

January 1981

# APL Reference Card

Order No. AV-K879A-TK

This reference card describes the language elements of two APL interpreters: APL-SF and APL-11.

APL-SF runs on the following operating systems:

- TOPS-10
- TOPS-20

APL-11 runs on the following operating systems:

- RT-11
- RSX-11M
- RSX-11M-PLUS

The color coding identifies the language elements associated with a particular interpreter, as follows:

black — describes language elements applicable to both APL-SF and APL-11

green — describes language elements applicable to APL-SF only

blue — describes language elements applicable to APL-11 only

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To write to ASCII file  
 )CREATE 1 DATA.TXT/FA  
 1⊠.FM DATA  
 )CLOSE 1

ZKT88-81

## THE APL KEYBOARD (LA37 TERMINAL)



## APL CHARACTER SET

### Single-Strike Characters

| APL Set | TTY Set | Name                                    |
|---------|---------|---|
| A-Z     | A-Z     | alphabet                                |
| 0-9     | 0-9     | numbers                                 |
| +       | +       | add                                     |
| ^       | &       | and                                     |
| ←       | —       | assignment<br>(back-arrow or underline) |
| .       | .       | catenate                                |
| :       | :       | colon                                   |
| .       | .       | decimal point                           |
| ÷       | %       | divide                                  |
| \$      | \$      | dollar (format)                         |
| =       | =       | equal to                                |
| \       | \       | expand (scan)                           |
| *       | *       | exponentiate                            |
| >       | >       | greater than                            |
| [       | [       | left bracket                            |
| (       | (       | left parenthesis                        |
| <       | <       | less than                               |
| x       | #       | multiply                                |
| '       | '       | quote string                            |
| ?       | ?       | question (roll and deal)                |
| /       | /       | reduce (compress)                       |
| ]       | ]       | right bracket                           |
| )       | )       | right parenthesis                       |
| ;       | ;       | semicolon                               |
| -       | -       | subtract                                |
| ↑       | ^       | take                                    |
|         | .AB     | residue (ABSolute value)                |
| α       | .AL     | ALpha                                   |
| ⊠       | .BX     | quad (BoX)                              |
| ⌈       | .CE     | CEiling (maximum)                       |
| ↓       | .DA     | drop (Down Arrow)                       |
| ⋄       | .DD     | Dieresis                                |
| ⊥       | .DE     | DEcode                                  |
| ∇       | .DL     | DeL                                     |
| ◇       | .DM     | DiaMond                                 |
| ∩       | .DU     | Down Union                              |
| ⌊       | .EN     | ENcode                                  |
| €       | .EP     | EPsilon                                 |
| ⌋       | .FL     | FLoor                                   |

## Single-Strike Characters (Cont.)

| APL Set | TTY Set | Name                     |
|---------|---------|--------------------------|
| ≥       | .GE     | Greater than or Equal to |
| →       | .GO     | GO to (branch)           |
| ↑       | .IO     | IOta                     |
| ⌊       | .LB     | Left curly Brace         |
| Δ       | .LD     | delta (Lower Del)        |
| ≤       | .LE     | Less than or Equal to    |
| ⌊       | .LK     | Left tack                |
| ○       | .LO     | circle (Large O)         |
| ∪       | .LU     | Left Union               |
| ≠       | .NE     | Not Equal to             |
| ∩       | .NG     | NeGation                 |
| ~       | .NT     | NoT                      |
| ω       | .OM     | OMega                    |
| ∩       | .OR     | OR                       |
| ⌋       | .RB     | Right curly Brace        |
| ⌋       | .RK     | Right tack               |
| ○       | .RO     | RhO                      |
| ∪       | .RU     | Right Union              |
| ◊       | .SO     | jot (Small O)            |
| ⌋       | .US     | UnderScore               |
| ∪       | .UU     | Up Union                 |

## Overstruck Characters

| APL Set | Characters to Strike Over | TTY Set | Name                    |
|---------|---------------------------|---------|-------------------------|
| !       | !                         | !       | factorial (shriek)      |
| ∇       | ∇                         | .GD     | Grade Down              |
| ∇       | ∇                         | .GU     | Grade Up                |
| ⌈       | ⌈                         | .IB     | I-Beam                  |
| ⊙       | ⊙                         | .LG     | LoGarithm               |
| ∞       | ∞                         | .NN     | NaNd                    |
| ∞       | ∞                         | .NR     | NoR                     |
| ∞       | ∞                         | .CB     | Column Backslash        |
| ∞       | ∞                         | .CR     | Column Rotate           |
| /       | /                         | .CS     | Column Slash            |
| ⊘       | ⊘                         | .DQ     | Divide Quad             |
| ⊘       | ⊘                         | .IQ     | Input Quad              |
| ⊘       | ⊘                         | .OQ     | Output Quad             |
| ⊘       | ⊘                         | .OU     | OUT                     |
| ∇       | ∇                         | .PD     | Protected Del           |
| ∇       | ∇                         | .QD     | Quad Del                |
| ∇       | ∇                         | .QQ     | Quote Quad              |
| ∇       | ∇                         | .RV     | ReVersal                |
| ∇       | ∇                         | .TR     | TRanspose               |
| ∇       | ∇                         | .XQ     | eXecute                 |
| ∇       | ∇                         | .FM     | ForMat                  |
| ∇       | ∇                         | "       | Comment (lamp)          |
| ∇       | ∇                         | .ZA-ZZ  | underscored alphabetics |
| ∇       | ∇                         | .Z@     | underscored delta       |
| ∇       | ∇                         | .PT     | file PoinTer            |
| ∇       | ∇                         | .SS     | SubSet                  |
| ∇       | ∇                         | .CO     | COnTains                |

## APL FUNCTIONS AND OPERATORS

### Scalar Functions

| Function | Meaning                             |
|----------|-------------------------------------|
| +Y       | Y                                   |
| -Y       | Negative of Y                       |
| ×Y       | Sign of Y                           |
| +Y       | Reciprocal of Y                     |
| *Y       | e to the Yth power                  |
| Y        | Magnitude of Y                      |
| ⌈Y       | Ceiling of Y                        |
| ⌊Y       | Floor of Y                          |
| ⊙Y       | Natural logarithm of Y              |
| !Y       | Factorial of Y                      |
| ?Y       | A random integer of 1Y              |
| ○Y       | Pi times Y                          |
| X+Y      | Add X to Y                          |
| X-Y      | Subtract Y from X                   |
| X×Y      | Multiply X and Y                    |
| X÷Y      | Divide X by Y                       |
| X*Y      | X to the Yth power                  |
| X Y      | X residue of Y                      |
| X∩Y      | Maximum of X and Y                  |
| X∪Y      | Minimum of X and Y                  |
| X⊙Y      | Log of Y to the base X              |
| X!Y      | Combination of Y things X at a time |

### Dyadic Circle Function

| Expression | Result     | Expression | Result                                 |
|------------|------------|------------|--|
| 00Y        | (1-Y*2)*.5 |            |  |
| 10Y        | sine Y     | -10Y       | arcsin Y                               |
| 20Y        | cosine Y   | -20Y       | arccos Y                               |
| 30Y        | tangent Y  | -30Y       | arctan Y                               |
| 40Y        | (1+Y*2)*.5 | -40Y       | (×Y)×(1-÷Y*2)*.5<br>for Y≠0, 0 for Y=0 |
| 50Y        | sinh Y     | -50Y       | arcsinh Y                              |
| 60Y        | cosh Y     | -60Y       | arccosh Y                              |
| 70Y        | tanh Y     | -70Y       | arctanh Y                              |

### Relational and Logical Functions

| Function | Meaning                      |
|----------|------------------------------|
| X<Y      | X less than Y                |
| X≤Y      | X less than or equal to Y    |
| X=Y      | X equal to Y                 |
| X≥Y      | X greater than or equal to Y |
| X>Y      | X greater than Y             |
| X≠Y      | X not equal to Y             |
| X∧Y      | X and Y                      |
| X∨Y      | X or Y                       |
| X∞Y      | X nand Y (not both X and Y)  |
| X∞Y      | neither X nor Y              |
| ~Y       | not Y                        |

## Mixed Functions

| Function | Meaning   |
|----------|---|
| X,Y      | Catenate X to Y along the last axis of X.   |
| X.[N]Y   | Catenate/laminate X to Y along the Nth axis of X.   |
| X/Y      | X (logical) compression along the last axis of Y.   |
| X/[N]Y   | X (logical) compression along the Nth axis of Y.  |
| X÷Y      | X (logical) compression along the first axis of Y.  |
| X\Y      | X (logical) expansion along the last axis of Y.   |
| X\[N]Y   | X (logical) expansion along the Nth axis of Y.  |
| X∖Y      | X (logical) expansion along the first axis of Y.  |
| X?Y      | Deal X integers selected randomly from 1Y without duplication.  |
| X1Y      | Decode the representation of Y in number system X.  |
| XTY      | Encode Y in number system X.  |
| ΨY       | Generate an index vector such that Y[ΨY] is in descending order.  |
| ΔY       | Generate an index vector such that Y[ΔY] is in ascending order.   |
| 1Y       | Generate the first Y consecutive integers from current origin.  |
| X1Y      | Find the first occurrence of Y in vector X.   |
| .Y       | Return the ravel of Y (make Y a vector).  |
| ρY       | Return the shape of Y.  |
| XρY      | Reshape Y to shape specified by X.  |
| φY       | Reverse along the last axis of Y.   |
| φ[N]Y    | Reverse along the Nth axis of Y.  |
| ⊙Y       | Reverse along the first axis of Y.  |
| XφY      | Rotate by X along the last axis of Y.   |
| Xφ[N]Y   | Rotate by X along the Nth axis of Y.  |
| X⊙Y      | Rotate by X along the first axis of Y.  |
| X+Y      | For X>0, take first X elements of Y; for X<0, take last  X  elements of Y.  |
| X+Y      | For X>0, drop first X elements of Y; for X<0, drop last  X  elements of Y.  |
| ⊙Y       | Transpose the axes of Y (for a matrix, exchange the rows and columns).  |
| X⊙Y      | Permute the axes of Y according to X.   |
| X∈Y      | Determine the membership of X in Y.   |
| ∩Y       | Eliminate the duplicate elements in set Y.  |
| X∪Y      | Determine the union of sets X and Y.  |
| X∩Y      | Determine the intersection of sets X and Y.   |
| X~Y      | Determine the elements in set X that are not in set Y.  |
| X⊂Y      | Determine whether set X is a proper subset of set Y.  |
| X⊆Y      | Determine whether set X is a subset of set Y.   |
| X⊃Y      | Determine whether set X is a strict superset of set Y.  |
| X⊇Y      | Determine whether set X is a superset of set Y.   |
| ⊞Y       | Invert the matrix Y.  |
| X⊞Y      | Perform matrix division, solve linear equations, find a least squares solution.   |
| εY       | Execute the character string Y. If an error occurs, a special error code is returned.   |
| ⌈Y       | Execute the character string Y. Produces normal error messages. Branching permitted.  |
| X\$Y     | Format data in Y with respect to X.   |
| ∇Y       | Format array Y.   |
| X∇Y      | Format array Y with width and precision specified by X.   |
| ⌈Y       | For numeric Y, convert to a character string - for character string Y, if Y is not a variable or function name, return the null vector; if Y is a variable, convert to a character string; if Y is a function, convert to a character string consisting of the lines of Y separated by a carriage return/line feed. |

## Operators

| Function  | Meaning                                   |
|-----------|---|
| X f.g Y   | Inner product                             |
| X o.f Y   | Outer product                             |
| f / Y     | The f reduction along the last axis of Y  |
| f / [N] Y | The f reduction along the Nth axis of Y   |
| f ÷ Y     | The f reduction along the first axis of Y |
| f \ Y     | The f scan along the last axis of Y       |
| f \ [N] Y | The f scan along the Nth axis of Y        |
| f ∖ Y     | The f scan along the first axis of Y      |
| [n]       | Axis for φ, /, \, Δ, Ψ                    |

# APL I/O

## Keyboard I/O Functions

| Function | Meaning                      |
|----------|------------------------------|
| X←□      | Quad (evaluated) input       |
| X←□      | Quote-quad (character) input |
| X←⊞      | Quad-del (unedited) input    |
| □←X      | Quad output                  |
| □←X      | Bare output                  |
| ⊞←X      | Output catenator             |

## File I/O Functions

| Function  | Meaning          |
|---|------------------|
| ⊞ { { [mode] } [record] } channel [header [type [length]]]      | File input       |
| channel ⊞ [ [type] ] N  |                  |
| data ⊞ { { [mode] } [record] } channel [header [type [length]]] | File output      |
| channel ⊞ [ [type] ] data                                       |                  |
| channel ⊞ [ [type] ] N  | Set file pointer |

## File System Functions

| Function  | Meaning  |
|---|--|
| data ⊞ APPEND channel [header [type [length]]]                  | Allows you to write after the end-of-file.   |
| ⊞ ASS [channel] filespec [password] [/fileorg] [/SHARE] [/DUMP] | Assigns a file on the specified channel number.  |
| ⊞ CHS channel(s)  | Returns the file organization and the open status of the files on one or more channels.                                    |
| ⊞ CIQ [header [type]]   | Unpacks data accumulated for storage with ⊞ COQ.   |
| ⊞ CLS channel(s) data ⊞ COQ                                     | Closes the files on one or more channels. Packs data of different types into a variable for storage as one logical record. |
| ⊞ DAS channel(s)  | Deassigns the files on one or more channels.   |
| ⊞ DEQ channel [lock number]                                     | Synchronizes shared access to multiple-user files by releasing the locked file.  |
| ⊞ DVC channel(s)  | Returns device characteristics word and blocksize for one or more files.   |
| ⊞ ENQ channel [lock number] [share bit]                         | Synchronizes shared access to multiple-user files by issuing a request to enqueue on a lock pair.                          |
| ⊞ FCM channel   | Returns information about the records in a direct-access file.   |
| ⊞ FLS channel(s)  | Returns the sharing status and other information about files on one or more channels.                                      |
| channel ⊞ MTP operations  | Performs several magnetic tape operations including rewinding, setting density, and returning data mode.                   |
| filespec ⊞ RENAME channel                                       | Renames a currently assigned file.   |

# I/O Arguments

| Argument              | Meaning  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
|-----------------------|--|-----------|---|--------|---------|------|------------|-----------------------|--------------------|------|------------------|------------|-------------------------------------|-----------|---------------------------|---------|---------------------|------|------|---|--|-----|------|--|-------------------------------|-----|------|--|------------------------------------|-----|------|--|------------------------------|------|------|--|----------------------------------|-----|------|--|---|
| channel               | An integer in range 1 to 12 inclusive specifying the channel on which the file being referenced is assigned.   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| data                  | The value to be input or output by the I/O function.   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| filespec              | A standard filespec in the following format:<br>For TOPS-10 and TOPS-20:<br>device:name.extension<protection>[directory]<br>For RT-11:<br>device:name.extension[size]<br>For RSX-11M and RSX-11M-PLUS:<br>device:[directory]name.extension;version<br>All fields except the name itself are optional. If you include the protection, enclose it in angle brackets. If you include the size or directory, enclose it in square brackets. Names are a maximum of six letters and/or numbers. An extension consists of a period or comma followed by a maximum of three letters and/or numbers. Defaults are the following:<br><table border="1"> <thead> <tr> <th>Component</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>device</td> <td>DSK:</td> </tr> <tr> <td>name</td> <td>No default</td> </tr> <tr> <td>extension (file type)</td> <td>File-org dependent</td> </tr> <tr> <td>size</td> <td>Size of the file</td> </tr> <tr> <td>protection</td> <td>Installation-dependent</td> </tr> <tr> <td>directory</td> <td>Current default directory</td> </tr> <tr> <td>version</td> <td>Current version</td> </tr> </tbody> </table> | Component | Meaning   | device | DSK:    | name | No default | extension (file type) | File-org dependent | size | Size of the file | protection | Installation-dependent              | directory | Current default directory | version | Current version     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| Component             | Meaning  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| device                | DSK:   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| name                  | No default   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| extension (file type) | File-org dependent   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| size                  | Size of the file   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| protection            | Installation-dependent   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| directory             | Current default directory  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| version               | Current version  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| fileorg               | One of the following:<br><table border="1"> <thead> <tr> <th>Switch</th> <th>Default</th> <th>Ext</th> <th>Meaning</th> </tr> </thead> <tbody> <tr> <td>/AS</td> <td>.AAS</td> <td></td> <td>ASCII sequential</td> </tr> <tr> <td>/AS*</td> <td>.AAS</td> <td></td> <td>ASCII sequential; opened for append</td> </tr> <tr> <td>/IS</td> <td>.AIS</td> <td></td> <td>Internal sequential</td> </tr> <tr> <td>/IS*</td> <td>.AIS</td> <td></td> <td>Internal sequential; opened for append</td> </tr> <tr> <td>/DA</td> <td>.ADA</td> <td></td> <td>Direct-access; read and write</td> </tr> <tr> <td>/DI</td> <td>.ADA</td> <td></td> <td>Direct-access; read only (default)</td> </tr> <tr> <td>/BS</td> <td>.ABI</td> <td></td> <td>Binary-access; read or write</td> </tr> <tr> <td>/BS*</td> <td>.ABI</td> <td></td> <td>Binary-access; opened for append</td> </tr> <tr> <td>/BU</td> <td>.ABI</td> <td></td> <td>Binary-access; read and write; one user at a time</td> </tr> </tbody> </table>  | Switch    | Default   | Ext    | Meaning | /AS  | .AAS       |                       | ASCII sequential   | /AS* | .AAS             |            | ASCII sequential; opened for append | /IS       | .AIS                      |         | Internal sequential | /IS* | .AIS |   | Internal sequential; opened for append | /DA | .ADA |  | Direct-access; read and write | /DI | .ADA |  | Direct-access; read only (default) | /BS | .ABI |  | Binary-access; read or write | /BS* | .ABI |  | Binary-access; opened for append | /BU | .ABI |  | Binary-access; read and write; one user at a time |
| Switch                | Default  | Ext       | Meaning   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /AS                   | .AAS   |           | ASCII sequential                                  |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /AS*                  | .AAS   |           | ASCII sequential; opened for append               |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /IS                   | .AIS   |           | Internal sequential                               |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /IS*                  | .AIS   |           | Internal sequential; opened for append            |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /DA                   | .ADA   |           | Direct-access; read and write                     |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /DI                   | .ADA   |           | Direct-access; read only (default)                |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /BS                   | .ABI   |           | Binary-access; read or write                      |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /BS*                  | .ABI   |           | Binary-access; opened for append                  |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| /BU                   | .ABI   |           | Binary-access; read and write; one user at a time |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| header                | A specification indicating whether or not a header is included to indicate the type and number of values in the input or output; 1 is the default and indicates a header; 0 indicates no header.   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| length                | The number of values to be written in one operation.   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| lock number           | A number in range 0 through 1-2*33 used to synchronize shared file access by multiple users.   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| mode                  | Mode of input or output (ASCII sequential file). Can be:<br><table border="1"> <thead> <tr> <th>Type</th> <th>Char Set</th> <th>Mode</th> </tr> </thead> <tbody> <tr> <td>□</td> <td>TTY</td> <td>1</td> </tr> <tr> <td>⊞</td> <td>TTY</td> <td>2</td> </tr> <tr> <td>⊞</td> <td>TTY</td> <td>3</td> </tr> <tr> <td>□</td> <td>APL</td> <td>4</td> </tr> <tr> <td>⊞</td> <td>APL</td> <td>5</td> </tr> <tr> <td>⊞</td> <td>APL</td> <td>6</td> </tr> </tbody> </table>   | Type      | Char Set  | Mode   | □       | TTY  | 1          | ⊞                     | TTY                | 2    | ⊞                | TTY        | 3                                   | □         | APL                       | 4       | ⊞                   | APL  | 5    | ⊞ | APL                                    | 6   |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| Type                  | Char Set   | Mode      |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| □                     | TTY  | 1         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| ⊞                     | TTY  | 2         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| ⊞                     | TTY  | 3         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| □                     | APL  | 4         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| ⊞                     | APL  | 5         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| ⊞                     | APL  | 6         |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| N                     | The file byte or value referenced by the pointer, or the number of values to be read.  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| operations            | A vector containing codes indicating particular magnetic tape operations; identical to the meaning of codes used by the TAPOP UUU on TOPS-10.  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| password              | Up to eight characters preceded by a hyphen (-). The null and default password is the hyphen.  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| record                | Record to be read or written (direct-access file).   |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |
| share bit             | A specification indicating whether or not a user is willing to share access to a lock on a file; 1 indicates that sharing is desired; 0 is the default and indicates exclusive use of the lock.  |           |   |        |         |      |            |                       |                    |      |                  |            |                                     |           |                           |         |                     |      |      |   |  |     |      |  |                               |     |      |  |                                    |     |      |  |                              |      |      |  |                                  |     |      |  |   |

# I/O Arguments (Cont.)

| Argument | Meaning  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
|----------|--|-------|------|---|----------------------|---|-----------------------|---|--|---|---|---|------------------------|---|--------------------|---|------------------|---|------|---|---------|---|--------------|---|---------------------------------|---|---------------------------------|
| type     | Type of value to be input or output; one of the following:<br><table border="1"> <thead> <tr> <th>Value</th> <th>Type</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Integer (1 per word)</td> </tr> <tr> <td>2</td> <td>Boolean (36 per word)</td> </tr> <tr> <td>3</td> <td>Single-precision floating-point (1 per word)</td> </tr> <tr> <td>4</td> <td>Double-precision floating-point (2 words per)</td> </tr> <tr> <td>5</td> <td>APL 9-bit (4 per word)</td> </tr> <tr> <td>6</td> <td>ASCII (5 per word)</td> </tr> <tr> <td>0</td> <td>ASCII sequential</td> </tr> <tr> <td>1</td> <td>Byte</td> </tr> <tr> <td>2</td> <td>Integer</td> </tr> <tr> <td>3</td> <td>APL internal</td> </tr> <tr> <td>4</td> <td>Single-precision floating-point</td> </tr> <tr> <td>5</td> <td>Double-precision floating-point</td> </tr> </tbody> </table> | Value | Type | 1 | Integer (1 per word) | 2 | Boolean (36 per word) | 3 | Single-precision floating-point (1 per word) | 4 | Double-precision floating-point (2 words per) | 5 | APL 9-bit (4 per word) | 6 | ASCII (5 per word) | 0 | ASCII sequential | 1 | Byte | 2 | Integer | 3 | APL internal | 4 | Single-precision floating-point | 5 | Double-precision floating-point |
| Value    | Type   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 1        | Integer (1 per word)   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 2        | Boolean (36 per word)  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 3        | Single-precision floating-point (1 per word)   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 4        | Double-precision floating-point (2 words per)  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 5        | APL 9-bit (4 per word)   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 6        | ASCII (5 per word)   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 0        | ASCII sequential   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 1        | Byte   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 2        | Integer  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 3        | APL internal   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 4        | Single-precision floating-point  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| 5        | Double-precision floating-point  |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |
| word     | Word to be read or written (binary-access file).   |       |      |   |                      |   |                       |   |  |   |   |   |                        |   |                    |   |                  |   |      |   |         |   |              |   |                                 |   |                                 |

## FORMAT FUNCTION

The format function is used with the following syntax:

FMT \$ (V;V2;...VN)

or

FMT \$ V

where

V can be any variable or expression.

FMT must be a character vector containing one or more format fields chosen from the following list:

| Format      | Meaning  |
|-------------|--|
| 'mAw'       | Character data; cannot be used with numeric values |
| 'mEw.d'     | Floating-point numeric data with exponent          |
| 'mqFw.d'    | Fixed-point numeric data                           |
| 'mqIw'      | Integer numeric data with automatic rounding       |
| 'mXw'       | Blanks inserted in edited line                     |
| 'm[]text[]' | Literal text inserted in edited line               |

where

m is the optional repetition factor.

w is the field width.

d is the number of decimal positions.

q is any number of qualifiers chosen from the following list:

| Qualifier | Meaning                                 |
|-----------|---|
| B         | Blank field if value is 0               |
| C         | Insert commas                           |
| L         | Left-justify                            |
| Z         | Zero-fill                               |
| M[]text[] | Insert text left of negative result     |
| M[]text[] | Insert text right of negative result    |
| P[]text[] | Insert text left of nonnegative result  |
| Q[]text[] | Insert text right of nonnegative result |
| R[]text[] | Insert text in background               |

You must separate format fields with commas. Up to 18 significant digits can be specified.

The symbol A can be used instead of [].

## System Variables

| Variable                | Meaning   |
|-------------------------|---|
| <b>Can be reset:</b>    |   |
| <code>␣AUS</code>       | Periodically backs up active workspace if equal to 1.   |
| <code>␣CT</code>        | Degree of tolerance or relative fuzz applied in comparisons. Must be in range 0 through 1E-8(.38).        |
| <code>␣ERROR</code>     | Three-line character vector describing last error that occurred.  |
| <code>␣GAG</code>       | Indicates whether messages sent from other users are accepted or refused. 1 means refuse; 0 means accept. |
| <code>␣IO</code>        | Index origin for arrays; must be 0 or 1.  |
| <code>␣LX</code>        | Expression executed automatically when workspace is loaded.   |
| <code>␣PP</code>        | Precision of non-integer output; range integers 1 through 18(16).   |
| <code>␣PW</code>        | Maximum number of characters in output line; range is integers 30 through 390.                            |
| <code>␣RL</code>        | Link in chain of random numbers used in roll and deal functions; range is 0 through 1+2*35(1+2*15).       |
| <code>␣SF</code>        | Prompt for evaluated input.   |
| <code>␣TIMELIMIT</code> | Limit on time to respond to quote-quad input requests.  |
| <code>␣TRAP</code>      | Expression executed when error occurs.  |

### Cannot be reset (retain system-specified values):

|                       |  |
|-----------------------|--|
| <code>␣AI</code>      | Account information on current APL session. Includes user identification; and CPU, connect, and keying time. |
| <code>␣ALPHA</code>   | Vector of 27 characters: $\Delta$ and A through Z.   |
| <code>␣ALPHAU</code>  | Vector of 27 underlined characters: $\underline{\Delta}$ and $\underline{A}$ through $\underline{Z}$ .       |
| <code>␣ASCII</code>   | Vector of 128 ASCII characters.  |
| <code>␣AV</code>      | Vector of all APL characters.  |
| <code>␣CTRL</code>    | Vector of 32 control characters.   |
| <code>␣LC</code>      | Vector of line numbers in workspace state indicator. Most recently suspended function appears first.         |
| <code>␣NUM</code>     | Vector of 10 digits 0 through 9.   |
| <code>␣TIMEOUT</code> | Equals 1 if user ran out of time during quote-quad input request; otherwise, equals 0.                       |
| <code>␣TS</code>      | Current date and time in base 10 format.   |
| <code>␣TT</code>      | Type of terminal being used in current APL session. 0 means TTY, >0 means APL.                               |
| <code>␣UL</code>      | System job number (base 10) associated with current APL session.   |
| <code>␣WA</code>      | Maximum amount in bytes that the active workspace can increase.  |

## System Functions

| Function             | Meaning  |          |      |   |        |   |           |   |           |
|----------------------|--|----------|------|---|--------|---|-----------|---|-----------|
| <code>␣BREAK</code>  | Suspends function execution and returns control to immediate mode.   |          |      |   |        |   |           |   |           |
| <code>␣CR</code>     | Returns a canonical representation of a defined function whose name is the character string specified.   |          |      |   |        |   |           |   |           |
| <code>␣DL</code>     | Delays execution of the function in which it is included by number of seconds specified.   |          |      |   |        |   |           |   |           |
| <code>␣EX</code>     | Expunges an existing use of a name in the workspace.   |          |      |   |        |   |           |   |           |
| <code>␣FI</code>     | Converts character argument to numeric, placing zeroes in each position not corresponding to a valid number.   |          |      |   |        |   |           |   |           |
| <code>␣FX</code>     | Reverses the operation of the <code>␣CR</code> system function.  |          |      |   |        |   |           |   |           |
| <code>␣NC</code>     | Returns the classification of one or more names.   |          |      |   |        |   |           |   |           |
| <code>␣NL</code>     | Constructs a list of named objects residing in the active workspace.   |          |      |   |        |   |           |   |           |
|                      | <table border="1"> <thead> <tr> <th>Argument</th> <th>List</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>labels</td> </tr> <tr> <td>2</td> <td>variables</td> </tr> <tr> <td>3</td> <td>functions</td> </tr> </tbody> </table> | Argument | List | 1 | labels | 2 | variables | 3 | functions |
| Argument             | List   |          |      |   |        |   |           |   |           |
| 1                    | labels   |          |      |   |        |   |           |   |           |
| 2                    | variables  |          |      |   |        |   |           |   |           |
| 3                    | functions  |          |      |   |        |   |           |   |           |
| <code>␣QCO</code>    | Copies a workspace.  |          |      |   |        |   |           |   |           |
| <code>␣QLD</code>    | Loads a workspace.   |          |      |   |        |   |           |   |           |
| <code>␣QPC</code>    | Copies a workspace with certain protection.  |          |      |   |        |   |           |   |           |
| <code>␣SIGNAL</code> | Passes an error up the stack one level to the caller of the function in error.   |          |      |   |        |   |           |   |           |
| <code>␣VI</code>     | Returns logical vector of where valid numbers are in <code>␣FI</code> of argument.   |          |      |   |        |   |           |   |           |

## SYSTEM COMMANDS

| Command   | Meaning   |
|---|---|
| <code>)ASSIGN channel filespec</code>   | Assigns existing file on channel.   |
| <code>)BLOT [n]</code>  | Conceals confidential input by generating mask in random pattern of length n. The default for n is 25.  |
| <code>)CALL [n] file-spec</code>  | Saves active workspace in CONTIN.APL and runs program specified. The program is run from DSK: by default.   |
| <code>)CHARGE</code>  | Displays installation-dependent information about the current APL session.  |
| <code>)CLEAR</code>   | Replaces active workspace with clear workspace.   |
| <code>)CLOSE channel</code>   | Closes file on channel.   |
| <code>)CONTINUE [HOLD]</code>   | Saves active workspace as the continue workspace and exits from APL. If HOLD is omitted, job is logged off the system.  |
| <code>)COPY wsname [password] [named-object-list]</code>                        | Copies objects in named-object-list from wsname to current workspace. If list is omitted, all variables, functions, and groups are copied.  |
| <code>)CREATE file-size [channel] file-spec [password] [blocking factor]</code> | Creates direct-access file and specifies its password, blocking factor, and number of records. Creates and allocates space for new file. If channel is specified, file remains open; otherwise, file is created and closed. |
| <code>)DIGITS [n]</code>  | Displays or changes the number of significant digits. Maximum value is 18(16); default is 10.   |
| <code>)DROP wsname</code>   | Deletes workspace wsname from your disk area.   |
| <code>)ECHO [{ON}][OFF]</code>  | Starts or stops display of error lines. Default is ON.  |
| <code>)ERASE name-list</code>   | Erases the named global objects from the current workspace.   |
| <code>)FNS [letter]</code>  | Displays alphabetic list of function names in workspace.  |
| <code>)GROUP group-name [group-member-list]</code>                              | Collects named objects in group-member-list into group-name.  |
| <code>)GRP group-name</code>  | Lists members of group-name.  |
| <code>)GRPS [letter]</code>   | Displays alphabetic list of group-names.  |
| <code>)INPUT [file-spec] [/character set]</code>                                | Makes file-spec source of terminal input. Character set is APL or TTY.  |
| <code>)LIB [wsname] [switch-list]</code>  | Displays names of workspaces. If you omit wsname, all workspaces in your disk area are listed.  |
| <code>)LOAD wsname [password]</code>  | Retrieves a workspace from secondary storage.   |
| <code>)MAXCORE [{P-of-memory}][K-of-memory]</code>                              | Displays or changes setting for maximum workspace size. Maximum for K is smaller of 176K words or system limit. Maximum for P is 352P. Defaults are 20K, 40P.   |
| <code>)MINCORE [{P-of-memory}][K-of-memory]</code>                              | Displays or changes setting for minimum workspace size. Minimum and default are 0.  |
| <code>)MON</code>   | Returns you to operating system command level. You can subsequently return to APL by typing CONTINUE command.   |
| <code>)OFF [HOLD]</code>  | Ends current APL session. If HOLD is omitted, job is logged off the system.   |
| <code>)ORIGIN [n]</code>  | Displays or changes the index origin; n can be 0 or 1.  |
| <code>)OUTPUT [file-spec] [/character set]</code>                               | Makes file-spec the destination for terminal output. Character set is APL or TTY.   |
| <code>)OWNER</code>   | Displays directory of user who created currently active workspace, and the creation date and terminal on which the workspace was created.   |

## SYSTEM COMMANDS (Cont.)

| Command   | Meaning   |
|---|---|
| <code>)PASSWORD [password]</code>                         | Displays or changes password of the active workspace.   |
| <code>)PCOPY wsname [password] [named-object-list]</code> | Same as <code>)COPY</code> but protects names already in use in active workspace.                                 |
| <code>)RUN [n] file-spec</code>                           | Ends current APL session and runs the specified program. The program is run from DSK: by default.                 |
| <code>)SAVE [wsname] [password]</code>                    | Saves a copy of the active workspace on secondary storage.  |
| <code>)SEAL [{ON}][OFF]</code>                            | Displays or changes the setting of the workspace seal. The default is OFF.  |
| <code>)SI</code>  | Displays the workspace state indicator which reports function execution progress.                                 |
| <code>)SIV</code>   | Displays the workspace state indicator, along with local variable names at each level.                            |
| <code>)SIZE</code>  | Displays the size of the active workspace.  |
| <code>)TABS [n]</code>                                    | Displays or changes the increment between tab settings for APL output.  |
| <code>)TIME</code>  | Displays connect and CPU time accumulated while current workspace has been active.                                |
| <code>)VARS [letter]</code>                               | Displays an alphabetic list of global variables.  |
| <code>)VERSION</code>                                     | Displays the APL version number with which the active workspace was saved.  |
| <code>)WIDTH [n]</code>                                   | Displays or changes the terminal line width; range is integers from 30 through 390.                               |
| <code>)WSID [wsname] [password]</code>                    | Displays or changes the name of the active workspace. Optionally changes but does not display workspace password. |

## FUNCTION EDITING

| Format                       | Meaning   |
|------------------------------|---|
| <code>∇ function-name</code> | Open function for editing.  |
| <code>∇</code>               | End function editing.   |
| <code>[n]</code>             | Define or change line n.  |
| <code>[Δ n]</code>           | Delete line n.  |
| <code>[n□]</code>            | Display line n.   |
| <code>[□n]</code>            | Display all lines, beginning with line n.   |
| <code>[□]</code>             | Display all lines of function.  |
| <code>[m□n]</code>           | Edit line m; begin at character position n. In immediate mode, opens last executed line for character editing, for any m. |
| <code>/</code>               | In character editing, type beneath each character you want to delete.   |
| <code>n</code>               | In character editing, inserts n spaces before current character.  |
| <code>letter</code>          | In character editing, inserts multiple of five spaces — A inserts 5 spaces, B inserts 10 spaces, and so on.               |

Note that the header is line number 0.