

# GNU APL Reference Card

(for GNU APL version 1.8)

Use `C-x gnu-apl` to start GNU APL in Emacs.

## Emacs mode

### Interaction mode:

beginning of defun	C-M-a
end of defun	C-M-e
find function at point	M-.
apropos symbol	C-c C-a
edit function	C-c C-f
show help for symbol	C-c C-h
finnapl list	C-c TAB
show keyboard	C-c C-k
plot line	C-c RET
edit variable	C-c C-v
trace	C-c C-.

### Edit mode:

go to beginning of defun	C-M-a
go to end of defun	C-M-e
find function at point	M-.
apropos symbol	C-c C-a
interactive send current function	C-c C-c
help for symbol	C-c C-h
finnapl list	C-c TAB
show keyboard	C-c C-k
interactive send buffer	C-c C-l
interactive send region	C-c C-s
switch to interactive	C-c C-z
trace	C-c C-.
indent	C-M-q

## System

Notation for commands:

F	filename	L	library	P	path
G	logging facility	O	object	S	symbol
W	workspace				

### APL standard commands

check workspace integrity	)CHECK
clear workspace	)CLEAR
save workspace as CONTINUE and exit	)CONTINUE
copies objects from given workspace	)COPY [L] W [0 ...]
remove W	)DROP [L] W
dump W (readable, HTML escaped)	)DUMP-HTML [[L] W]
dump W (readable APL)	)DUMP [[L] W]
dump W (readable APL, verbose)	)DUMPV [[L] W]
erase symbol(s)	)ERASE S ...
show functions	)FNS [from-to]
help	)HELP [primitive]
history	)HIST [CLEAR]
runs command on host	)HOST command ...

loads workspace (IBM .atf format)	)IN F [0 ...]
show libraries and paths	)LIBS [[L] path]
show saved workspaces	)LIB [L P] [from-to]
load workspace W	)LOAD [L] W
show more error info	)MORE
lists symbols matching name	)NMS [from-to]
quit APL	)OFF
show operators	)OPS [from-to]
dump workspace (IBM .atf format)	)OUT name [0 ...]
protects during copying	)PCOPY [L] W [0 ...]
protects during loading	)PIN F [0 ...]
quiet load	)QLOAD [[L] W]
reset state indicator	)RESET
save workspace as W	)SAVE [[L] W]
clear suspended functions	)SIC
see suspended functions and locals	)SINL
see suspended functions	)SIS
state indicator	)SI
show symbol count	)SYMBOLS [count]
show values in use by interpreter	)VALUES
show variables	)VARS [from-to]
get/set workspace ID	)WSID [W]

### GNU extension commands (mostly for debugging)

toggles boxing of values when printing	]BOXING [OFF num]
toggle colored output	]COLOR [ON OFF]
dump W in HTML file	]DOXY [path]
expected error count in test suite	]EXPECT error_count
help	]HELP [primitive]
show keyboard layout	]KEYB
as )LIB, but shows fil eextensions	]LIB [L P] [from-to]
show/set logging facilities	]LOG [G [ON OFF]]
next testcase file	]NEXTFILE
performance statistics	]PSTAT [CLEAR SAVE]
as )SIS, with more details	]SIS
as )SI, with more details	]SI
shared variables	]SVARS
describe internal details of symbol S	]SYMBOL S
define user command	]USERCMD [ ... ]
toggle output coloring on console	]XTERM [ON OFF]

### System variables:

character input/output	<input type="checkbox"/> M
evaluated input/output	<input type="checkbox"/>
account information	<input type="checkbox"/> AI
command line arguments	<input type="checkbox"/> ARG
atomic vector	<input type="checkbox"/> AV
comparison tolerance	<input type="checkbox"/> CT
event message	<input type="checkbox"/> EM
event type	<input type="checkbox"/> ET
format control	<input type="checkbox"/> FC
index origin (indexes start: 1, can be set to 0)	<input type="checkbox"/> IO
left argument	<input type="checkbox"/> L
line counters	<input type="checkbox"/> LC
latent expression (executed when workspace is loaded)	<input type="checkbox"/> LX
print precision (number of digits)	<input type="checkbox"/> PP
print style	<input type="checkbox"/> PS
print width (max characters in each printed line)	<input type="checkbox"/> PW

right argument	<input type="checkbox"/> R
random link	<input type="checkbox"/> RL
shared variable event	<input type="checkbox"/> SVE
system limits	<input type="checkbox"/> SYL
terminal control characters	<input type="checkbox"/> TC
time stamp (current time)	<input type="checkbox"/> TS
time zone (offset from GMT)	<input type="checkbox"/> TZ
user load	<input type="checkbox"/> UL
axis argument	<input type="checkbox"/> X
workspace available (bytes for workspace)	<input type="checkbox"/> WA
dfn axis argument	X
dfn result	$\lambda$
dfn left value arg	$\alpha$
dfn left function arg	$\underline{\alpha}$
dfn right value arg	$\omega$
dfn right function arg	$\underline{\omega}$

### System functions:

atomic function	<input type="checkbox"/> AF
attributes	<input type="checkbox"/> AT
char representation	<input type="checkbox"/> CR
delay	<input type="checkbox"/> DL
D. Knuth's dancing links	<input type="checkbox"/> DLX
execute alternate	<input type="checkbox"/> EA
execute both	<input type="checkbox"/> EB
execute controlled	<input type="checkbox"/> EC
environment	<input type="checkbox"/> ENV
event simulate	<input type="checkbox"/> ES
expunge	<input type="checkbox"/> EX
fast Fourier transform	<input type="checkbox"/> FFT
file I/O	<input type="checkbox"/> FIO
FiX (FFI/call native functions)	<input type="checkbox"/> FX
Gtk GUI	<input type="checkbox"/> GTK
MAP ravel elements	<input type="checkbox"/> MAP
input from script	<input type="checkbox"/> INP
name association	<input type="checkbox"/> NA
name class	<input type="checkbox"/> NC
name list	<input type="checkbox"/> NL
plot a graph	<input type="checkbox"/> PLOT
regular expression, regex <input type="checkbox"/> RE string	<input type="checkbox"/> RE
random APL value	<input type="checkbox"/> RVAL
state indicator	<input type="checkbox"/> SI
SQL functions	<input type="checkbox"/> SQL
shared variable control	<input type="checkbox"/> SVC
shared variable offer	<input type="checkbox"/> SVO
shared variable query	<input type="checkbox"/> SVQ
shared variable retraction	<input type="checkbox"/> SVR
shared variable state	<input type="checkbox"/> SVS
STOP vector	<input type="checkbox"/> STOP
transfer form	<input type="checkbox"/> TF
TRACE vector	<input type="checkbox"/> TRACE
unicode character	<input type="checkbox"/> UCS

## Notation

comment	$\rho$
statement separator	$\diamond$
assignment	$A \leftarrow \dots$
assignment	$(A\ B\ C) \leftarrow \dots \dots \dots$
function definition	$\nabla$

zilde (empty vector)	$\emptyset$
a	$+ a$
a + b	$a + b$
- a	$- a$
a - b	$a - b$
magnitude of a	$  a$
b mod a	$a   b$
signal (-1, 0, +1)	$\times a$
ab	$a \times b$
1/a	$\div a$
a/b	$a \div b$
floor of a	$\lfloor a$
min(a,b)	$a \lfloor b$
ceiling of a	$\lceil a$
max(a,b)	$a \lceil b$
$e^a$	$* a$
$a^b$	$a * b$
$\log(a)$	$\otimes a$
$\log_b(a)$	$b \otimes a$
first $n$ non-negative integers	$\iota n$
<hr/>	
a = b	$a = b$
a < b	$a < b$
a > b	$a > b$
a ≤ b	$a \leq b$
a ≥ b	$a \geq b$
expression max depth	$\equiv a$
match (value and type)	$a \equiv b$
expression min depth	$\neq a$
not match	$a \neq b$
not a	$\approx a$
a or b	$a \vee b$
a and b	$a \wedge b$
a nor b	$a \nabla b$
a nand b	$a \nA b$
a ∈ b ?	$a \in b$
find a in b (binary index)	$a \subseteq b ?$
bitwise a or b	$a \overline{\vee} b$
bitwise a and b	$a \overline{\wedge} b$
bitwise a nor b	$a \overline{\nabla} b$
bitwise a nand b	$a \overline{\nA} b$
bitwise a ≠ b	$a \overline{\neq} b$
bitwise a = b	$a \overline{=} b$
<hr/>	
$a! \binom{b}{a}$	$!a$ $a!b$
<hr/>	
$a\pi$	$\otimes a$
circle (trig) function	$a \otimes b$
random integer in [1,a]	$?a$
a distinct random integers in [1,b]	$a?b$
<hr/>	
makes a vector out of A	$, A$
append B to A	$A, B$
number of components in each dimension of A	$\rho A$
array with shape A and data elements B	$A\rho B$
inverse matrix of A	$\overline{\div} A$

$B^{-1}A$ (solution to $Bx = A$ )	$A\overline{\div}B$
reverse elements of A ( $1^{st}$ index)	$\ominus A$
rotate B by A positions	$A\ominus B$
reverse elements of A (last index)	$\oplus A$
rotate B by A positions (last index)	$A\oplus B$
drop first A elements of B	$A\downarrow B$
select first A elements of B	$A\uparrow B$
intersection	$A\cap B$
set (remove duplicates)	$\cup A$
union	$A\cup B$
identity	$\vdash A$
take right hand side (B)	$A\vdash B$
take left( $X_i = 0$ ) or right( $X_i = 1$ )	$A\vdash [X]B$
null	$\neg A$
take left hand side (A)	$A\vdash B$
i-th element of A	$A[i]$
elements of A with indices i, j, k, ...	$A[i \ j \ k \ \dots]$
element of A w/indices i, j, ... in $1^{st}$ dimension, k, l, ... in second, ...	$A[i \ \dots; k \ \dots; \dots]$

transpose of A	$\Re A$
transpose of B, axes ordered by A	$A\Re B$
maps A: 1 for a∈ B, 0 for a∉ B	$A\in B$
grade up A	$\Uparrow A$
grade up B with elements of A as top priority	$A\Uparrow B$
grade down A	$\Downarrow A$
grade down B with elements of A as low priority	$A\Downarrow B$
transpose of A	$\Re A$
enclose A	$\subset A$
enclose B with selected elements given the binary vector A	$A\subset B$
disclose A	$\supset A$
recursively pick elements of B given the indices in A	$A\supset B$

Decode single digits of B with respect to base A	$A\perp B$
Encode B with respect to bases given by A	$A\top B$

line label A	<b>A:</b>
branch to line A	$\rightarrow A$

execute APL expression A	$\pmb{A}$
format A as chars	$\overline{\pmb{A}}$

user input	$\square$
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system var/function	$\square$
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reduce <b>op</b> over array A	<b>op/A</b>
compress: select B using A as mask	<b>A/B</b>
A/B on last dimension	<b>A÷B</b>
expand: insert zeros in B using A as mask	<b>A\B</b>
A\B on last dimension	<b>A÷B</b>
inner product with functions f, g	<b>Af.gB</b>
outer product with function f	<b>Ao.fB</b>
for each b∈B, apply: Ab	<b>A”B</b>

rank: apply left operand function to cells specified by array on right	<b>Aö B</b>
axis: AfC, over Bth axis	<b>Af [B]C</b>
commute 1-x over array A	$1 - \sim A$

## ⌈CR, ⌈FIO, ⌈PLOT, ⌈SQL

When called with an empty string as right argument, these will show a table with all their possible uses.

## Circle function

A	A◊B	A	A◊B
0	$\sqrt{1-B \times B}$		
−1	arcsin B	1	sin B
−2	arccos B	2	cos B
−3	arctan $\frac{B}{\phantom{B}}$	3	tan B
−4	$\sqrt{-1+B \times B}$	4	$\sqrt{1+B \times B}$
−5	arcsinh B	5	sinh B
−6	arccosh B	6	cosh B
−7	arctanh B	7	$\tanh \frac{B}{\phantom{B}}$
−8	$\neg(8\circ B)$	8	$\pm\sqrt{-1+B \times B}$
−9	B	9	real part of B
−10	+B	10	B
−11	0J1×B	11	imag part of B
−12	*0J1×B ( $e^{iB}$ )	12	arc B (phase of B)

For A= 8, the sign before the square root is opposite of  $B$ .

## Function Definition

Example:  $f(d,v) = \left(v_1^d + \dots + v_n^d\right)^{1/d}$

**Dynamic function definition (dfn):**

$\alpha$  is the left argument,  $\omega$  is the right argument.

**f** ← { ( +/ω\*α ) \* (÷α) }

**Traditional function definition (tradfn):**

$\nabla$ : begin/end defun. “ $\nabla R \leftarrow A \text{ f } B ;U ;V$ ” is “f takes left arg A, right arg B, has local vars U, V, and returns result in R”.

$\nabla res \leftarrow d \text{ f } v ;sq ;sum$

$\phantom{\nabla}sq \leftarrow v * d$

$\phantom{\nabla}sum \leftarrow +/sq$

$\phantom{\nabla}res \leftarrow sum*(\div d)$

$\nabla$

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https://www.github.com/jpellegrini/gnu-apl-refcard