# J Reference Card for version 6.01

## Arithmetic Dyads

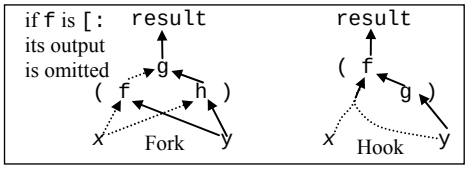
| | | |
|---|---|---|
| `2 + 8` | Plus | `10` |
| `2 - 8` | Minus | `_6` |
| `2 * 8` | Times | `16` |
| `2 % 8` | Divide | `0.25` |
| `2 \| 8` | Residue | `0` |
| `2 ^ 8` | Exponent | `256` |
| `2 ^. 8` | Log | `3` |
| `3 %: 8` | Root | `2` |
| `2 >. 6` | Greater | `6` |
| `2 <. 6` | Lesser | `2` |
| `36 +. 24` | GCD | `12` |
| `36 *. 24` | LCM | `72` |
| `10 10 #. 8 3` | Base | `83` |
| `10 10 #: 83` | Antibase | `8 3` |
| `2 ! 8` | CombOutOf | `28` |
| `2 ? 8` | Deal | `4 2` |

## Arithmetic Monads

| | | |
|---|---|---|
| `<. 4.5` | Floor | `4` |
| `>. 4.5` | Ceiling | `5` |
| `* _4 0 3` | Sign | `_1 0 1` |
| `! 4` | Factorial | `24` |
| `? 20` | Random in `i. y` | `7` |
| `? 0` | Random in (0,1) | `0.452` |

## Legend

| | |
|---|---|
| `x y` | args to verbs |
| `m n` | nouns |
| `u v` | verbs |
| *italics* | optional |




## Comparisons (result 1 if TRUE)

| | | | | | |
|---|---|---|---|---|---|
| `=` | Equal | `>` | Greater | `>:` | GreaterOrEqual |
| `~:` | NotEqual | `<` | Less | `<:` | LessOrEqual |

`-:` Match (rank _ _): equal in shape, boxing, and values; but if empty, type does not matter

`'re' E.'reread'` WindowedMatch (ranks may be > 1) `1 0 1 0 0 0`

Comparisons are tolerant; follow by `!.0` for exact comparison

## Assignments

| | |
|---|---|
| `(n) =. v` | AssignInd: value of `n` gives name(s) to assign |
| `'n1 n2' =. v1;v2` | AssignMult: one level of boxing is removed |
| `` '`add sub' =. +`- `` | AssignAR |

## Shorthands

| | | | |
|---|---|---|---|
| `<: 5` | `y-1` | Decrement | `4` |
| `>: 5` | `y+1` | Increment | `6` |
| `% 5` | `1%y` | Reciprocal | `0.2` |
| `-. 0.3` | `1-y` | Complement | `0.7` |
| `+: 9` | `y*2` | Double | `18` |
| `-: 9` | `y%2` | Halve | `4.5` |
| `*: 9` | `y^2` | Square | `81` |
| `%:` | `2%y` | SquareRoot | `3` |
| `^ 1` | `e^y` | Exp | `2.718` |
| `^. 7.389` | `e^.y` | NaturalLog | `2` |
| `#. 1 0 1` | `2#.y` | FromBase2 | `5` |
| `#: 5` | `2#:y` | ToBase2* | `1 0 1` |
| `m&#.^:_1` | `m#:y` | ToBasem* | |

* produce as many result items as needed to hold significance

## Searches

| | | |
|---|---|---|
| `'people' i. 'pow'` | IndexOf[1] | `0 2 6` |
| `'people' i: 'pow'` | IndexOfLast[1] | `3 2 6` |
| `'pow' e. 'people'` | ElementOf[1] | `1 1 0` |
| `I. 0 1 1 0 1` | IndicesOfOnes | `1 2 4` |
| `0 2 4 I. 2 3 _1 9` | FindInsertionPoint[12] | `1 2 0 3` |
| `(i. >./) 1 2 8 5` | IndexOfLargest[34] | `2` |
| `3 (= i. 1:) 1 3 3 0` | FindFirstTrue[456] | `1` |
| `3 ([: I. =) 1 3 3 0` | IndicesWhereTrue[67] | `1 2` |
| `m&i.  e.&n  m&i:` | FastSearch (when used repeatedly) | |

[1] rank searched for is rank of items of other operand [2] min index before which item can be inserted in order [3] or `<.` [4] or `i:` [5] or `0:` [6] any comp. or `e.` [7] or `+/ +./ *./`

## Operations on Ordered Sets

| | | |
|---|---|---|
| `'rare'-. 'er'` | RemoveItems | `a` |
| `~. 'rare'` | UniqueItems | `rae` |
| `~: 'rare'` | UniqueSieve | `1 1 0 1` |
| `i.~ 'rare'` | SelfClassify | `0 1 0 3` |

## Operations on Booleans

`16b1a` Base16 constant `26`

| Dyads | | Monad: `-.` NOT |
|---|---|---|
| `+.` OR | `*.` AND | `~:` XOR |
| `+:` NOR | `*:` NAND | `=` XNOR |

`> < >: <:` are also meaningful

`m b.` (0≤m<16) Boolean function with truth table `2 2#:4 4#:m` (`1 b.` is AND)

`m b.` (16≤m<32) bitwise Boolean; applies `(m-16) b.` to each bit of integers

| | | |
|---|---|---|
| `x 32 b. y` rotate `y` left `x` bits | `x 33 b. y` unsigned | `x 34 b. y` signed |
| | shift `y` L (x>0) or R (x<0) `x` bits | |

## Take and Drop

| | | |
|---|---|---|
| `2 {. i. 6` | Take | `0 1` |
| `_2 {. i. 6` | TakeLast | `4 5` |
| `2 }. i. 6` | Drop | `2 3 4 5` |
| `_2 }. i. 6` | DropLast | `0 1 2 3` |
| `4 {. 2 3` | Overtake | `2 3 0 0` |
| `4 {.!.9 (2 3)` | OvertakeCustom | `2 3 9 9` |
| `2 _2 {. i. 4 4` | TakeMultiAxis | `2 3`<br>`6 7` |

| Monad | . First | : Last |
|---|---|---|
| { Take | {. Head | {: Tail |
| } Drop | }. Behead | }: Curtail |

apply to `0 1 2`

| | |
|---|---|
| 0 | 2 |
| 1 2 | 0 1 |

## Box Operations

B is `0 1 | 2 3 | 4 5 | 6 7 | 8`

| | | |
|---|---|---|
| `L. B` | Level | `2` |
| `$ L:0 B` | AtLevel | `,2 \| ,2 \| ,2 \| ,2 \|` |
| `{. L:1 B` | AtLevel | `0 1 \| 6 \| 8` |
| `# S:0 B` | Spread | `2 2 2 2 1` |
| `\|.&.> B` | Each (fast) | `4 5 \| 2 3 \| 0 1 \| 7 \| 6 \| 8` |
| `1 {:: B` | Fetch | `6 7` |
| `0 \| 1 {:: B` | Fetch | `2 3` |
| `0 \| 2 0 \| {::B` | FetchList | `4 5 \| 0 1` |

## Join and Reshape

| | | |
|---|---|---|
| `ab , cd` | Enfile | `abcd` |
| `'ab' , 'cd'` | Append | `abcd` |
| `0 1 / 2 3 , 8 9` | Append (unequal ranks) | `0 1`<br>`2 3`<br>`8 9` |
| `0 1 / 2 3 , ,8` | Append (short) | `0 1`<br>`2 3`<br>`8 0` |
| `0 1 / 2 3 , 8` | Append (atom) | `0 1`<br>`2 3`<br>`8 8` |
| `,. 'ab'` | EnfileItems | `a`<br>`b` |
| `'ab' ,. 'cd'` | AppendItems | `ac`<br>`bd` |
| `$ ,: 'ab'` | Itemize (adds leading axis) | `1 2` |
| `'ab' ,: 'cd'` | Laminate | `ab`<br>`cd` |
| `3 $ 0 1 / 2 3` | ReshapeItems | `0 1`<br>`2 3`<br>`0 1` |
| `3 ($,) 0 1 / 2 3` | Reshape | `0 1 2` |
| `3 ; (4 ; 5)` | Link | `3 \| 4 \| 5` |
| `3 ,&< (4 ; 5)` | JoinBoxed | `3 \| 4 \| 5` |
| `; 0 1 / 2 3 \| ,4 \| 6` | Raze (expand items of opened boxes to size of largest, then append) | `0 1`<br>`2 3`<br>`4 0`<br>`6 6` |
| `;: '2  wds'` | JWords | `2 \| wds` |
| `;:^:_1 \| w1 \| w2` | RazeWords | `w1 w2` |

## Selections

A is `abcd / efgh / ijkl / mnop`

| | | |
|---|---|---|
| `1 0 2 # 'abc'` | Copy | `acc` |
| `1j1 0 2 # 'abc'` | CopyFill | `a cc` |
| `1j1 0 2 #!.'*' 'abc'` | CopyCustom | `a*cc` |
| `1 0 1&#^:_1 'ab'` | Expand | `a b` |
| `1 0 1&#^:_1!.'*' 'ab'` | ExpandCustom | `a*b` |
| `_1 1 { A` | ItemsFrom | `mnop`<br>`efgh` |
| `1 3 {"1 A` | FromEachRow | `bd`<br>`fh`<br>`jl`<br>`np` |
| `2 1 \| { A` | From (All axes scalar) | `j` |
| `1 3 \| { A` | From (Omitted trailing axis) | `efgh`<br>`mnop` |
| `1 \| 2 { A` | From (Axis 1 complementary) | `efh` |
| `1 3 \| 1 0 2 { A` | From (General axes) | `feg`<br>`nmo` |
| `(<a:;2 0) { A` | From (Omitted early axis) | `ca`<br>`ge`<br>`ki`<br>`om` |
| `1 1 / 3 2 (<"1@[ { ]) A` | FromUnboxed (fast form) | `fo` |

**Monad i. & i:**

| |
|---|
| `i. 3`<br>`0 1 2` |
| `i. _3`<br>`2 1 0` |
| `i. 2 3`<br>`0 1 2`<br>`3 4 5` |
| `i: 2`<br>`_1 0 1` |

## Whole-Array Operations

| | | |
|---|---|---|
| `\|. 'abcde'` | Reverse | `edcba` |
| `2 \|. 'abcde'` | RotateLeft | `cdeab` |
| `_2 \|. 'abcde'` | RotateRight | `deabc` |
| `2 \|.!.'*' 'abcde'` | ShiftLeft | `cde**` |
| `\|.!.'*' 'abcde'` | ShiftRightOne | `*abcd` |
| `1 _1 \|. abcd / efgh / ijkl / mnop` | Rotate (multiaxis) | `hefg`<br>`lijk`<br>`pmno`<br>`dabc` |
| `\|: abcd / efgh / ijkl / mnop` | Transpose (reverse axes) | `aeim`<br>`bfjn`<br>`cgko`<br>`dhlp` |
| `x \|: y` | ReorderAxes (moves axes x to end of axes) | |
| `'c0 c1 c2' =. \|: y` | AssignIndividualColumns | |
| `/: 3 1 4 1` | GradeUp* | `1 3 0 2` |
| `/:~ 3 1 4 1` | SortUp* | `1 1 3 4` |
| `'abcd' /: 3 1 4 1` | SortUpUsing* | `bdac` |
| `/:@/: 3 1 4 1` | Ordinals* | `2 0 3 1` |
| `'*' (<1 2)} abcd / efgh / ijkl / mnop` | Amend | `abcd`<br>`ef*h`<br>`ijkl`<br>`mnop` |
| `'*+' [`(#@[)`]} ab / ef / ij / mn` | Amend (gerund form) | `ab`<br>`ef`<br>`*+`<br>`mn` |
| `y =. x m} y` | AmendInPlace (fast form) | |

* use `\:` for descending ordering

## Partitions

| | | |
|---|---|---|
| `<\ i. 3` | Prefixes | `,0 \| 0 1 \| 0 1 2` |
| `2 <\ i. 4` | Infixes | `0 1 \| 1 2 \| 2 3` |
| `_2 <\ i. 5` | Infixes, no overlap | `0 1 \| 2 3 \| ,4` |
| `<\. i. 3` | Suffixes | `0 1 2 \| 1 2 \| ,2` |
| `3 <\. i. 5` | Outfixes | `3 4 \| 0 4 \| 0 1` |
| `_3 <\. i. 5` | Outfixes, no overlap | `3 4 \| 0 1 2` |
| `3 4 / 2 2 u;.3` | **u** applied to SubArrays[1] (**bold** and ***italic***) | **abc**d**ef**gh<br>**ij**k**lmn**op<br>qrstuvwx<br>**yx**01**23**45<br>**67**89**AB**CD<br>EFGHIJKL<br>***MN***OP***QR***ST |
| `3 4 / 2 2 u;._3` | **u** applied to FullSubArrays[1] (**bold**) | |
| `1 _2 / 3 2 u;.0` | **u** applied to SubArray[2] (**bold**) | abcdef<br>ghi**jk**l<br>mno**pq**r<br>stu**vw**x |
| `<;.1 'people'` | CutOnHead[3] | `peo \| ple` |
| `0 1 0 1 <;.1 i. 4` | CutStartAtOne[3] | `1 2 \| ,3` |
| `<;.2 'people'` | CutOnTail[3] | `pe \| ople` |
| `0 1 0 1 <;.2 i. 4` | CutEndAtOne[3] | `0 1 \| 2 3` |
| `'people' <\/. i. 6` | Key | `0 3 \| 1 5 \| ,2 \| ,4` |

The operation, shown in **bold** in the examples as **<** or **u**, can be replaced by any verb, or with a gerund `m` in which case the components of `m` are applied cyclically, one per partition.

[1] `x` is *`boundary,:`*`shape`. Subarrays start at all possible combinations of multiples of the atoms of `boundary`, and have the shape `|shape`. A negative component of `shape` reverses that axis in each subarray.

[2] `x` is *`corner,:`*`shape`. The subarray starts at `corner` and has shape `|shape`. A negative component of `corner` causes the subarray to extend backward in that component; a negative component of `shape` reverses that axis in the subarray.

[3] `;._1` omits the first, and `;._2` the last, item in each partition.

## Format

| | | |
|---|---|---|
| `99 ". '2 5.5 xx'` | Numbers | `2 5.5 99` |
| `5j2 ": 1.468 2.3` | Format | `1.47 2.30` |
| `7j_2 ": 2.3` | Format | `2.30e0` |
| `'n[CR]4.' 8!:2 ]3 _5` | Format | `3 5CR` |

## Adverbs and Conjunctions

| | |
|---|---|
| `u~ y` | Reflexive: `y u y` |
| `x u~ y` | Passive: `y u x` |
| *`x`* `u^:n y` | Power: execute *`x`*`&u` for `n` times; if `n<0`, execute inverse of *`x`*`&u` for –`n` times; if `n=0`, result is `y` |
| *`x`* `u^:v y` | Power, where `n` is given by *`x`* `v y` |
| *`x`* `u^:v y` | If: `y` if *`x`* `v y` is false (`0`), *`x`* `u y` if *`x`* `v y` is true (`1`) |
| `u^:_` | Converge: repeat `u` until result is constant |
| *`x`* `u^:v^:_ y` | DoWhile: repeat `u` while *`x`* `v y` is `1` |
| `u^:a:` | ConvergeHistory: repeat `u` until result is constant, return all intermediate values |
| `{~^:a:&0` | ChaseChain: follow chain of record positions |
| `u :.v` | Inverse: like `u`, but inverse is `v` |
| `u ::v` | Adverse: `u`, but execute `v` if error during `u` |
| *`x`* `u@:v y` | At: `u` *`x`* `v y` |
| *`x`* `u@v y` | Atop: *`x`* `u@:v"v y` |
| `1 2 +/@* 3 4` | `3 8  NB. (+/ 1*3) , (+/ 2*4)` |
| `1 2 +/@:* 3 4` | `11  NB. +/ 1 2 * 3 4` |
| *`x`* `u&:v y` | Appose: *`(v x)`* `u v y` |
| *`x`* `u&v y` | Compose*: *`x`* `u&:v"mv y` |
| *`x`* `u&.:v y` | Dual: `v^:_1` *`(v x)`* `u v y` |
| *`x`* `u&.v y` | Dual*: *`x`* `u&.:v"mv y` |
| `>:&.> 1 2 3` | `2 \| 3 \| 4` |
| `>:&.:> 1 2 3` | `2 3 4` |
| `m&v y` or `u&n y` | MonadFromDyad: `m v y` or `y u n` |
| `x m&v y` | same as `(m&v)^:x y` (`x u&n y` similarly) |

* `mv` is monadic rank of `v`

## Control Structures

```
if. T do. B0 else. B1 end.
if. T do. B0 elseif. T1 do. B1 elseif. T2 do. B2 end.[1]
while. T do. B end.[1]        whilst. T do. B end.[1] (skips T first tme)
for. T do. B end. loop #T times    for_xyz. T do. B end.[2]
    break. jump out of loop    continue. go to end of loop
select. T fcase. T0 do. B0 fcase T1 do. B1 end.[1] (fcase falls through)
try. B0 catch. B1 catcht. B2 end.  execute B1 if error in B0[3]
returncode return.
```

[1] omitted T is true [2] sets *`xyz`* and *`xyz`*`_index` for each loop [3] `catcht.` catches `throw.` from a called function

## Insert

| | | |
|---|---|---|
| `u/ y` | Insert `u` between items of `y` | |
| `u/ 1 3 5` | Insert | `1 u 3 u 5` |
| `+/ 1 3 5` | Sum | `9` |
| `+/\ 1 3 5` | RunningSum | `1 4 9` |
| `+/\. 1 3 5` | RevRunningSum | `9 8 5` |
| `m/ y` | Insert verbs from gerund `m` | |

## Gerunds

| | | |
|---|---|---|
| `u` ` v` | TwoVerbGerund | |
| `u` ` '' | OneVerbGerund | |
| `+:` ` *: ` ` :0 i. 3` | Append verb results | `0 2 4`<br>`0 1 2` |
| `+` ` '' ` ` :6` | MakeVerb | `+` |
| `]` ` !` ` -@.* 0 3 _2` | Agenda* | `0 6 2` |

*`u@.v` (rank `v`) is *`x`* `((`*`x`* `v y){u)` ` :6 y`

## Shape and Rank

| | |
|---|---|
| `$ i. 2 3` | ShapeOf `2 3` |
| `# i. 2 3` | TallyOf `2` |
| `#@$ i. 2 3` | RankOf `2` |
| `+/ 0 1 / 2 3` | `2 4` |
| `+/"1 0 1 / 2 3` | `1 5` |
| `+/"0 0 1 / 2 3` | `0 1 / 2 3` |
| `1 2 +"0 0 1 2 / 3 4 5` | `1 2 3 / 5 6 7` |
| `1 2 3 +"1 0 1 2 / 3 4 5` | `1 3 5 / 4 6 8` |
| `1 2 3 +"0 0 1 2 / 3 4 5` | `length error` |

`x u/ y` applies `u` between each cell of `x` and all of `y`

## Trigonometry and Calculus

| | | |
|---|---|---|
| `1 o. 1r3p1` | Sin | `0.866` |
| `2 o. 1r3p1` | Cos | `0.5` |
| `3 o. 1r3p1` | Tan | `1.732` |
| `other o. y` | Trig Functions | |
| `o. 1` | PiTimes | `3.1416` |
| `p. 6 5 1` | Roots | `1 \| _3 _2` |
| `p. 1 \| _3 _2` | Coeffs | `12 10 2` |
| `1 2 1 p. 2` | EvalPoly | `9` |
| `1 \| _1 _1 p. 2` | EvalPoly | `9` |
| `p.. 1 2 1` | PolyDeriv | `2 2` |
| `9 p.. 1 2 1` | PolyIntegral | `9 1 1 0.33` |
| `*: d. 1` | Derivative | `+:` |
| `*: D. 1` | PartialDeriv | |
| `*:` ` +: D. 1` | AssignDeriv | |
| `1e_8 u D: n y` | SecantSlope of nth derivative | |
| `^ t. 1 2 3` | TaylorCoeff | `1 0.5 0.167` |
| `u` ` v t. n` | AssignTaylor | |
| `^ t: 1 2 3` | ExpTaylor | `1 1 1` |
| `^ T. 3` | TaylorApprox | `1 1 0.5&p.` |
| `m H. n` | HypergeometricSeries | |

## Matrix Operations

| | |
|---|---|
| `%. y` | MatrixInverse |
| `x %. y` | MatrixDivide |
| `x +/ .* y` | MatrixMultiply |
| `-/ .* y` | Determinant |
| `+/ .* y` | Permanent |

## Mathematics

| | | |
|---|---|---|
| `A. 2 0 1` | AnagramIndex | `4` |
| `4 A. 'abc'` | Anagram | `cab` |
| `C. 2 1 0` | PermForm | `1 \| 2 0` |
| `1 \| 2 0 C. 'abc'` | Permute | `cba` |
| `C.!.2 y` | PermParity | `_1 0 1` |
| `p: 3` | YthPrime | `7` |
| `x p: y` | PrimeInfo | various |
| `q: 56` | PrimeFactors | `2 2 2 7` |
| `_ q: 56` | PrimeExps | `3 0 0 1` |
| `__ q: 56` | PrimeFacExp | `2 7`<br>`3 1` |
| `x: 1%3` | Exact | `1r3` |
| `x:^:_1 (1r3)` | Inexact | `0.3333` |
| `2 x: 1r2` | NumDenom | `1 2` |

## Complex Numbers

| | | |
|---|---|---|
| `2x1` | ExpNum | `2*`*`e`*`^1` |
| `1p2` | CircNum | `1*`*`π`*`^2` |
| `+ 3j4` | Conjugate | `3j_4` |
| `+. 3j4` | RealImag | `3 4` |
| `*. 3j4` | LenAngle | `5 0.927` |
| `\| 3j4` | Magnitude | `5` |
| `j. 1j2` | TimesJ | `_2j1` |
| `3 j. 4` | Complex | `3j4` |
| `r. 1r3p1` | Cis (`^j. y`) | `0.5j0.87` |
| `2 r. 1p1` | TimesCis | `_2j0` |

## Selected Foreigns & Miscellaneous

| | |
|---|---|
| `". '2 + 3'` | `5` Execute sentence |
| `u b. y` | Info on `u`: `y=_1` inverse; `0` ranks; `1` identity function |
| `3!:0 y` | Datatype of `y` |
| `3!:1 y` | Binary representation of `y` as coded character string |
| `3!:3 y` | Binary representation of `y` as displayable hex array |
| `x 3!:4 inty`<br>`x 3!:5 floaty` | Numeric/bytestring conversion. `x>0`: convert list `y` to char list, `2^x` (int) or `2^>:x` (float) chars/number. `x<0`: convert char list `y` to numeric list, `2^-x` (int) or `2^1-x` (float) chars/number. `x=0`: 2-byte short to unsigned int |
| `4!:0 <'name'` | Class of `name`, `_1` if undefined |
| `5!:5 <'name'` | String which, if interpreted, creates the value of `name` |
| `6!:0 ''` | Current time Y M D H M S |
| *`x`* `6!:2 'sentence'` | Average execution time of `sentence` over *`x`* samples |
| `7!:2 'sentence'` | Space to execute `sentence` |

`$.` Sparse matrix  `$:` Recursion  `s:` Symbol  `u:` Unicode

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