APLSE Basic *APL* Commands & Operations

Contents:

Introduction: This is intended to help users unfamiliar with the *APL* language to get started using *APLSE*, *MARTHA* and LLAMA. It isn't meant as a complete reference to *APL*, but it should provide the basics. It also covers features specific to *APLSE*, especially the editing system. There are directions on finding more complete documentation and built in help information provided with *APLSE* and in the *PLUSDEMO* programs. An *APLSE* keyboard map and command reference is included on the last page that you can print out.

Workspaces: *APL* stores collections of "functions" (programs) in "workspaces" (program files). The workspace files (with the extension ".AWS", for *APL* Work*s*pace) are organized into "libraries" (directories) that are referred to by number. For example, when you start *APLSE*, it will automatically load the workspace *INI0* from Library #4. The standard configuration has the LLAMA workspaces in Library #8. If you want to work with the plotting software, you "load" the workspace by typing:

```
      )load 8 llplot
```

APL responds with:

`8 LLPLOT SAVED 8/26/2007 18:03:00` (along with the opening info for the workspace).

This simple operation points out several important things. When *APL* is waiting for user input, it normally parks the cursor 6 spaces over from the left. When *APL* produces a result, it starts at the left edge of the screen. The "`)load`" command is not case sensitive, but most other *APL* operations are. Historically, the original mainframe *APL* only had uppercase letters available. As a result, older *APL* code (like *MARTHA* and LLAMA) uses uppercase for most function names. The convention used in *MARTHA* and LLAMA is that the regular functions are in upper case, and "background" functions, that aren't typically called by users, are in lower case. Most people find it easiest to turn Caps Lock on at the beginning of an *APL* session. It used to be possible to automate this, but not in Windows NT or XP.

Workspace System Commands: Here is a summary of some basic system commands:

Command Syntax	Function
)*LOAD* Lib# WSName	Loads workspace from disk (Overwrites existing workspace)
)*SAVE*	Saves current workspace to disk
)*OFF*	Exits *APL* session (be sure to save your files first!)
)*CLEAR*	Starts a new empty workspace
)*WSID* Lib# WSName	Changes current workspace name
)*LIBS*	Lists all *APL* libraries
)*LIB* Lib#	Lists all workspaces and files in specified library
)*CMD* DOS Command	Executes a DOS command (change directory, etc.)

System Commands for *APL* Workspace Objects: Here are some of the additional commands for working with *APL* "objects", i.e. variables and functions:

Command Syntax	Function
)*COPY* Lib# WSName Object(s)	Copy functions/variables to current workspace (overwrites!)
)*ERASE* Object(s)	Erases functions / variables from current workspace
)*FNS*	Lists all functions in the current workspace
)*VARS*	Lists all variables in the current workspace

Working in *APL*: *APL* is an interpreted language, and is capable of operating in "immediate" mode, where it performs calculations directly on screen. You can use it as a "super calculator" to perform operations without having to write any *APL* programs. For example, you can type:

```
      12+36
```

and when you press <Enter>, it will respond with:

```
48
```

This isn't too exciting until you realize that *APL* includes mathematical operators like matrix inversion that allow you to perform calculations vastly more complex than simple addition. If you load a workspace that includes *APL* functions, you can run the functions (programs) directly as well. For example, if you have a function called *VOL* that computes the product of three numbers, and another function named *FtoM* that converts feet to meters, the volume of a 3’ by 4’ by 6’ box in meters is calculated :

```
      VOL FtoM 3 4 6
2.152
```

This illustrates a couple more points about *APL*. Calculations are normally performed strictly from right to left, so *FtoM* operates on the vector of dimensions before the result is passed on to *VOL*. You can use parentheses to force a different order of execution if you need to, but with a little forethought, you can frequently eliminate many of them. Vectors can be entered as a series of numbers separated by commas or spaces. *APL* is an array based language, and performing operations on vectors and matrices is built in. To expand the first trivial math example above, if you needed to add two series of numbers, you could do it as follows:

```
      1 2 3+4,5,6
5 7 9
```

Numbers in *APL*: One quirk of *APL* is how you must enter negative numbers. A negative number is preceded by a “high” minus sign, i.e. ¯2. The high minus sign is typed using <Alt> 2. *APL* uses the conventional minus sign “-“ as an “operator”. If it is used as a “dyadic” operator (2 arguments), it performs subtraction, i.e. 6−2. If it is used as a monadic (one argument) operator, it negates the argument:

```
      4 5 6-1 ¯2 3
3 7 3
      -4 5 6-1 ¯2 3
¯3 ¯7 ¯3
```

APL can use scientific notation for large or small numbers, using ‘E” for the exponent:

```
      1E¯2 100000000000
0.01 1E11
```

Variables: Similar to the issues with the minus sign operator, *APL* uses the equal sign as a computational operator to test equality, not for assigning values to variables. The “left arrow” symbol “←” is used instead. This is typed using <Alt> [. For example:

```
      A←12
      B←6
      A−B
6
```

Variable names can be as long as you want, but can’t contain spaces. Variables can be numbers, letters, vectors, or matrices. Character vectors (strings) are entered using single quotes:

```
      A←'APL IS FUN'
```

System variables: *APL* includes a number of "system variables" that set certain characteristics. Some can be modified to suit your needs. For example, to control the number of digits displayed, you can use the "Print Precision" system variable, "⎕*PP*". The "quad" symbol is typed using <Alt> L.

```
      1.23456
1.23456
      ⎕PP←3
      1.23456
1.23
```

Another sometimes useful variable is the "index origin", "⎕*IO*". This sets whether *APL* starts counting from "0" or "1" when doing things like indexing into arrays or matrices. For most work, ⎕*IO* is usually set to "1", but occasionally it is useful (especially for booleon & binary operations) to temporarily set it to "0". The first thing many workspaces & functions do is set ⎕*IO* to the desired value just to be sure. If it's wrong, you can get some very surprising results.

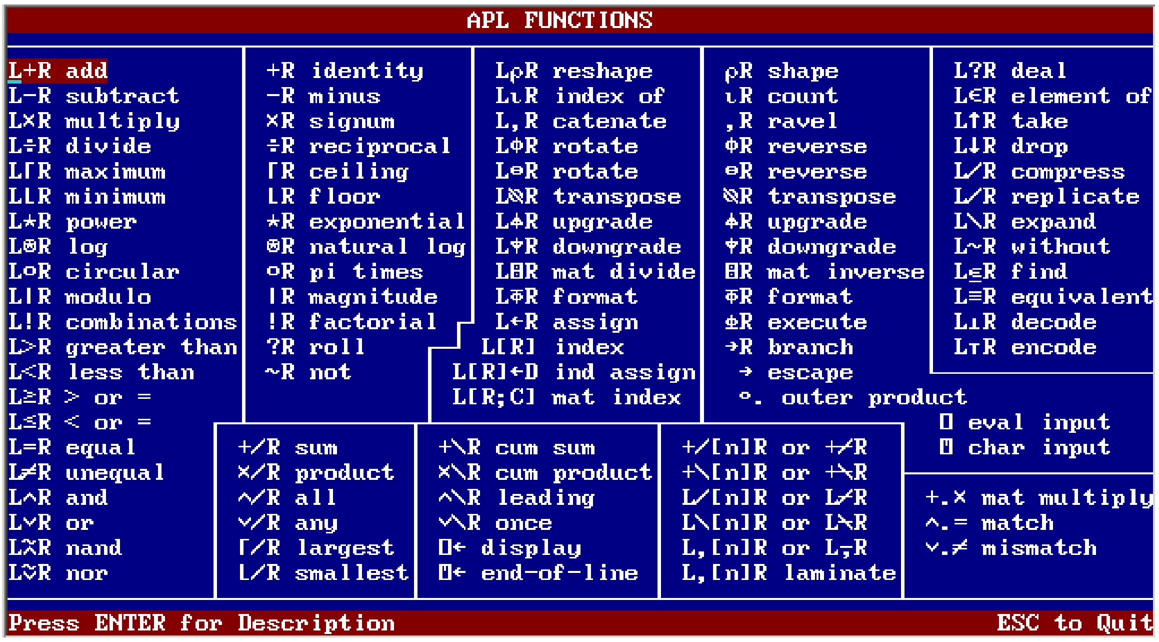
Matrices: As was mentioned earlier, *APL* is very much at home working with matrices. To create a matrix, you typically use the dyadic "reshape" operator "ρ" (<Alt> R). The left argument is the "shape" you want (rows & columns for a 2 dimensional matrix, but you can create as many dimensions as you can keep track of), and the left argument is the data you want in the matrix. If you specify a larger matrix than the data supplied, it starts over at the beginning, and if you specify too much data, it gets truncated:

```
      2 3ρ1 2 3 4 5 6
 1 2 3
 4 5 6
      2 3ρ1 2 3 4
 1 2 3
 4 1 2
      2 3ρ1 2 3 4 5 6 7 8
 1 2 3
 4 5 6
```

***APL* Functions:** The real power of *APL* is in writing your own functions. Any useful discussion of how this is done is beyond the scope of this tutorial, but there is detailed info in the *APLSE* documentation and the *PLUSDEMO* package on how to do this.

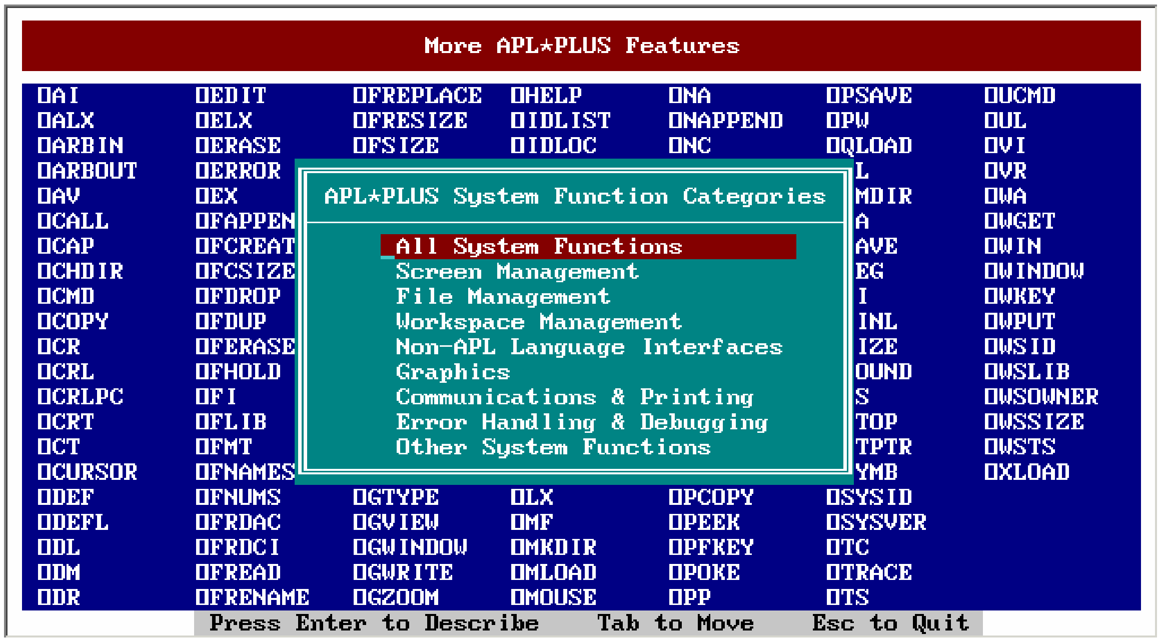
Available *APL* Operators: The table below (from the *PLUSDEMO* package) lists the various operators that are available in *APLSE*. Many of these are fairly straightforward, but a large number require much more explanation than can be covered in a brief table like this. For example, the dyadic "circular" operator "○" can perform all of the standard trigonometric functions (and some not so common ones) depending on the value of the left argument. You can get a complete description by running *PLUSDEMO* and accessing the detailed information linked to each operator, or from the *APLSE* documentation.

APLSE Basic *APL* Commands & Operations



```
                                 APL FUNCTIONS

L+R add           +R identity      LρR reshape       ρR shape          L?R deal
L-R subtract      -R minus         LιR index of      ιR count          L∊R element of
L×R multiply      ×R signum        L,R catenate      ,R ravel          L↑R take
L÷R divide        ÷R reciprocal    L⌽R rotate        ⌽R reverse        L↓R drop
L⌈R maximum       ⌈R ceiling       L⊖R rotate        ⊖R reverse        L/R compress
L⌊R minimum       ⌊R floor         L⍉R transpose     ⍉R transpose      L/R replicate
L⋆R power         ⋆R exponential   L⍋R upgrade       ⍋R upgrade        L\R expand
L⍟R log           ⍟R natural log   L⍒R downgrade     ⍒R downgrade      L~R without
L○R circular      ○R pi times      L⌹R mat divide    ⌹R mat inverse    L⍷R find
L|R modulo        |R magnitude     L⍕R format        ⍕R format         L≡R equivalent
L!R combinations  !R factorial     L←R assign        ⍎R execute        L⊥R decode
L>R greater than  ?R roll           L[R] index       →R branch         L⊤R encode
L<R less than     ~R not          L[R]←D ind assign   → escape
L≥R > or =                        L[R;C] mat index    ∘. outer product
L≤R < or =                                                             ⎕ eval input
L=R equal          +/R sum        +\R cum sum      +/[n]R or +⌿R       ⍞ char input
L≠R unequal        ×/R product    ×\R cum product  +\[n]R or +⍀R
L∧R and            ∧/R all        ∧\R leading      L/[n]R or L⌿R     +.× mat multiply
L∨R or             ∨/R any        ∨\R once         L\[n]R or L⍀R     ∧.= match
L⍲R nand           ⌈/R largest    ⎕← display       L,[n]R or L⍪R     ∨.≠ mismatch
L⍱R nor            ⌊/R smallest   ⍞← end-of-line   L,[n]R laminate

Press ENTER for Description                                              ESC to Quit
```

APLSE also has a large number of "system functions", which perform a wide range of operations, from file handling, to graphics, to communicating with other computer languages. The table below (also from *PLUSDEMO*) shows the wide variety of additional features and capabilities available.

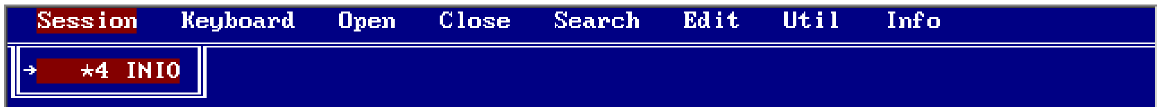


```
                          More APL★PLUS Features

⎕AI       ⎕EDIT     ⎕FREPLACE ⎕HELP     ⎕NA       ⎕PSAVE    ⎕UCMD
⎕ALX      ⎕ELX      ⎕FRESIZE  ⎕IDLIST   ⎕NAPPEND  ⎕PW       ⎕UL
⎕ARBIN    ⎕ERASE    ⎕FSIZE    ⎕IDLOC    ⎕NC       ⎕QLOAD    ⎕VI
⎕ARBOUT   ⎕ERROR                                  L         ⎕VR
⎕AV       ⎕EX        APL★PLUS System Function Categories  MDIR  ⎕WA
⎕CALL     ⎕FAPPEN                                 A         ⎕WGET
⎕CAP      ⎕FCREAT       All System Functions      AVE       ⎕WIN
⎕CHDIR    ⎕FCSIZE       Screen Management         EG        ⎕WINDOW
⎕CMD      ⎕FDROP        File Management           I         ⎕WKEY
⎕COPY     ⎕FDUP         Workspace Management      INL       ⎕WPUT
⎕CR       ⎕FERASE       Non-APL Language Interfaces  IZE    ⎕WSID
⎕CRL      ⎕FHOLD        Graphics                  OUND      ⎕WSLIB
⎕CRLPC    ⎕FI           Communications & Printing  S        ⎕WSOWNER
⎕CRT      ⎕FLIB         Error Handling & Debugging TOP      ⎕WSSIZE
⎕CT       ⎕FMT          Other System Functions    TPTR      ⎕WSTS
⎕CURSOR   ⎕FNAMES                                 YMB       ⎕XLOAD
⎕DEF      ⎕FNUMS    ⎕GTYPE    ⎕LX       ⎕PCOPY    ⎕SYSID
⎕DEFL     ⎕FRDAC    ⎕GVIEW    ⎕MF       ⎕PEEK     ⎕SYSVER
⎕DL       ⎕FRDCI    ⎕GWINDOW  ⎕MKDIR    ⎕PFKEY    ⎕TC
⎕DM       ⎕FREAD    ⎕GWRITE   ⎕MLOAD    ⎕POKE     ⎕TRACE
⎕DR       ⎕FRENAME  ⎕GZOOM    ⎕MOUSE    ⎕PP       ⎕TS
          Press Enter to Describe   Tab to Move   Esc to Quit
```

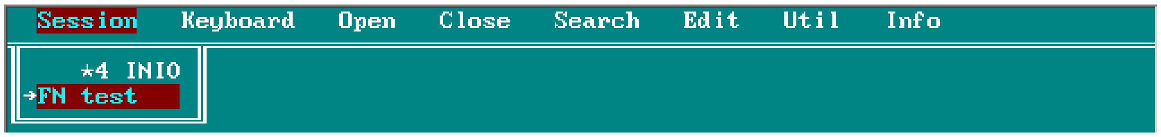
These are not described in the *APLSE* documentation, which is why it's useful to have access to *PLUSDEMO* as well. It may seem a little imposing, but most of the system functions are in groups related to specific types of operations, and you may never have to deal with them. For example, unless you get heavily involved with file operations, graphics, or the internal window system, you'll never see over half of these. I wouldn't recommend getting too far into any of the *APLSE* specific functions unless you can find a full set of *APL★PLUS/PC* manuals.

APLSE Command Menu Operations

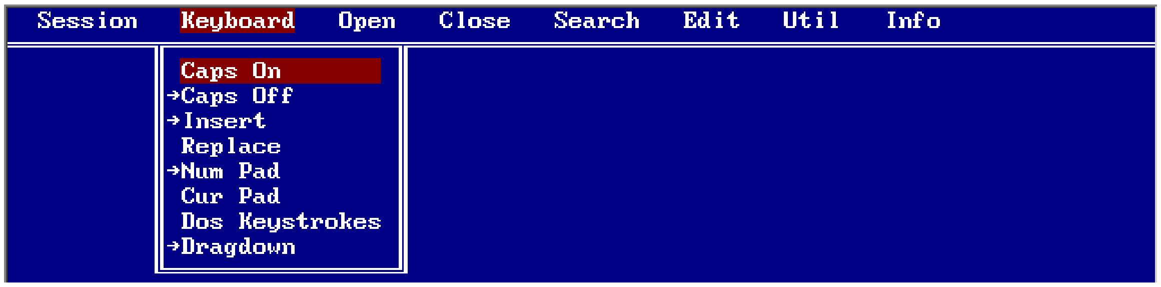
Holding down <Ctrl> and hitting the "/" key in *APLSE* opens a command menu at the top of the screen. In DOS, you can use the mouse to move between options. In Windows NT & XP, you have to use the arrow keys. The command menu will open with the Session menu selected at the far left:



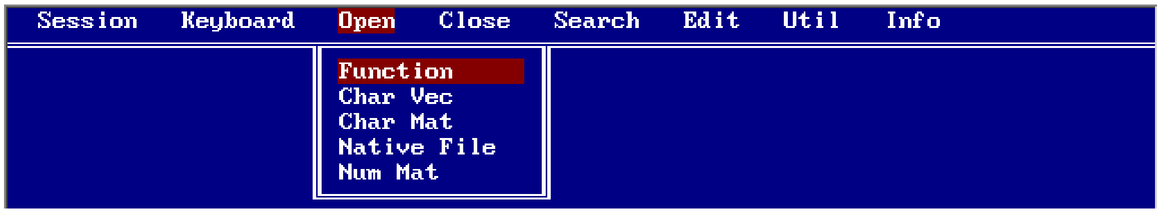
This indicates that the only session is the workspace "*INIO*" in Library 4. If you open a function, variable or file for editing, the screen changes color, and the Session menu will show the object you are working on. You can have multiple objects open at one time, and this command menu allows switching from one to another quickly.



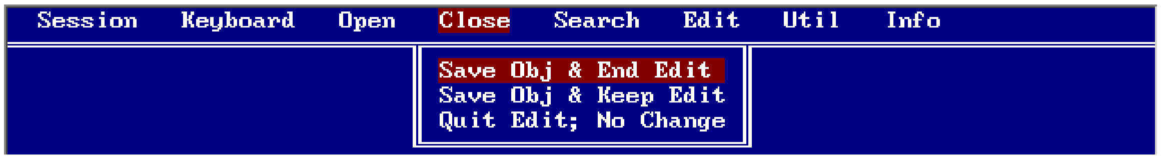
This shows an editing session on the function "test". You can switch back and forth between the editing session and the main *APL* session here. This is useful if you are copying or moving text between the main session and your editing session using "tags", which are described later.



The "Keyboard" menu shows the status of the keyboard. In Windows NT & XP, it shows status only. You can't use this to change any of the settings.

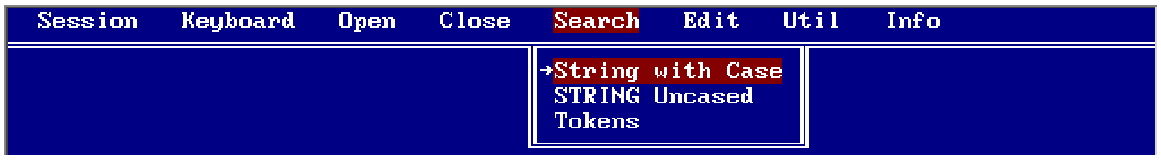


The "Open" menu allows you to edit *APL* objects (variables or functions), as well as "native" (DOS) files.

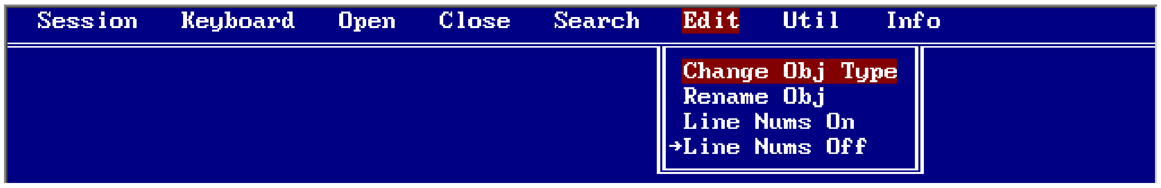


The "Close" menu gives several options for exiting and/or saving the current editing session.

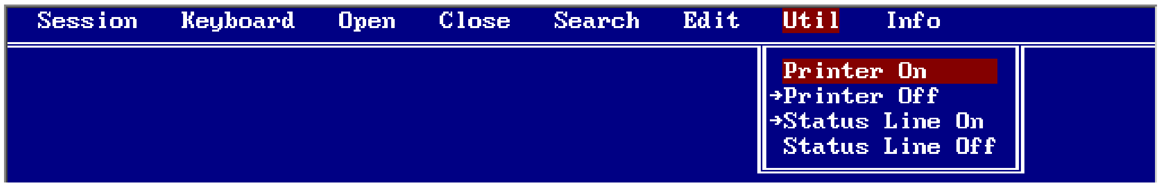
APLSE Command Menu Operations



The “Search” menu allows you to find strings in the edit session (case-sensitive or not), and “tokens”, which are strings that are not part of a longer string. For example, using the Token search for “and” would only find instances of “and”, and wouldn’t locate the word “sand”.

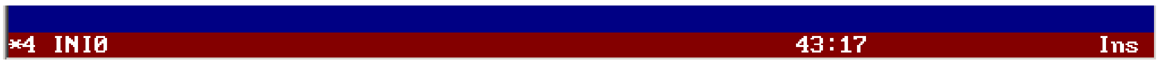


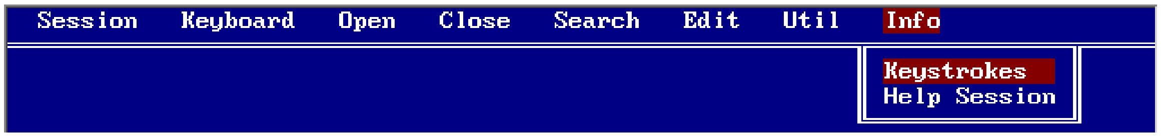
The “Edit” menu allows you to modify the type or name of an object, and to toggle line numbers on and off.



The “Printer On” / “Printer Off” selections are equivalent to using <Ctrl> - PrtSc to send screen information to the printer. When on, it will send any new computations, function listings, etc. to the printer until it is toggled off. Note: In Windows NT & XP, the printer output is buffered, and won’t immediately send the data to the printer unless you send a form-feed to the printer. The *INI0* workspace assigns a printer form-feed command to the function key F1, for this purpose.

The Status Line is the one-line display at the bottom of the screen indicating the active workspace, cursor location, keyboard settings (insert, caps lock, etc.) and printer status. The image below shows that the workspace is *INI0* in library 4, the cursor is 47 lines down from the top of the session (not the visible screen) & 17 characters to the right, and the keyboard insert mode is active:



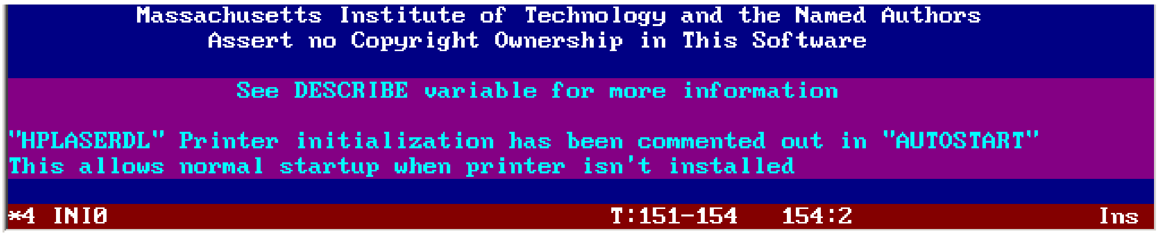


The “Info” menu also you to access on-line help. The “Keystrokes” menu item brings up a summary of editing and menu commands. Ordinarily, “Help Session” would load Help information from a file, but the required file isn’t supplied with *APLSE*. We are working on getting permission to include this in the future.

Editing Operations With The Mouse & Keyboard

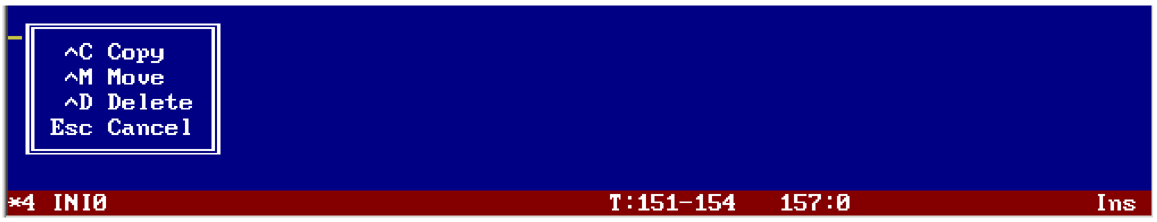
Editing Operations With The Mouse: There are a number of editing features in `APLSE` that can use the mouse. The basic process consists of "tagging" a block of code or text, which can then be copied, moved or deleted. Warning!: the normal Window shortcut keys for cutting & pasting do NOT work. In fact, <Ctrl> C does the equivalent of a paste instead of a copy!

To tag a collection of entire lines, you merely hold down the right mouse button while dragging down over the desired material. When you release the mouse button, the text will remain hi-lighted, and there will be a "T" indicator in the status line that shows the line numbers:



```
          Massachusetts Institute of Technology and the Named Authors
               Assert no Copyright Ownership in This Software

                   See DESCRIBE variable for more information

"HPLASERDL" Printer initialization has been commented out in "AUTOSTART"
This allows normal startup when printer isn't installed

*4 INI0                                   T:151-154   154:2            Ins
```

You can now move elsewhere in your session, or open up an editing window with a new or existing variable. When you left click the mouse at the desired location, a small menu pops up to ask what you want to do with the tagged text:



```
*4 INI0                                   T:151-154   157:0            Ins
```

You can either use one of the indicated shortcut keys (the "^" indicates holding down the <Ctrl> key), or click on the appropriate option with the mouse. To clear the tagged selection, just right click anywhere on the screen.

To tag part of a line or an arbitrary section of the screen, click BOTH mouse buttons simultaneously and hold them down as you drag over the text you want. After that, the process for working with the tagged information is the same as before.

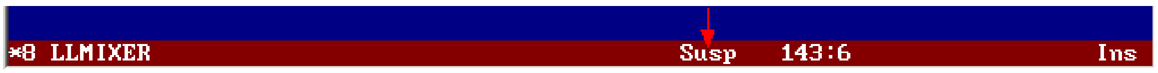
Tagging Blocks With the Keyboard: You can also use the keyboard to tag blocks. You use <Ctrl> T to start and end the tagging process. After pressing <Ctrl> T at the beginning of the block you want, move the cursor to where you want the block to end using the up & down keypad arrows and then press <Ctrl> T again.

To tag blocks containing partial lines, use <Ctrl-Shift> T to initiate and end the tagging process. Use the arrow keys, PgUp, PgDn, Home or End to move the cursor around the screen to select the block desired. You can end the tagging process by just hitting <Enter>, although <Ctrl> T or <Ctrl-Shift> T will also work.

What To Do If Things Go Wrong

Don't Panic! If you are working in the editor and accidentally mess things up, <Ctrl> Q will exit without saving anything. If you accidentally write a function that seems to be stuck or is in an infinite loop, <Ctrl> Esc should get you out. It also works if a function is asking for input & you have no idea what it wants.

One thing to watch out for is the "State Indicator". This keeps track of where you were when a function crashes. It can be a handy debugging tool, because it saves everything in the state it was in when it encountered a problem. However, this means there is also a lot of memory being used to hold this information, and there are variables and settings present that you don't expect. The status line at the bottom of the screen will show the word "Susp" to indicate that something is suspended:



```
*8 LLMIXER                                    Susp    143:6              Ins
```

Here is an example using the LLAMA mixer spur program. The program was run with a pair of single quotes as the right argument for the function *MIXSPUR*. This creates an "empty" input vector to the program, and it prompts the user for the required data. In this case, the user typed in a question mark, which the program didn't expect.

```
      MIXSPUR ''
LO, RF(low), RF(high), IF(low), IF(high), Max Order:
?
SYNTAX ERROR
MIXSPUR[17]⌽ ?
             ^
```

The system indicates that *MIXSPUR* has a problem on line [17]. The status line also indicates that there is a suspended operation present. To see what is going on, you can check the State Indicator by typing ")*SI*". In this case, only one function was running, and it verifies that MIXSPUR is hung up at line [17]

```
      )SI
MIXSPUR[17]★
```

Before you try to go back to work, you should clear the State Indicator. This is done by typing a right arrow "→" (<Alt>]). To check the State Indicator, type ")*SI*" again:

```
      →
      )SI
```

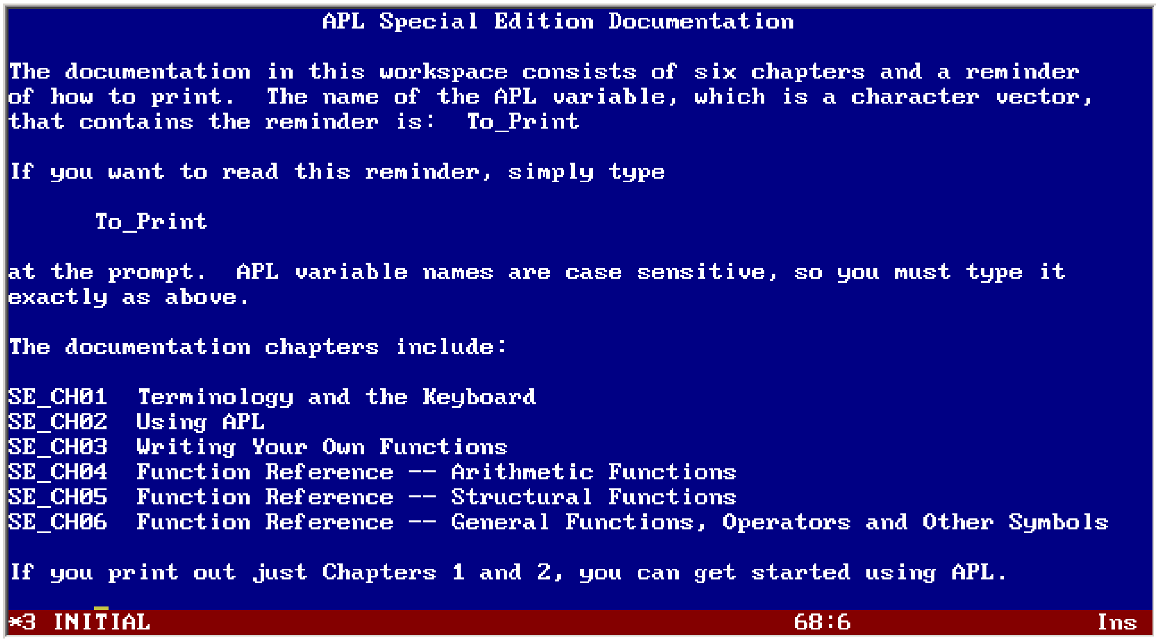
The State Indicator is now empty, and you can continue normally. Sometimes you can lose track, and there will be several suspended operations piled up. You need to keep entering right arrows until the State Indicator is empty and the "Susp" indicator in the status line goes away.

Additional Documentation in *APLSE* and *PLUSDEMO*

INITIAL* Workspace in *APLSE: *APLSE* provides some documentation in the workspace *INITIAL*, which should be in Library 3. If you execute:

```
      )load 3 initial
```

You will get the following screen:



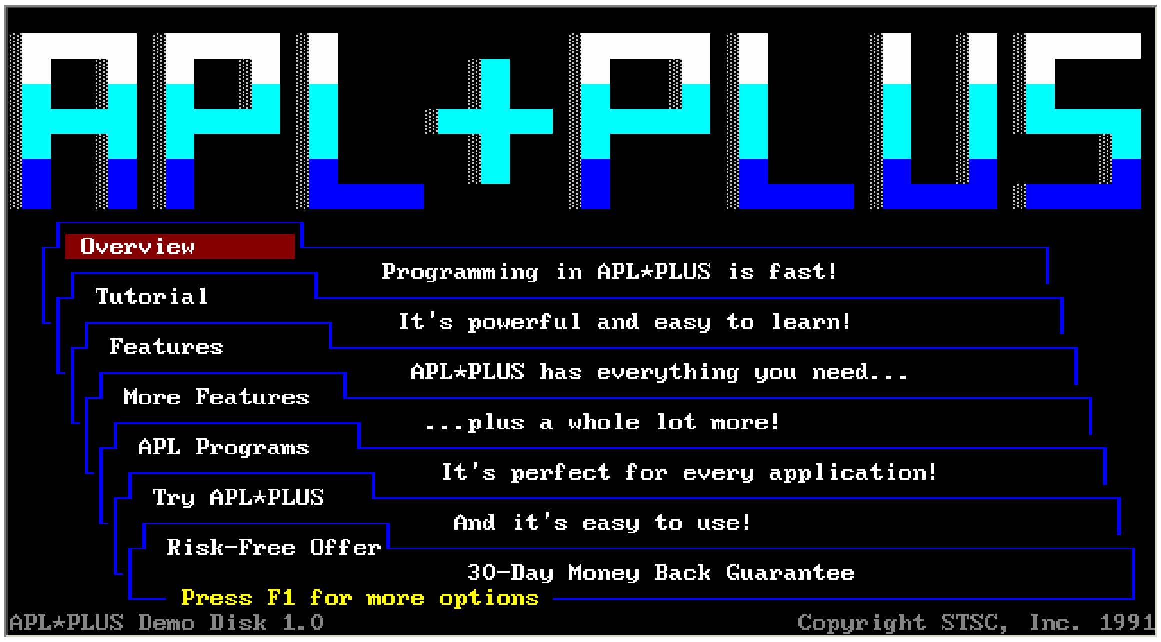
```
                          APL Special Edition Documentation

The documentation in this workspace consists of six chapters and a reminder
of how to print.  The name of the APL variable, which is a character vector,
that contains the reminder is:  To_Print

If you want to read this reminder, simply type

      To_Print

at the prompt.  APL variable names are case sensitive, so you must type it
exactly as above.

The documentation chapters include:

SE_CH01  Terminology and the Keyboard
SE_CH02  Using APL
SE_CH03  Writing Your Own Functions
SE_CH04  Function Reference -- Arithmetic Functions
SE_CH05  Function Reference -- Structural Functions
SE_CH06  Function Reference -- General Functions, Operators and Other Symbols

If you print out just Chapters 1 and 2, you can get started using APL.

*3 INITIAL                                                   68:6           Ins
```

You can view the documentation chapters on-line by just typing the name of the chapter, or if you have a printer set up, you can print the chapters using the instructions provided. All 6 chapters have been collected in a single PDF document that is included in the *APLSE* zip file.

The information on standard *APL* functions is quite good, but as was mentioned earlier, there is no documentation on "system functions" that allow you to work with files, graphics, etc. These typically start with the "quad" symbol "⎕" (<Alt> L on the keyboard). Most are system specific, but some are standard to many *APL* systems. For example, there are "quad" versions of many of the ")" system commands so that you can perform the required operation with in a function. Fortunately, the documentation *APLSE* is lacking in this area is covered to some extent by the *PLUSDEMO* package.

***PLUSDEMO* Software Package:** Before *APLSE* was made available, STSC/Manugistics had a software package called *PLUSDEMO* to demonstrate the capabilities of their *APL★PLUS/PC* software. Unlike *APLSE*, *PLUSDEMO* is not a fully functional *APL* package. However, it contains some very nice documentation on *APL* and its usage. For some reason they disabled the mouse, but you can navigate easily using the arrow keys. You can type <Esc> at any time to return to the main screen, or to exit the program from there. Here is the opening screen:

Additional Documentation in *APLSE* and *PLUSDEMO*


Overview

Programming in APL★PLUS is fast!

Tutorial

It's powerful and easy to learn!

Features

APL★PLUS has everything you need...

More Features

...plus a whole lot more!

APL Programs

It's perfect for every application!

Try APL★PLUS

And it's easy to use!

Risk-Free Offer

30-Day Money Back Guarantee

Press F1 for more options

APL★PLUS Demo Disk 1.0

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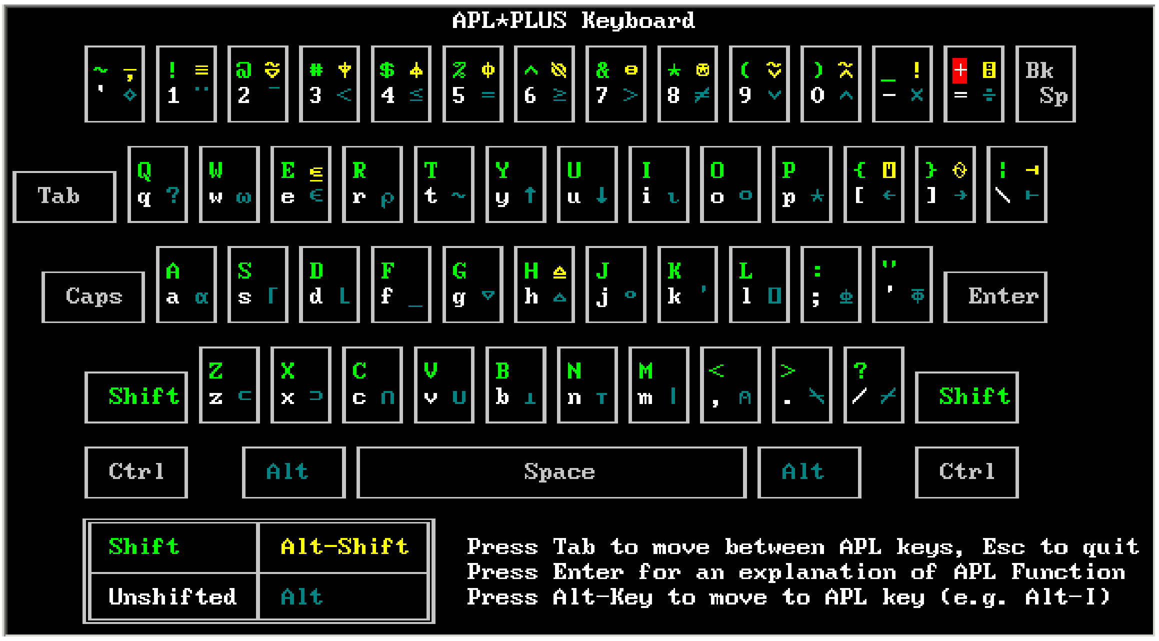
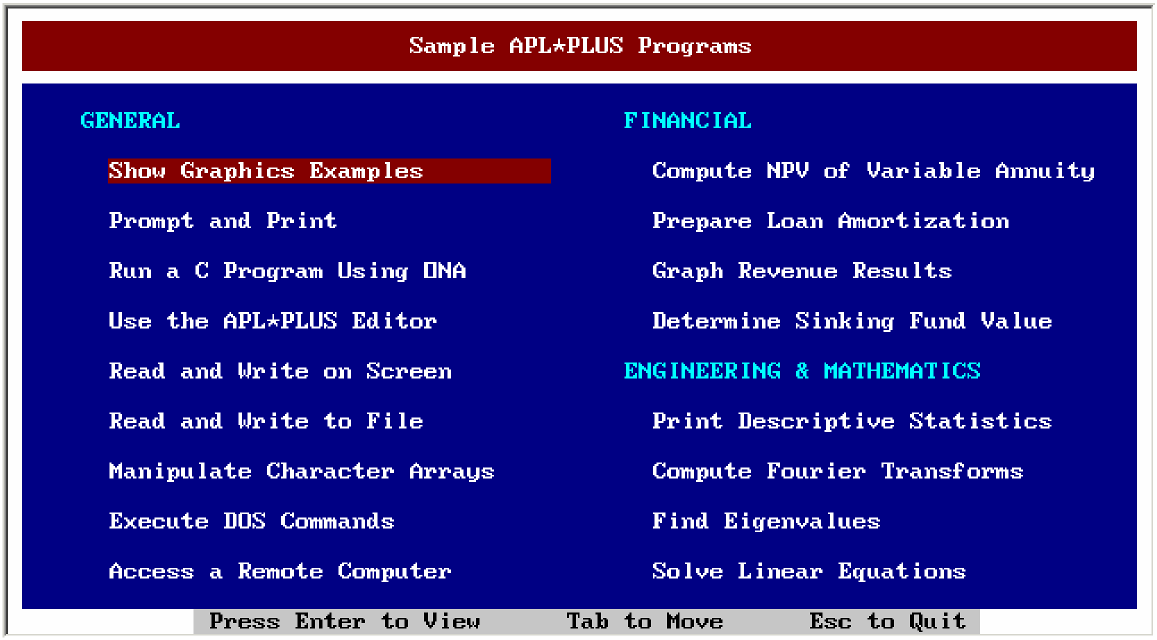
In addition to the instructional material, it has a very nice keyboard layout that can be accessed at any time by pressing F3. What is really useful is that hi-lighting any particular *APL* symbol and pressing <Enter> gives you a quick tutorial on what that *APL* operator does and its usage. If you are working in a newer Windows OS, you can run *PLUSDEMO* along side an *APLSE* session to have ready access to this feature. You can run one or both in a windowed mode by using <Alt-Enter> to switch back & forth from full-screen.



Press Tab to move between APL keys, Esc to quit
Press Enter for an explanation of APL Function
Press Alt-Key to move to APL key (e.g. Alt-I)

Additional Documentation in *APLSE* and *PLUSDEMO*

PLUSDEMO also includes a number of example programs that demonstrate a wide range of features & capabilities. The screen shot below shows the sample program page accessible from the "*APL* Programs" tab in the *PLUSDEMO* startup screen.



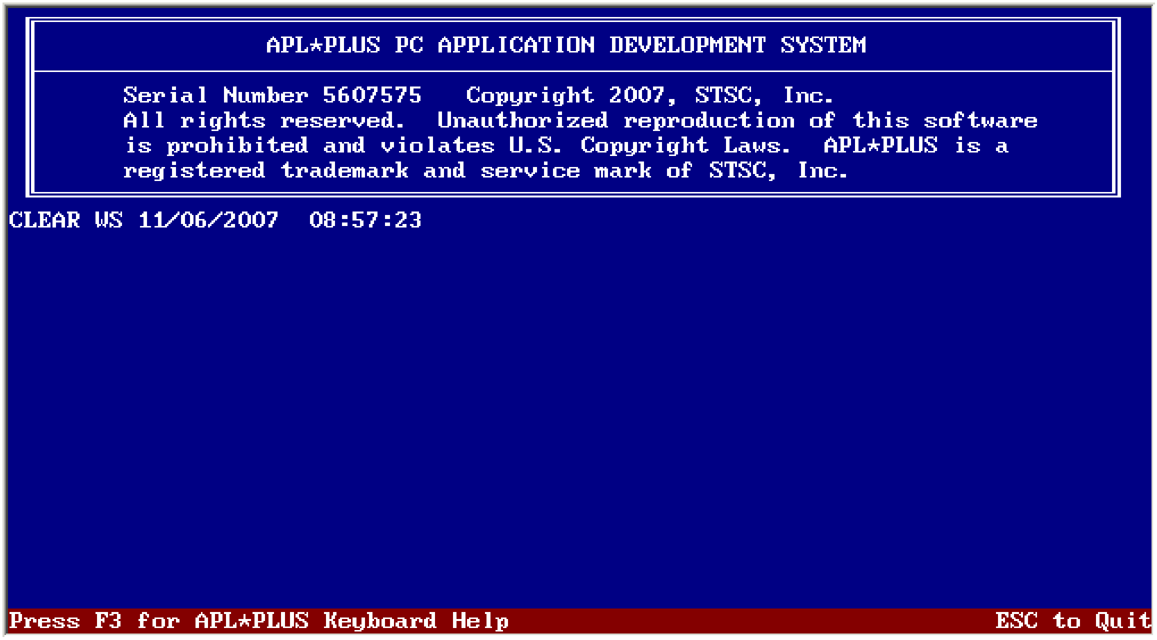
```
                     Sample APL*PLUS Programs

    GENERAL                              FINANCIAL

      Show Graphics Examples               Compute NPV of Variable Annuity
      Prompt and Print                     Prepare Loan Amortization
      Run a C Program Using ⎕NA            Graph Revenue Results
      Use the APL*PLUS Editor              Determine Sinking Fund Value
      Read and Write on Screen           ENGINEERING & MATHEMATICS
      Read and Write to File               Print Descriptive Statistics
      Manipulate Character Arrays          Compute Fourier Transforms
      Execute DOS Commands                 Find Eigenvalues
      Access a Remote Computer             Solve Linear Equations

            Press Enter to View      Tab to Move       Esc to Quit
```

In addition to the various documentation features, *PLUSDEMO* allows you to experiment with *APL* expressions and even small programs with a built in interpreter. This is accessed from the main *PLUSDEMO* screen from the "*Try APL★PLUS*" tab:



```
              APL*PLUS PC APPLICATION DEVELOPMENT SYSTEM

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         All rights reserved.  Unauthorized reproduction of this software
         is prohibited and violates U.S. Copyright Laws.  APL*PLUS is a
         registered trademark and service mark of STSC, Inc.
CLEAR WS 11/06/2007   08:57:23







Press F3 for APL*PLUS Keyboard Help                            ESC to Quit
```
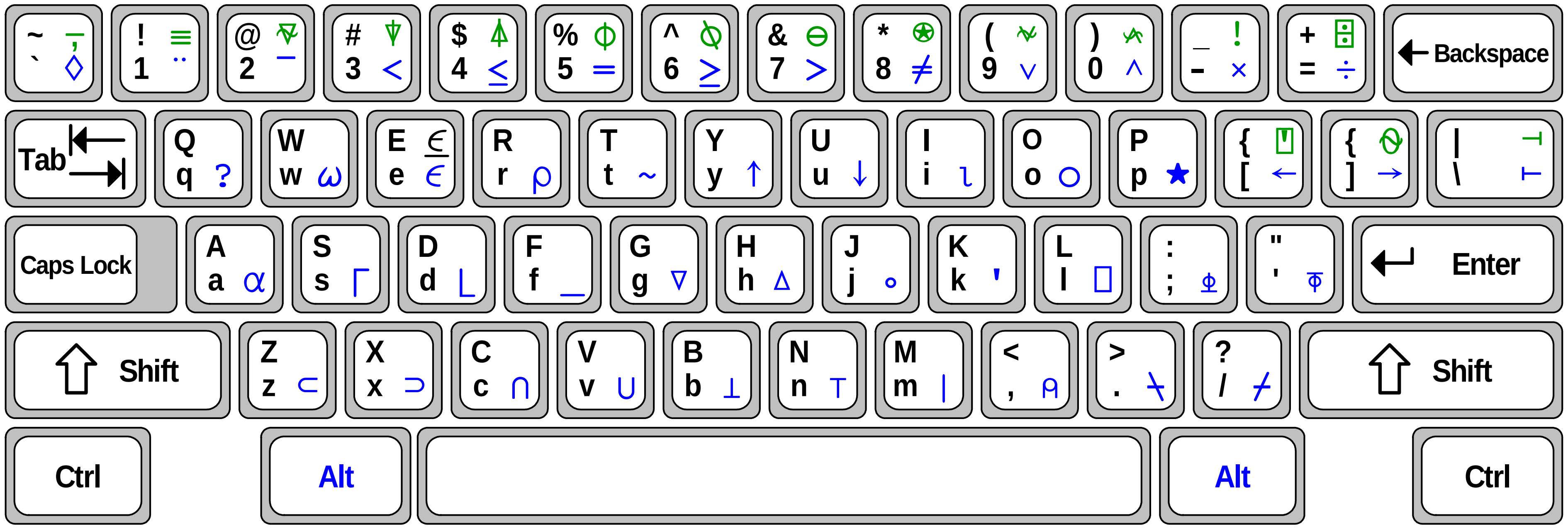

APLSE Keyboard Layout And Keyboard Shortcuts



Most Special APL Characters Are Typed Using The < Alt > Keys
"Shifted" APL Characters Require Using < Shift > & < Alt > Together

---- Menu Operations ----

Ctrl-/:	Invoke menus
Esc:	Exit menus
←/→/↑/↓/Tab/Backtab:	Move highlight
Enter or Ins:	Select option
Del:	Deselect option

---- Page Navigation ----

PgUp/PgDn:	Scroll screen up / down 1 line
Ctrl-PgUp/ PgDn:	Scroll up / down 1 page
Ctrl-Home/End:	Cursor to top / bottom of screen

--- Session Management ---

Ctrl-I:	Initialize new editing session
Ctrl-Shift-I:	Initialize new session with name at cursor
Ctrl-E:	save edit object & End session
Ctrl-Q:	Quit this session without saving
Ctrl-S:	Save edit object & keep session
Ctrl-X:	eXit to *APL* session - keep edit session
Ctrl-Shift-P:	move to Previous session
Ctrl-Shift-N:	move to Next session
Ctrl-A:	Alter session type (character only)
Ctrl-Shift-R:	Rename session