SYSTEM COMMANDS

FUNCTION	COMMAND			RESPONSE		TROUBLE REPORTS
Terminal Control Commands						
Sign-on designated user and start work session.	)123846		[:PASSWORD]	Port, time, date, user; system; time, date		1 2 3 4 5 7 8
End a work session.	)OFF		[:NEWPASSWORD]	Port, time, date, user code; time used		16
End work session and hold dial-up connection.	)OFF HOLD		[:NEWPASSWORD]	Port, time, date, user code; time used		16
End work session and store active workspace.	)CONTINUE		[:NEWPASSWORD]	Time, date,		6 16
				Port, time, date, user code; time used		
End work session, store active workspace, and hold dial-up connection.	)CONTINUE HOLD		[:NEWPASSWORD]	Time, date,		6 16
				Port, time, date, user code; time used		

FUNCTION	COMMAND		RESPONSE	TROUBLE REPORTS
Communication Commands				
Send message to designated port.	)MSGN	PORT (TEXT)	SENT	15 16
Send message to designated port and lock keyboard for reply.	)MSG	PORT (TEXT)	SENT	15 16
Send message to APL Operator.	)OPRN	(TEXT)	SENT	15 16
Send message to APL Operator and lock keyboard for reply.	)OPR	(TEXT)	SENT	15 16

FUNCTION	COMMAND			RESPONSE		TROUBLE REPORTS
Workspace Control Commands						
Activate a clear workspace.	)CLEAR			CLEAR WS	Time, Date	16
Replace active workspace with a copy of a stored WS.	)LOAD	WSID			Time, Date	7 8 16
Copy an individual function or variable from a stored WS.	)COPY	WSID	NAME	SAVED,	Time, Date	6 7 8 9 10 16
Copy all functions and variables from a stored workspace.	)COPY	WSID		SAVED,	Time, Date	6 7 8 10 16
Copy an individual function or variable from a stored WS protecting the active workspace.	)PCOPY	WSID	NAME	SAVED,	Time, Date	6 7 8 9 10 16
Copy all functions and variables from a stored workspace protecting the active workspace.	)PCOPY	WSID		SAVED,	Time, Date	6 7 8 10 16
Gather functions and variables into a group; first name is name of group.	)GROUP	NAME(S)		NONE		10 11 16
Erase functions and variables.	)ERASE	NAME(S)		[NOT ERASED,	List of names]	10 16
Set index origin.	)ORIGIN	0 or 1		WAS,	Former origin	16
Set maximum number of significant digits for output.	)DIGITS	1 to 16		WAS,	Former maximum	16
Set size of symbol table in clear workspace.	)SYMBOLS	Positive integer (min. 26)		WAS,	Former size	16
Set maximum width for an output line.	)WIDTH	30 to 130		WAS,	Former width	16
Change Workspace name.	)WSID	Name		WAS,	Former WSID	16
Re-store a copy of the active workspace.	)SAVE				Time, date, WSID	6 12 13 14 16
Store a copy of the active workspace.	)SAVE	WSID		WAS,	Time, date	6 12 13 14 16
Erase a stored workspace from a library.	)DROP	WSID		WAS,	Time, date	7 14 16

| FUNCTION	COMMAND		RESPONSE	TROUBLE REPORTS
Information Requests				
List names of defined functions.	)FNS		Function names	16
List names of global variables.	)VARS		Variable names	16
List names of groups.	)GRPS		Group names	16
List membership of designated group.	)GRP	NAME	Function names, variable names	16
List halted functions (state indicator).	)SI		Sequence of halted functions	16
List halted functions and associated local variables.	)SIV		Sequence of halted function with names of local variables	16
Give identification of Active workspace.	)WSID		WSID	16
List name of workspaces in designated library (either user's library or a public library).	)LIB	[NUMBER]	Names of stored workspaces	14 16
List ports in use and codes of connected users.	)PORTS		Port numbers and associated user codes	16
List port numbers associated with designated user code.	)PORT	CODE	Port numbers	16

TABLE 5

1	NUMBER NOT IN SYSTEM	7	WS NOT FOUND	12	NOT SAVED, QUOTA USED UP
2	INCORRECT SIGN-ON	8	WS LOCKED	13	NOT SAVED, THIS WS IS ...
3	ALREADY SIGNED-ON	9	OBJECT NOT FOUND	14	IMPROPER LIBRARY REFERENCE
4	NUMBER IN USE	10	WS FULL	15	MESSAGE LOST
5	NUMBER LOCKED OUT	11	NOT GROUPED, NAME IN USE	16	INCORRECT COMMAND
6	NOT WITH OPEN DEFINITION				

APL

IBM World Trade

APL Reference Data

APL\360 is a conversational time-sharing system based on a mathematical programming language first defined by Kenneth E. Iverson. The language is concise and has a simple syntax. It has a large set of primitive operations which work directly on arrays. The implementation provides a simple immediate-execution mode and a convenient program definition facility. It has fast response, and uses succinct diagnostic messages. It provides the ability to save work between sessions, to create programming packages, and to exchange programs and data between users. Uses of the system include mathematical and statistical calculation, symbol manipulation, and general data processing. It has been used extensively in computer-aided instruction, and in the design of hardware and software.
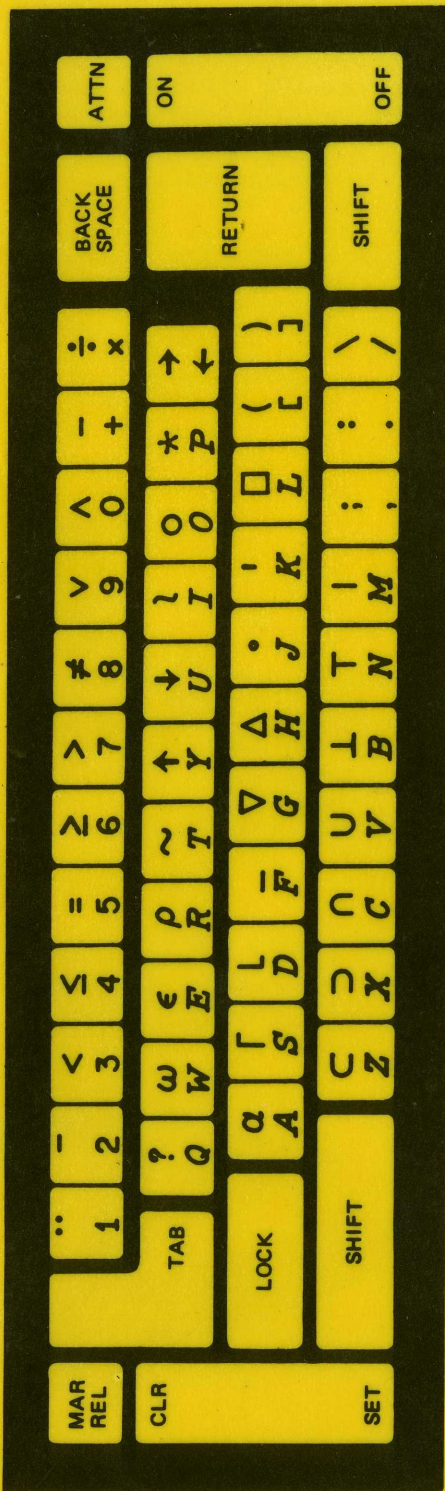
APL REFERENCE DATA

Scalar Dyadic Functions

$X+Y$	X plus Y
$X-Y$	X minus Y
$X\times Y$	X times Y
$X\div Y$	X divided by Y
$X*Y$	X to the Y-th power
$X\lceil Y$	maximum of X and Y
$X\lfloor Y$	minimum of X and Y
$X\mid Y$	X-residue of Y (see Table 4)
$X\circledast Y$	base-X logarithm of Y
$X!Y$	binomial coefficient; for integer X and Y, the number of combinations of Y things taken X at a time
$X\circ Y$	circular and hyperbolic functions and their inverses (Y is in radians) (see Table 1)
$X<Y$	X less than Y
$X\leq Y$	X less than or equal to Y
$X=Y$	X equal to Y
$X\geq Y$	X greater than or equal to Y
$X>Y$	X greater than Y
$X\neq Y$	X not equal to Y
$X\wedge Y$	X and Y
$X\vee Y$	X or Y
$X\barwedge Y$	not both X and Y (X nand Y)
$X\veebar Y$	neither X nor Y

result is 1 if the relation holds, 0 if it does not

$0\circ Y$	$(1-Y*2)*.5$	$4\circ Y$ $(1+Y*2)*.5$
$1\circ Y$	sin Y	$5\circ Y$ sinh Y
$2\circ Y$	cos Y	$6\circ Y$ cosh Y
$3\circ Y$	tan Y	$7\circ Y$ tanh Y

inverse functions are given by negative values of X, i.e. $^-1\circ Y \equiv$ arcsin Y.

Table 1

Scalar Monadic Functions

$+Y$	Y
$-Y$	0 - Y
$\times Y$	sign of Y (-1, 0, 1)
$\div Y$	reciprocal of Y
$*Y$	e to the Y-th power
$\lceil Y$	ceiling of Y
$\lfloor Y$	floor of Y } (See Table 3)
$\mid Y$	magnitude of Y
$\circledast Y$	natural logarithm of Y
$!Y$	factorial Y; Gamma function of Y + 1
$\circ Y$	π times Y
$?Y$	a random integer from the vector ιY
$\sim Y$	not Y

Table 2

X	Y	X∧Y	X∨Y	X⊼Y	X⊽Y
0	0	0	0	1	1
0	1	0	1	1	0
1	0	0	1	1	0
1	1	1	1	0	0

Table 3

Y	$\lceil Y$	$\lfloor Y$
-3.14	-4	-3
-3.14	-3	-4

Table 4

	X | Y
$X\neq 0$	$Y-X\times\lfloor Y\div X$
$X=0$	Y

Special Symbols

( ) Parentheses. Expressions may be of any complexity and are executed from right to left except as indicated by parentheses.

$\rightarrow X$ Branch to X, where X is a scalar or vector. If X is an empty vector, go to the next line in sequence. If X is not in the range of statement numbers in the function, leave the function.

$\rightarrow$ Terminate execution of a suspended function.

$\square\leftarrow X$ Print the value of X. The value of any expression or variable is also printed if no assignment is made.

$X\leftarrow\square$ Request input. Value of $\square$ is the resulting value after expression entered is evaluated.

$X\leftarrow\boxed{\square}$ Request input. Value of $\boxed{\square}$ is entire input text as literal characters, up to but not including carrier return.

$'XYZ'$ The literal characters XYZ.

_ Underline: Allows increased set of alphabetic characters, i.e., A and A̲ are both distinct characters.

Mixed Functions

$X\rho Y$	Reshape Y to have dimension X
ρY	Dimension of Y
$X[Y]$	The elements of X at locations Y
$X\iota Y$	First location of Y within vector X
ιY	The first Y consecutive integers from Origin (0 or 1 as set by set origin command)
$X\epsilon Y$	Each element of $X\epsilon Y$ is 1 or 0 if the corresponding element of X is or is not some element of Y
$X\top Y$	Representation of Y in number system X
$X\bot Y$	Value of the representation of Y in number system X
$X?Y$	X integers selected randomly without repetition from ιY
$X\phi Y$	Rotation by X along the last dimension of Y
$X\phi[Z]Y$	Rotation by X along the Zth dimension of Y
$X\ominus Y$	Rotation by X along the first dimension of Y
ϕY	Reversal along the last dimension of Y
$\phi[Z]Y$	Reversal along the Zth dimension of Y
$\ominus Y$	Reversal along the first dimension of Y
$X\Phi Y$	Transpose by X of the coordinates of Y
ΦY	Ordinary transpose of Y
X,Y	Y catenated to X
$,Y$	Ravel of Y (make Y a vector)
$X\uparrow Y$	If X positive take first X elements of Y; If X negative take last |X| elements of Y
$X\downarrow Y$	If X positive leave first X elements of Y; If X negative leave last |X| elements of Y
$X\leftarrow Y$	X specified by Y
ΔX	The indices of values of the vector X in sorted ascending order
∇X	The indices of values of the vector X in sorted descending order
$\circ$	Null
∇	See Program Definition Section
$\cap$	Comment

In the entries below $\circ$ stands for "any scalar dyadic operator"

Generalized Reduction

i.e., insert the symbol $\circ$ between each pair of elements of Y

$\circ/Y$	The $\circ$ reduction along the last dimension of Y
$\circ/[Z]Y$	The $\circ$ reduction along the Zth dimension of Y
$\circ\not Y$	The $\circ$ reduction along the first dimension of Y

Compression and Expansion

X/Y	X (logical) compressing along the last dimension of Y
$X/[Z]Y$	X (logical) compressing along the Zth dimension of Y
$X\not Y$	X (logical) compressing along the first dimension of Y
$X\backslash Y$	X (logical) expanding along the last dimension of Y
$X\backslash[Z]Y$	X (logical) expanding along the Zth dimension of Y
$X\backslash Y$	X (logical) expanding along the first dimension of Y

Generalized Matrix Operations

$X+.\times Y$	Ordinary matrix product of X and Y
$X\circ.\circ Y$	Generalized inner product of X and Y
$X\circ.\circ Y$	Generalized outer product of X and Y

All scalar functions are extended to operate element-by-element on dimensioned operands; i.e., vectors, matrixes, and higher-dimensional arrays.

A scalar or one-component vector may be used as one argument of a scalar dyadic function and will be extended to conform to the dimension of the other argument.

Overstruck Symbols

$\circledast \barwedge \veebar \circledcirc \mathrm{I} ! \nabla \Delta \Phi \square \cap \not \leftarrow \ominus$

$\underline{A}\ \underline{B}\ \underline{C}\ \underline{D}\ \underline{E}\ \underline{F}\ \underline{G}\ \underline{H}\ \underline{I}\ \underline{J}\ \underline{K}\ \underline{L}\ \underline{M}$
$\underline{N}\ \underline{O}\ \underline{P}\ \underline{Q}\ \underline{R}\ \underline{S}\ \underline{T}\ \underline{U}\ \underline{V}\ \underline{W}\ \underline{X}\ \underline{Y}\ \underline{Z}$

Definition Mode

A ∇ (called 'Del') preceding a function name declares a change from execution mode to function definition mode. In definition mode, no execution of commands occurs, and no errors other than character errors, editing errors, and label errors are reported. Instead, each command is stored as part of the definition. A ∇ terminates function definition.

```
     ∇T←Q HYP P
[1]    T←((Q*2)+P*2)*0.5∇
     3 HYP 4
5
```
dyadic function with explicit result

```
     ∇Z←AVG Y
[1]    Z←(+/Y)÷ρY∇
     AVG 2 4 9 3
4.5
```
monadic function with explicit result

```
     ∇Z←RAN
[1]    Z←?5ρ25∇
     RAN
4 19 12 14 6
```
niladic function with explicit result

```
     ∇A HYP B
[1]    T←((A*2)+B*2)*0.5∇
     3 HYP 4
     T
5
```
dyadic function without explicit result

```
     ∇AVG N;A
[1]    A←(+/N)÷ρN
[2]    'AVERAGE IS: ';A∇
     AVG 2 4 9 3
AVERAGE IS: 4.5
```
monadic function without explicit result; a local variable A is defined in the header

```
     ∇DRILL
[1]    'DO THESE PROBLEMS'
[2]    '...'
[3]    '...'∇
     DRILL
DO THESE PROBLEMS
...
...
```
niladic function without explicit result

A function body may be displayed in definition mode:

$[N\square]$ Display line N: if N is omitted, display entire function. Mode may be entered, function F displayed, and mode left, by typing $\nabla F[\square]\nabla$.

$[\square N]$ Display from line N to the end of the function.

$[N\square P]$ Display line N and position the printing element under position P (for editing line N).

Trace and Stop Controls

$S\Delta PROG\leftarrow N$ Halts execution of PROG immediately before line N is executed.

$T\Delta PROG\leftarrow N$ Displays result of calculation performed in line N of function PROG.

N may be a vector. Trace and Stop controls may be removed by $N\leftarrow 0$ or $\iota 0$.