution / Font size	Em Per Inch (MPI)
Character fraction	Em count / Type size	Em Character Ratio (ECR)
Character width	Character fraction · Em square	Units (U)
Line size	Lines / Inch	Lines Per Inch (LPI)
Line fraction	Em count / Line size	Em Line Ratio (ELR)
Ascender	Relative Units to zero-baseline	Units (U)
Descender	Relative Units to zero-baseline	Units (U)
Line height	Ascender - Descender = Line fraction · Em square	Units (U)

Table 1 - Variables and formulas to determine font metrics

To determine the width of your character in units, you first have to determine the actual width of one em square. The width of one em square equals the point size of a font divided by the resolution in DPI.

The number of em squares per inch equals the resolution in DPI divided by the point size.

The width of a character in inches can be determined by looking at the number of these characters you want in one inch. In case of Courier 12 pts. with a 72 DPI resolution, you want 10 characters per inch.

To determine the width of one character, you need to determine the fraction of a total em square by dividing the number of em squares by the number of characters per inch. In case of the specified Courier, the width of one character, including white spacing becomes a 6/10 fraction of the em square.

When you use an em square of 1000 UPM, this means the width of one character in units should then be $1000 \cdot 6 / 10 = 600$ units for the width of a character. To determine all of the basic metrics, see table 1.

Please note that in case of the *em square dimensions* the width equals the height, since it's a square. Also note the *descender* always has a negative value, determining its position relative to the zero-baseline of a character, as such being below this zero-baseline.

In the same way you can come up with an elaborate spreadsheet to include things like the CAP-height, x-height, and so forth. A lot can be automatized, but more on this in the next section... Oh, wait, here it is already.

A Design Pipeline for Font Design

Preparation is key. My first font design looked only at an isolated type of character, but what it failed to acknowledge is that character can't exist without context.

When you want to get to work, you shouldn't just regard the physical and the psychological in terms of the font, but you also need to reference the social: how does this font relate to everything else in the design. If you under develop one of these three key dimension, you're going to fail.

A character type is a means to an end. Only when you design a logo, can you kick against established social context to draw attention. Then and only then is it an end onto itself. You can compare it to business to business copywriting, and business to client copywriting. The first focuses on: what does this do? The latter on: how does this make people feel?

To people that need a font to do particular typesetting, how the end result makes people feel is determined by how they apply a specific font. As such they first look at what a font does and how they can apply it. As such a font is usually not a brand in itself, but something that can be used to establish a brand, when it is offered to the general community.

This is something you need to keep in mind: character in relation to context.

As soon as you have determined character in relation to context, you can translate these to a set of rules to adhere to. Because you need to adhere to rules, you need to find creative solutions within the limits of these rules to provide a solution, instead of being allowed to do anything.

Experience teaches that this actually stimulates creativity rather than limiting it, also increasing the quality of the work you deliver. The basic idea is that without a goal in mind, there will be no goal you reach. By just winging life, you don't establish anything. To some this may be a way to live: just enjoying it – in terms of leisure this may provide relief. In the end, however, it leads to aimlessness and as such a lack of direction.

Life is about something, so aim for it. If you haven't found it yet, why don't you take a test what interests you? If you want to be successful, this means that you need to adhere to rules. In the arts, if you don't adhere to any rules, you're not going to be successful.

One thing you for instance need to consider, is physical guidelines to your font. Is it a monospaced font? Variably spaced? Maybe bi-spaced, with two smaller characters, including their spacing, meeting the exact width of the larger character? Don't just think character width, when it comes to vertical alignment, you also need to consider spacing and boundaries to fonts.

Think about weight distribution. What lines will carry the most weight and what lines the least? When you place characters next to each other or above each other, do lines follow through from character to character, either horizontally or vertically?

What are we dealing with here to begin with? Serif? Sans-serif? Partial serif, partial sans-serif? How thick are the serifs? Think also in terms of your font having an *italic* or a **bold** type, not to mention pre-defined SMALL CAPS.

When you have these horizontal and vertical lines that follow through throughout your font, provided you implement your font in this way, what about the underlining? You can set this too. Does it have the same weight as one of the other standard lines? A proportional weight? Is the distance to the base of the font proportional to the thickness of any line in your font?

A lot of designers fail to consider the underlining and they choose a line that's either too thin or inappropriately strikes out the descenders. You should note, that underlining a font is a problem in typesetting. When I compare the way different word processors handle underlining when I apply it, they all seem to go against what I've defined in my type design.

When you specify underlining, in the font design software that I used, you specify the thickness, that's evenly distributed above and below the position specified by you in your font software. So, if you specify a location of -100 and a thickness of 99, 44 units of thickness will be to the top of the -100 location and 44 units will be below the -100 location.

When you consider underlining, you also need to consider default character spacing. The underlining will stick out as much to the left or right of the character borders as you provide additional empty space. Preferably, in most cases, as such the additional space to the left and to the right should be 0 and the spacing needs to be handled in the kerning.

If all spacing should be the same, you could make sure that all of the characters are a member of the same class. You then space the base character or any character, depending on what font design software you use, relatively speaking to all of the other characters, taking care of it in one go.

I'm not a methodical kind of guy myself. As such, when I need to go through specific methodical design steps, it's sometimes easier for me to predetermine certain features. You can easily make a spreadsheet, that predefines a lot of the features a font needs to adhere to, possibly in relation to the customer you're serving. It could contain formulae in case you prefer to make a proportional geometric font or a monospaced font.

Table 2 displays an example for Courier metrics, with everything in *italic* filled in by hand and everything in **blue** calculated by the formulae using table 1.

Font Metrics: (Font Name*) – (Weight*) – (Roman / Italic*)

Metric	Ratio (%)	Value	Measure
Resolution (value*)		72	Dots Per Inch (DPI)
Font size (value*)		12	Points (pts.)
Em square		1000	Units Per Em (UPM)
Em square dimensions		1/6	Inches (I)
Type size (value*)		10	Characters Per Inch (CPI)
Em count		6	Em Per Inch (MPI)
Character fraction		0,6	Em Character Ratio (ECR)
Character width		600	Units (U)
Line size (value*)		6	Lines Per Inch (LPI)
Line fraction		1	Em Line Ratio (ELR)
Ascender (ratio*)	70%	700	Units (U)
Descender		-300	Units (U)
Line height		1000	Units (U)
x-height (ratio*)	70%	490	Units (U)
CAP-height (ratio*)	90%	630	Units (U)

Table 2 - Sample spreadsheet with Courier metrics

Next, simply to illustrate how easy it is to use this, table 3 features the same Courier metrics as determined with a different em square size, the rest automatically calculated by the spreadsheet, without having to alter anything. As you can see I’ve now also officially filled in the names like you normally would.

The recommendation by font design software designers due to computational strength used to suggest a power of 2 in terms of the em square size in units. As you can see in table 3, this provides some measures that need to be rounded off in order to work. Especially when working with smaller em square sizes, this may actually provide a number of problems.

When you round off these figures and typeset on letter-sized paper using 12 pts. Courier, this will often not become apparent, but when it comes to typesetting, say, posters, it may. When you use a small em square size, like 300 upm, rounded off fractions of pixels will add up to millimeters, maybe even inches, when you magnify them at large resolutions. This is something you need to consider.

Type design isn’t rocket science, but sometimes it comes awfully close, especially when people need to follow your design. So, what’s your intent in designing type?

As soon as you’ve figured all of this out, maybe even adding things to your spreadsheet like ratios to determine the thickness of left-stems, right-stems, center-stem, baseline, midline, and topline, there’s just one more thing you might want to consider. How, when you’ve determined all of the key dimensions, are you going to make the design process as fast and effortless as possible, allowing you to focus all your strength of creativity?

Font Metrics: Courier – Regular – Roman

Metric	Ratio (%)	Value	Measure
Resolution (value*)		72	Dots Per Inch (DPI)
Font size (value*)		12	Points (pts.)
Em square		2048	Units Per Em (UPM)
Em square dimensions		1/6	Inches (I)
Type size (value*)		10	Characters Per Inch (CPI)
Em count		6	Em Per Inch (MPI)
Character fraction		0,6	Em Character Ratio (ECR)
Character width		1228,8	Units (U)
Line size (value*)		6	Lines Per Inch (LPI)
Line fraction		1	Em Line Ratio (ELR)
Ascender (ratio*)	70%	1433,6	Units (U)
Descender		-614,4	Units (U)
Line height		2048	Units (U)
x-height (ratio*)	70%	1003,52	Units (U)
CAP-height (ratio*)	90%	1290,24	Units (U)

Table 3 - Adjusted em square size for Courier

Automize, automatize, automatize.

Use your word processor, spreadsheet program, or vector drawing program also to quickly generate the proper ratios, that you can print repeatedly, so it's easier for you to sketch your characters between the lines. When you don't have to draw your lines by hand with a ruler, that makes it easier to start your design process.

It's also easier to shrink fit multiple outlines on a single page, in case you're still searching for your design. This way you can make smaller sketches first, before you translate them into bigger designs drawn on paper, that you then scan and outline in your font software as final character designs.

Conclusion

Although typesetters that handset letters, carving them out by hand, which is naturally a beautiful trade still, sometimes refuse to move on to design software, it doesn't have to be a limitation.

It's relatively easy to automatize everything in terms of predetermined metrics for a digital font, using the computer, combining the efficiency of the computer with the handwork that typedesign still entails.

All in all, I hope to have clarified a number of the basic issues that a lot of typedesigners seem to glaringly ignore, most importantly the fact that measures matter in typedesign. As

March 3rd, 2018

HOBO – page 8 of 8

such, I hope to have contributed a little. If you don't mind, and even if you do, I believe I've earned my coffee. Good luck.

Recommended Literature

Robert Bringhurst (2013) “The Elements of Typographic Style - Version 4.0 - 20th Anniversary Edition” : Hartley and Marks Publishers.