

JUlamono

a monospaced programming font  
with reasonable Unicode support

<https://github.com/cormullion/juliamono>

# JuliaMono Light

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

# JuliaMono Regular

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

# JuliaMono Medium

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

# JuliaMono Bold

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

# JuliaMono ExtraBold

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

# JuliaMono Black

abcdefghijklmnoprstuvwxyz 12345  
ABCDEFGHIJKLMNOPQRSTUVWXYZ 67890  
{ } [ ] ( ) <> \$ \* - + = / # \_ % ^ @ \ & | ~ ? ' " ` ! , . ; :

```
function _nloops(N::Int, itersym::Symbol, rangeexpr::Expr, args::Expr...)
    if rangeexpr.head !== :→
        throw(ArgumentError("second argument must be an anonymous function expression to compute the range"))
    end
    if !(1 ≤ length(args) ≤ 3)
        throw(ArgumentError("number of arguments must be 1 ≤ length(args) ≤ 3, got $args"))
    end
    body = args[end]
    ex = Expr(:escape, body)
    for dim = 1:N
        itervar = inlineanonymous(itersym, dim)
        rng = inlineanonymous(rangeexpr, dim)
        preexpr = length(args) > 1 ? inlineanonymous(args[1], dim) : (:(:nothing))
        postexpr = length(args) > 2 ? inlineanonymous(args[2], dim) : (:(:nothing))
        ex = quote
            for $(esc(itervar)) = $(esc(rng))
                $(esc(preexpr))
                $ex
                $(esc(postexpr))
            end
        end
    end
    ex
end

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                $ex
                $(esc(postexpr))
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    end
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```



**Ancient Greek** Ἀδμηθ', ὁρᾶς γὰρ τάμα πράγμαθ' ὡς ἔχει, λέξαι θέλω σοι πρὶν θανεῖν ἢ βούλομαι.

**Bulgarian** Я, пазачът Валъо уж бди, а скришом хапва кюфтенца зад щайгите.

**Catalan** «Dóna amor que seràs feliç!». Això, il·lus company geniüt, ja és un lluït rētol blavís d'onze kWh.

**Czech** Zvlášť zákeřný učeň s doličky běží podél zóny úlu

**Danish** Quizdeltagerne spiste jordbær med fløde, mens cirkusklovnen Walther spillede på xylofon.

**English** Sphinx of black quartz, judge my vow.

**Estonian** Põdur Zagrebi tšellomängija-fölljetonist Ciqo külmetas kehvas garaažis

**Finnish** Charles Darwin jammaili Åken hevixylofonilla Qatarin yöpub Zeligissä.

**French** Voix ambiguë d'un cœur qui au zéphyr préfère les jattes de kiwi.

**Georgian** სწრაფი ყავისფერი მელა ახტება ზარმაც ძაღლს.

**German** Victor jagt zwölf Boxkämpfer quer über den großen Sylter Deich.

**Greek** Ταχίστη αλώπηξ βαφής ψημένη γη, δρασκελίζει υπέρ νωθρού κυνός.

**Guarani** H̄ilandiagua kuñanguéra oho peteī sa'yju ypa'ūme Gavōme ombo'e hāguá ingyleñe'ẽ mitānguérale ne'ēndy'ŷ.

**Hungarian** Jó foxim és don Quijote húszwattos lámpánál ülve egy pár bűvös cipőt készít.

**IPA** [ ɛw?.nas.do:ŋ.kʰlja]  
[ɛjan.ɛzliwo.çiuɛn.χwa]

**Icelandic** Kæmi ný öxi hér, ykist þjófum nú bæði víl og ádrepa.

**Irish** Ćuaité bé mórsácar le dlúthspáid fiorfínn trí hata mo dea-porcáin big.

**Latvian** Muļķa hipiji mēģina brīvi nogaršot celofāna žņaudzējējusku.

**Lithuanian** Įlinkdama fechtuotojo špaga sublykčiojusi pragrėžę apvalų arbūzą.

**Macedonian** Сидарски пејзаж: шугав билмез со чудење џвака ќофте и кељ на туѓ цех.

**Norwegian** Jeg begynte å fortære en sandwich mens jeg kjørte taxi på vei til quiz

**Polish** Pchnąć w tę łódź jeża lub ósm skrzyń fig.

**Portuguese** Luís argüia à Júlia que «brações, fé, chá, óxido, pôr, zângão» eram palavras do português.

**Romanian** Înjurând pițigăiat, zoofobul comandă vexat whisky și tequila.

**Russian** Широкая электрификация южных губерний даст мощный толчок подъёму сельского хозяйства.

**Scottish** Mus d'fhàg Cèit-Ùna ròp i le ob.

**Serbian** Ајшо, лепото и чежњо, за љубав срца мога дођи у Хаџиће на кафу.

**Spanish** Benjamín pidió una bebida de kiwi y fresa; Noé, sin vergüenza, la más champaña del menú.

**Swedish** Flygande bäckasiner söka hwila på mjuka tuvor.

**Turkish** Pijamalı hasta yağız şoföre çabucak güvendi.

**Ukrainian** Чуєш іх, доцю, га? Кумедна жти, прощайся без ґольфів!

yotta	Y	$10^{24}$	1 000 000 000 000 000 000 000 000	septillion
zetta	Z	$10^{21}$	1 000 000 000 000 000 000 000 000	sextrillion
exa	E	$10^{18}$	1 000 000 000 000 000 000 000 000	quintillion
peta	P	$10^{15}$	1 000 000 000 000 000 000 000 000	quadrillion
tera	T	$10^{12}$	1 000 000 000 000 000	trillion
giga	G	$10^9$	1 000 000 000	billion
mega	M	$10^6$	1 000 000	million
kilo	k	$10^3$	1 000	thousand
hecto	h	$10^2$	100	hundred
deca	da	$10^1$	10	ten
deci	d	$10^{-1}$	0.1	tenth
centi	c	$10^{-2}$	0.01	hundredth
milli	m	$10^{-3}$	0.001	thousandth
micro	$\mu$	$10^{-6}$	0.000 001	millionth
nano	n	$10^{-9}$	0.000 000 001	billionth
pico	p	$10^{-12}$	0.000 000 000 001	trillionth
femto	f	$10^{-15}$	0.000 000 000 000 001	quadrillionth
atto	a	$10^{-18}$	0.000 000 000 000 000 001	quintillionth
zepto	z	$10^{-21}$	0.000 000 000 000 000 000 001	sextillionth
yocto	y	$10^{-24}$	0.000 000 000 000 000 000 000 001	septillionth

classical electron radius	$r_e$	$2.817940285 \times 10^{-15}$
Compton wavelength of the electron	$\lambda_c$	$2.426310215 \times 10^{-12}$
reduced Compton wavelength of the electron	$\tilde{\lambda}_c$	$3.8615926764 \times 10^{-13}$
Bohr radius of the hydrogen atom	$a_0$	$5.291772083 \times 10^{-11}$
natural units based on the electronvolt	$1 \text{ eV}^{-1}$	$1.97 \times 10^{-7}$
reduced wavelength of hydrogen radiation	$1/R_\infty$	$9.112670505509 \times 10^{-8}$
Planck length	$\ell_p$	$1.616199 \times 10^{-35}$
Stoney unit of length	$l_s$	$1.381 \times 10^{-35}$
quantum chromodynamics (QCD) unit of length	$l_{qcd}$	$2.103 \times 10^{-16}$

	mm		inches		points	
	w	h	w	h	w	h
A0	841	1189	33.11	46.81	2384	3370
A1	594	841	23.39	33.11	1684	2384
A2	420	594	16.54	23.39	1190	1684
A3	297	420	11.69	16.54	842	1190
A4	210	297	8.27	11.69	595	842
A5	148	210	5.83	8.27	420	595
A6	105	148	4.13	5.83	298	420
A7	74	105	2.91	4.13	210	298
A8	52	74	2.05	2.91	148	210
Letter (ANSI A)	215.9	279.4	8.5	11	612	792
Legal	215.9	355.6	8.5	14	612	1008
Ledger (ANSI B)	279.4	431.8	11	17	792	1224
Tabloid (ANSI B)	431.8	279.4	17	11	1224	792
Executive	184.1	266.7	7.25	10.55	522	756
ANSI C	559	432	22	17	1584	1224
ANSI D	864	559	34	22	2448	1584
ANSI E	1118	864	44	34	3168	2448
Foolscap	336	419	13.25	16.5	954	1188
Small Post	368	469	14.5	18.5	1044	1332
Sheet and 1/3 cap	336	588	13.25	22	954	1584
Sheet and 1/2 cap	336	628	13.25	24.75	954	1782
Demy	394	507	15.5	20	1116	1440
Large Post	419	533	16.5	21	1188	1512
Small medium	444	558	17.5	22	1260	1584
Medium	457	584	18	23	1296	1656
Small Royal	482	609	19	24	1368	1728
Royal	507	634	20	25	1440	1800
Imperial	559	761	22	30	1584	2160

ꝝ

weierstrass  
u+2118

ꝑ

palm branch  
u+2e19

Ꝉ

swash ampersand  
u+1f675

♻

recycled paper  
u+267c

Ꝋ

transversal intersect  
u+2adb

Ꝋ

trans Pluto  
u+2bd7

ꝋ

per  
u+214c

Ꝍ

division times  
u+22c7

ꝍ

cada una  
u+2106

Ꝏ

alef  
u+2135

ꝉ

G circled  
u+24bc

ꝉ

Z Notation Schema Composition  
u+2a1f

Ꝋ

git PR  
u+e726

ꝋ

segno  
u+1d10b

Ꝍ

blackboard a  
u+1d552

Ꝍ

triple dagger  
u+2e4b

ꝏ

editorial coronis  
u+2e0e

ꝑ

coptic 800  
u+102fa

Ꝏ

Pluto  
u+2bd4

Ꝉ

psi  
u+3c8

ꝉ

circled asterisk  
u+229b

Ꝋ

hbar  
u+210f

Ꝍ

cube root  
u+221b

ꝍ

blackboard S  
u+1d54a

Ꝏ

numero  
u+2116

Ꝏ

random  
Ꝏ right-pointing angle trigram divergence amalgamation Or Coproduct  
u+2e16

Ꝏ

left arrow subset  
u+1d310

Ꝏ

or amalgamation Or Coproduct  
u+2a3f

Ꝏ

Sharp S  
u+1e9e

Ꝍ

triangle > small triangle  
u+27c1

ꝏ

speech bubble  
u+1f4ac

Ꝏ

triple integral  
u+222d

Ꝏ

devangari 5  
u+96b

Ꝏ

selection  
left arrow subset  
u+297a

Ꝏ

Roman 50K  
u+2187

Ꝏ

hryvnia  
u+20b4

Ꝍ

eternity  
u+58e

ꝏ

APL dot tack jot  
u+234e

Ꝏ

hexagram completion  
u+4df6

Ꝏ

fist  
u+270a

Ꝏ

subset with +  
u+2abf

Ꝏ

ace of spades  
u+1f0a1

Ꝏ

heavy 12pt Pinwheel Star  
u+1f7d4

Ꝍ

heavy right arrow  
u+1f882

ꝍ

R fraktur  
u+211c

Ꝏ

white upperleft square  
u+25f0

Ꝉ

Tifinagh Yach  
u+2d5e

Ꝏ

Braille 2345 (t)  
u+281e

Ꝏ

subscript b  
u+e805

Ꝏ

earth ground  
u+23da

Ꝍ

Mayan 14  
u+1d2ee

random  
selection  
Unicode  
characters

## contextual alternates

calt off	calt on
->	→
=>	⇒
>	▷
<	△
::	::
-->	→
<--	←
<-->	↔

## stylistic sets

zero	0	0	slashed zero
ss01	g	g	alternate g
ss02	@	@	alternate @
ss03	j	j	alternate j
ss04	ø	ø	alternate ø
ss05	*	*	lighter asterisk
ss06	a	a	simple a
ss07	`	`	smaller grave
ss08	->	→	distinct ligatures+
ss09	f	f	alternate f
ss10	r	r	alternate r
ss11	`	`	thinner grave
ss12	=====	=====	equal join (>= 4)

+ with calt off

git PR  
u+e726Makie  
u+e831julia dots  
u+e800subscript z  
u+e814subscript y  
u+e813powerline  
u+e0a2C++  
u+e61dcreative commons  
u+e789css  
u+e614

flux

flux  
u+e832superscript q  
u+e807cc  
u+e789subscript b  
u+e805subscript ∞  
u+e817subscript δ  
u+e816powerline  
u+e0b2subscript f  
u+e810MIT  
u+e78bgit commit  
u+e729subscript asterisk  
u+e809windows  
u+fab2hacker  
u+e826luxor  
u+e837

Differential Equation

u+e830

powerline  
u+e0a1gear  
u+e615cormullion  
u+e803git compare  
u+e728Vcat the pirate cat  
u+e838vim  
u+e62bpowerline  
u+e0b1powerline  
u+e0a3julia computing  
u+e802julia logo  
u+e801subscript α  
u+e815folder  
u+e613subscript q  
u+e806C  
u+e61elinux  
u+e712text  
u+e612Plots  
u+e833Markdown  
u+e609git merge  
u+e727Python  
u+e606git branch  
u+e725julia  
u+e624github  
u+e709powerline  
u+e0b0powerline  
u+e0a0subscript parallel  
u+e808(julia) con  
u+e834symbolix  
u+e835

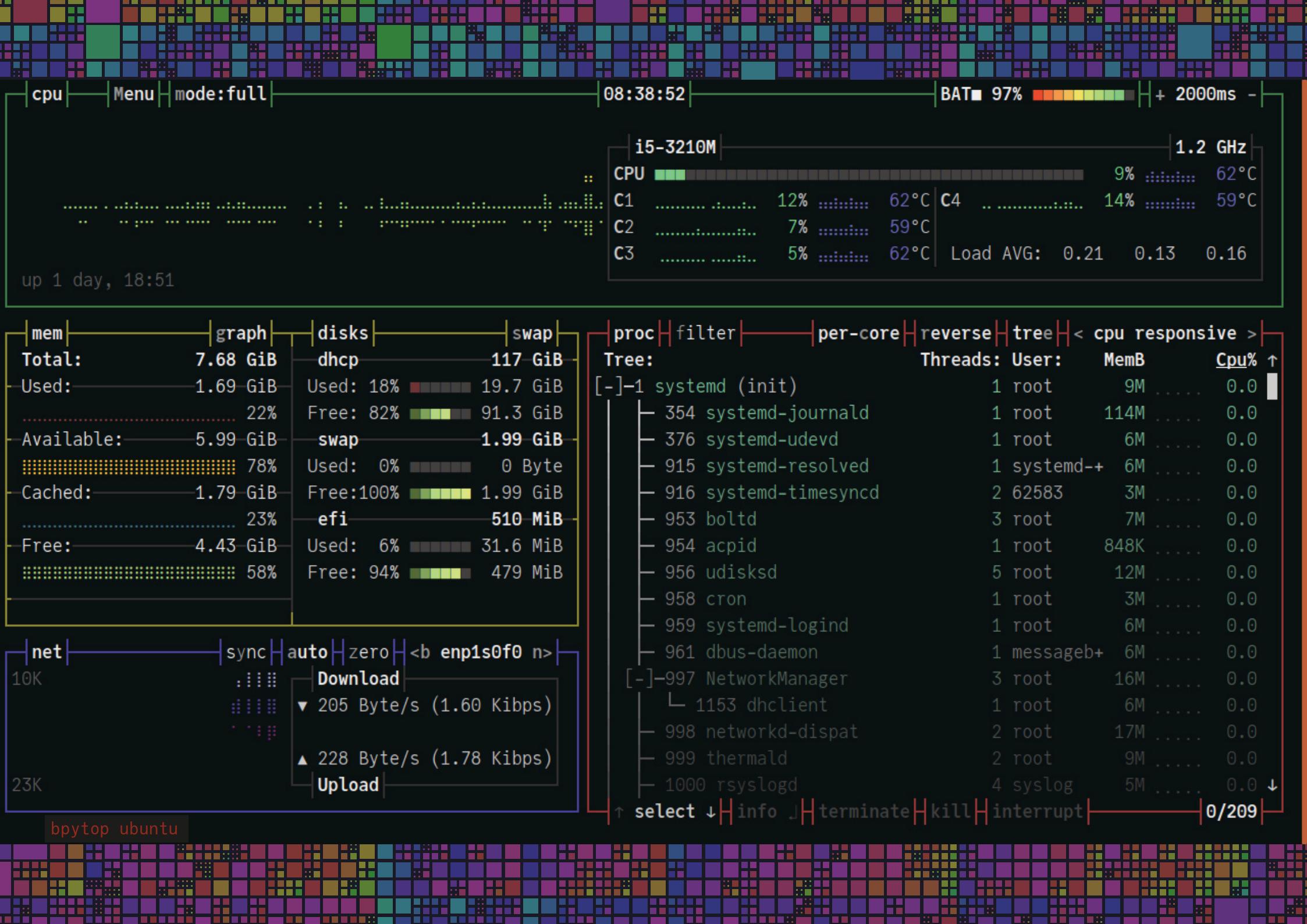
some characters from the private use areas

Private

Areas

```
45 @inline function ntuple(f::F, ::Val{N}) where {F,N}
46     N::Int
47     (N >= 0) || throw(ArgumentError(string("tuple length should be ≥ 0, got ", N)))
48     if @generated
49         quote
50             @nexprs $N i → t_i = f(i)
51             @ncall $N tuple t
52         end
53     else
54         Tuple(f(i) for i = 1:N)
55     end
56 end
57
58 @inline function fill_to_length(t::Tuple, val, ::Val{_N}) where {_N}
59     M = length(t)
60     N = _N::Int
61     M > N && throw(ArgumentError("input tuple of length $M, requested $N"))
62     if @generated
63         quote
64             (t..., $(fill(:val, (_N::Int) - length(t.parameters))...))
65         end
66     else
67         (t..., fill(val, N-M)...)
```

```
@inline function _foldoneto(op, acc, ::Val{N}) where N
    @assert N::Integer > 0
    if @generated
        quote end
            acc_0 = acc
            Base.Cartesian.@nexprs $N i →
                acc_{i} = op(acc_{i-1},
                    return $(Symbol(:acc_, N)))
    quote end
    else
        for i in 1:N
            acc = op(acc, i)
        end
    end
end
```





The title of the painting, which is known in English as *Mona Lisa*, comes from a description by Renaissance art historian Giorgio Vasari, who wrote "Leonardo undertook to paint, for Francesco del Giocondo, the portrait of *Mona Lisa*, his wife." *Mona* in Italian is a polite form of address originating as *ma donna* – similar to *Ma'am*, *Madam*, or *my lady* in English. This became *madonna*, and its contraction *mona*. The title of the painting, though traditionally spelled *Mona* (as used by Vasari), is also commonly spelled in modern Italian as *Monna Lisa* (*mona* being a vulgarity in some Italian dialects), but this is rare in English. Vasari's account of the *Mona Lisa* comes from his biography of Leonardo published in 1550, 31 years after the artist's death. It has long been the best-known source of information on the provenance of the work and identity of the sitter. Leonardo's assistant Salai, at his death in 1524, owned a portrait which in his personal papers was named *la Gioconda*, a painting bequeathed to him by Leonardo. That Leonardo painted such a work, and its date, were confirmed in 2005 when a scholar at Heidelberg University discovered a marginal note in a 1477 printing of a volume by ancient Roman philosopher Cicero. Dated October 1503, the note was written by Leonardo's contemporary Agostino Vespucci. This note likens Leonardo to renowned Greek painter Apelles, who is mentioned in the text, and states that Leonardo was at that time working on a painting of *Lisa del Giocondo*. In response to the announcement of the discovery of this document, Vincent Delieuvin, the Louvre representative, stated "Leonardo da Vinci was painting, in 1503, the portrait of a Florentine lady by the name of *Lisa del Giocondo*. About this we are now certain. Unfortunately, we cannot be absolutely certain that this portrait of *Lisa del Giocondo* is the painting of the Louvre." The model, *Lisa del Giocondo*, was a member of the Gherardini family of Florence and Tuscany, and the wife of wealthy Florentine silk merchant Francesco del Giocondo. The painting is thought to have been commissioned for their new home, and to celebrate the birth of their second son, Andrea. The Italian name for the painting, *La Gioconda*, means 'jocund' ('happy' or 'joyful') or, literally, 'the jocund one', a pun on the feminine form of *Lisa*'s married name, *Giocondo*. In French, the title *La Joconde* has the same meaning. Before that discovery, scholars had developed several alternative views as to the subject of the painting. Some argued that *Lisa del Giocondo* was the subject of a different portrait, identifying at least four other paintings as the *Mona Lisa* referred to by Vasari. Several other women have been proposed as the subject of the painting. Isabella of Aragon, Cecilia Gallerani, Costanza d'Avalos, Duchess of Francavilla, Isabella d'Este, Pacifica Brandano or Brandino, Isabela Gualanda, Caterina Sforza, Bianca Giovanna Sforza—even Salai and Leonardo himself—are all among the list of posited models portrayed in the painting. The consensus of art historians in the 21st century maintains the long-held traditional opinion that the painting depicts *Lisa del Giocondo*. History: Leonardo da Vinci had begun working on a portrait of *Lisa del Giocondo*, the model of the *Mona Lisa*, by October 1503. It is believed by some that the *Mona Lisa* was begun in 1503 or 1504 in Florence. Although the Louvre states that it was "doubtless painted between 1503 and 1506", art historian Martin Kemp says that there are some difficulties in confirming the dates with certainty. In addition, many Leonardo experts, such as Carlo Pedretti and Alessandro Vezzosi, are of the opinion that the painting is characteristic of Leonardo's style in the final years of his life, post-1513. Other academics argue that, given the historical documentation, Leonardo would have

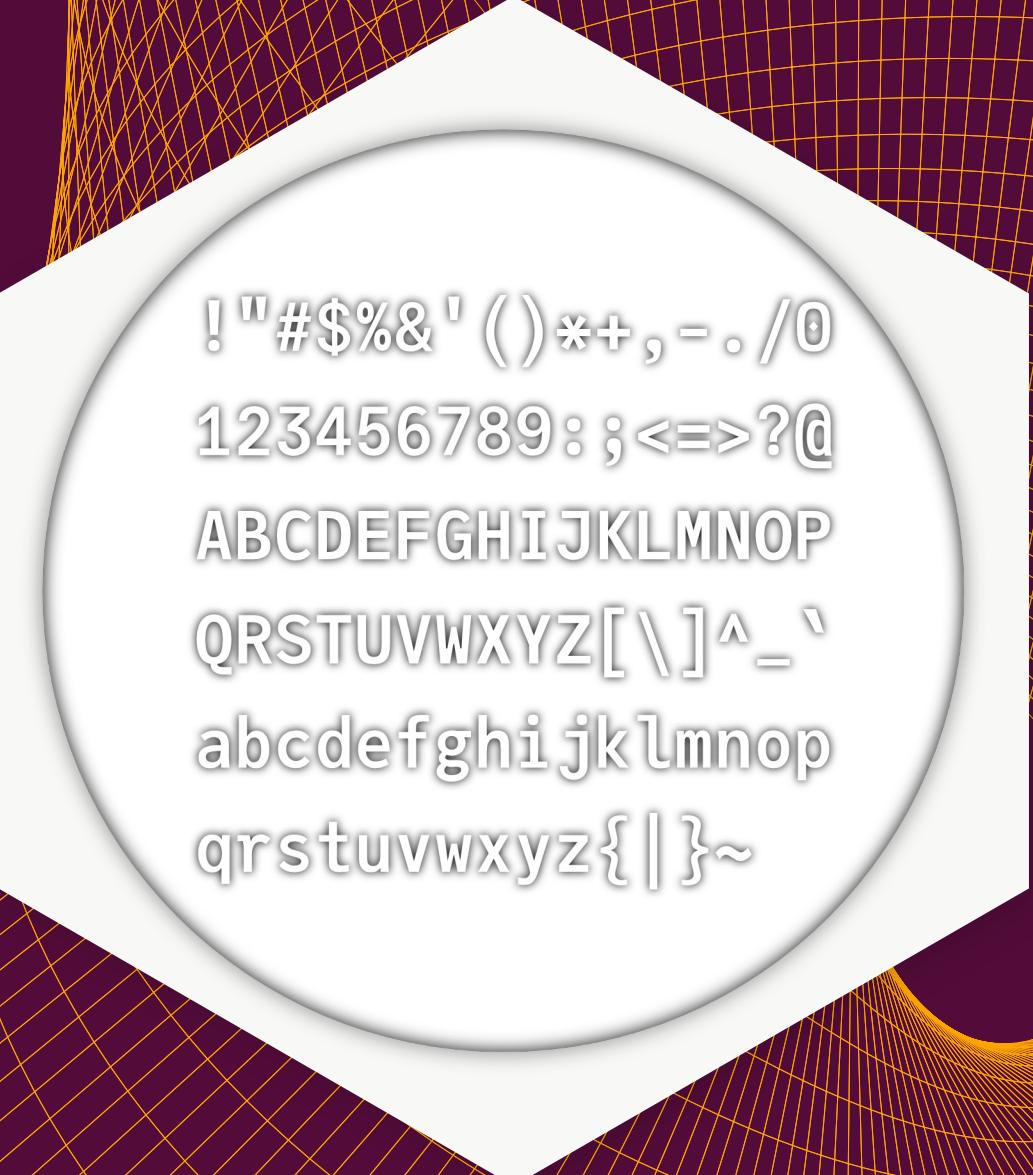
painted the work from 1513. According to Vasari, "after he had lingered over it four years, left it unfinished". In 1516, Leonardo was invited by King Francis I to work at the Clos Lucé near the Château d'Amboise; it is believed that he took the *Mona Lisa* with him and continued to work on it after he moved to France. Art historian Carmen C. Bambach has concluded that Leonardo probably continued refining the work until 1516 or 1517. Leonardo's right hand was paralytic circa 1517, which

2004. In view of this, Vincent Delieuvin, curator of 16th-century Italian painting at the Louvre, states that the sketch and these other copies must have been inspired by another version, while Zöllner states that the sketch may be after another Leonardo portrait of the same subject. The record of an October 1517 visit by Louis d'Aragon states that the *Mona Lisa* was executed for the deceased Giuliano de' Medici, Leonardo's steward at the Belvedere Palace between 1513 and

and assistant Salai's possession until his death in 1524. The second, commissioned by Giuliano de' Medici circa 1513, would have been sold by Salai to Francis I in 1518 and is the one in the Louvre today. Others believe that there was only one true *Mona Lisa*, but are divided as to the two aforementioned fates. At some point in the 16th century, a varnish was applied to the painting. It was kept at the Palace of Fontainebleau until Louis XIV moved it to the Palace of Versailles, where it remained until the French Revolution. In 1797, it was put on to permanent display at the Louvre. In the early 21st century, French scientist Pascal Cotte hypothesized a hidden portrait underneath the surface of the painting, circumstantial evidence for which was produced using reflective light technology. The underlying portrait appears to be of a model looking to the side, but lacks the flanking columns drawn by Raphael. Having been given access to the painting by the Louvre in 2004, Cotte spent ten years studying the painting with layer-amplification methods. However, the alleged portrait does not fit with historical descriptions of the painting: both Vasari and Gian Paolo Lomazzo describe the subject as smiling, unlike the subject in Cotte's portrait. Cotte admits that his reconstitution had been carried out only in support of his hypotheses and should not be considered as objective proof of an underlying portrait. Refuge, theft and vandalism After the French Revolution, the painting was moved to the Louvre, but spent a brief period in the bedroom of Napoleon (d. 1821) in the Tuileries Palace. The *Mona Lisa* was not widely known outside the art world, but in the 1800s, a portion of the French intelligentsia began to hail it as a masterpiece of Renaissance painting. During the Franco-Prussian War (1870–1871), the painting was moved from the Louvre to the Brest Arsenal. Vacant wall in the Louvre's Salon Carré after the painting was stolen in 1911 "*La Joconde est Retrouvée*" ("*Mona Lisa is Found*"), Le Petit Parisien, 13 December 1913. In 1911, the painting was still not popular among the lay-public. On 21 August 1911, the painting was stolen from the Louvre. The missing painting was first noticed the next day by painter Louis Béroud. After some confusion as to whether the painting was being photographed somewhere, the Louvre was closed for a week for investigation. French poet Guillaume Apollinaire came under suspicion and was arrested and imprisoned. Apollinaire implicated his friend Pablo Picasso, who was brought in for questioning. Both were later exonerated. The real culprit was Louvre employee Vincenzo Peruggia, who had helped construct the painting's glass case. He carried out the theft by entering the building during regular hours, hiding in a broom closet, and walking out with the painting hidden under his coat after the museum had closed. Peruggia was an Italian patriot who believed that Leonardo's painting should have been returned to an Italian museum. Peruggia may have been motivated by an associate whose copies of the original would significantly rise in value after the painting's theft. After having kept the *Mona Lisa* in his apartment for two years, Peruggia grew impatient and was caught when he attempted to sell it to Giovanni Poggi, director of the Uffizi Gallery in Florence. It was exhibited in the Uffizi Gallery for over two weeks and returned to the Louvre on 4 January 1914. Peruggia served six months in prison for the crime and was hailed for his patriotism in Italy. A year after the theft, Saturday Evening Post journalist Karl Decker met an alleged accomplice named Eduardo de Valfierro, who claimed to have masterminded the theft. Forger Yves Chaudron was to have created ... [text by Wikipedia contributors. "*Mona Lisa*." Wikipedia, The Free Encyclopedia.]

may indicate why he left the *Mona Lisa* unfinished. Circa 1505, Raphael executed a pen-and-ink sketch, in which the columns flanking the subject are more apparent. Experts universally agree that it is based on Leonardo's portrait. Other later copies of the *Mona Lisa*, such as those in the National Museum of Art, Architecture and Design and The Walters Art Museum, also display large flanking columns. As a result, it was thought that the *Mona Lisa* had been trimmed. However, by 1993, Frank Zöllner observed that the painting surface had never been trimmed; this was confirmed through a series of tests in

1516—but this was likely an error. According to Vasari, the painting was created for the model's husband, Francesco del Giocondo. A number of experts have argued that Leonardo made two versions (because of the uncertainty concerning its dating and commissioner, as well as its fate following Leonardo's death in 1519, and the difference of details in Raphael's sketch—which may be explained by the possibility that he made the sketch from memory). The hypothetical first portrait, displaying prominent columns, would have been commissioned by Giocondo circa 1503, and left unfinished in Leonardo's pupil



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JuliaMono Light

JuliaMono Regular

JuliaMono Medium

JuliaMono Bold

JuliaMono ExtraBold

JuliaMono Black



```

# inferable ntuple (enough for bootstrapping)
ntuple(f, ::Val{0}) = ()
ntuple(f, ::Val{1}) = (@_inline_meta; (f(1),))
ntuple(f, ::Val{2}) = (@_inline_meta; (f(1), f(2)))
ntuple(f, ::Val{3}) = (@_inline_meta; (f(1), f(2), f(3)))

@inline function ntuple(f::F, ::Val{N}) where {F,N}
    N::Int
    (N >= 0) || throw(ArgumentError(string("tuple length should be ≥ 0, got ", N)))
    if @generated
        quote
            @nexprs $N i → t_i = f(i)
            @ncall $N tuple t
        end
    else
        Tuple(f(i) for i = 1:N)
    end
end

```

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```

@inline function fill_to_length(t::Tuple, val, ::Val{_N}) where {_N}
    M = length(t)
    N = _N::Int
    M > N && throw(ArgumentError("input tuple of length $M, requested $N"))
    if @generated
        quote
            (t..., $(fill(:val, (_N::Int) - length(t.parameters))...))
        end
    else
        Tuple(val for i = 1:N)
    end
end

```