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DATAPLOT™

Introduction and Overview

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DATAPLOT — Introduction and Overview

James J. Filliben

Center for Applied Mathematics
National Engineering Laboratory
National Bureau of Standards
Washington, DC 20234

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

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Preface

The DATAPLOT language was designed and developed in 1976 in response to data analysis problems encountered in the scientific/research environment at the National Bureau of Standards. At such time it became increasingly evident that the 3 highest priority computing activities of the scientist/engineer were

1. *graphics (especially continuous);*
2. *fitting (especially non-linear);*
3. *operations with functions.*

Up to that time, the generation of such continuous graphics, the carrying out of such non-linear fits, and the application of such function operations was typically done in a subroutine-dependent, batch-oriented fashion which was time-consuming and non-conducive to the continuity of thought which is so important in scientific investigations. The need was seen, therefore, for the development of a

high-level,
English-syntax,
interactive

language which included single-command capabilities for

continuous graphics;
non-linear fitting;
function evaluation/transformations.

The realization of this goal occurred in early 1977 with the NBS implementation of the DATAPLOT language with its 3 kernel commands--

PLOT (for graphics);
FIT (for fitting);
LET (for function operations).

These 3 commands were from the beginning the core of the DATAPLOT language and their central role as such has become a distinctive mark of the language.

In addition to the above core activities, however, the language has extensive capabilities in

1) graphics (continuous or discrete);
2) fitting (non-linear or linear);
3) general data analysis;
4) mathematics.

DATAPLOT commands are high-level, English-syntax, and self-descriptive, such as

```
PLOT Y X
PLOT EXP(-X**2) FOR X = -3 .1 3
FIT Y = A+B*EXP(-ALPHA*X)
BOX PLOT Y X
ANOVA Y X1 X2 X3
LET FUNCTION F = DERIVATIVE EXP(-X**2)/(A;B*X) WRT X
```

Although DATAPLOT may be used in a batch environment, the language was designed for (and is most effectively used in) an interactive environment. DATAPLOT has proven to be a valuable time-saving tool (from the early stages of an analysis through to the final presentation graphics) for the scientist, engineer, data analyst, and general researcher alike. No programming experience is assumed in using DATAPLOT; it is used by both the novice programmer and by the veteran analyst.

This book should serve as a comprehensive reference for all DATAPLOT programmers. It is the author's intention that the layout of this book will

- *facilitate the learning of the DATAPLOT language;*
- *encourage the use of the many features of the language;*
- *result in more thorough and insightful analyses; and*
- *result in significant savings of the analyst's time.*

Indeed, the use of the DATAPLOT language as a computing tool in solving the variety of problems which arise daily in a research environment will allow the scientist to "think science" as opposed to "think computing".

The National Technical Information Service (NTIS) has been distributing the NBS-DATAPLOT tape since March of 1982. There have been 3 major releases--

March 1982--ANSI FORTRAN 66, General Version
July 1982--ANSI FORTRAN 77, General Version
June 1983--ANSI FORTRAN 77, Vax-Specific Version

The language defined in this book is consistent with the source code released from NBS to NTIS for distribution as of September 1983. Prior versions may differ slightly from specifications outlined in this manual. In particular, the LOOP command, the IF command, the VALU() sub-command, the bar plot patterns/spacing, and the symbolic differentiation do not apply for earlier versions.

The NBS source code tape which NTIS distributes is portable--out of the 600 ANSI FORTRAN subroutines (= 200,000 lines of FORTRAN code), only a few (less than 10) of the subroutines need be changed in going from one computer to the next. Known implementations exist on Univac, Vax, Honeywell, and Prime computers; other implementations are in progress. For distribution information, contact

National Technical Information Service
United States Department of Commerce
Springfield, Virginia 22161
703-487-4805

This book has had the benefit of constructive and insightful comments from a number of different individuals--both inside and outside of NBS. Particular thanks are extended to my NBS colleagues Stefan Leigh and Roland DeWit whose excellent reviewing and editing served to substantially improve earlier versions of this manual. Additionally, the comments of my colleagues in the Center for Applied Mathematics at NBS have been extremely valuable in regard to both this manual and the DATAPLOT language. In spite of the above, however, there no doubt still remain discrepancies, errors, omissions, and other technical ambiguities in this manual. In such case, the author welcomes the opportunity of receiving feedback from readers, and will be glad to make corrections and clarifications. Please direct such questions and comments to

James J. Filliben
Statistical Engineering Division
Center for Applied Mathematics
Administration Building, Room A-337
National Bureau of Standards
Washington, D. C. 20234
301-921-3651

James J. Filliben
May 1984

Disclaimer

The purpose of the manual is to give the analyst a broad overview of the structure, capabilities, and features of the DATAPLOT language.

Certain commercial brand names (e.g., Tektronix, Calcomp, Texas Instruments, etc.) are mentioned in this document. This does not constitute an endorsement of such products by either the author or the United States Government.

The features and capabilities described in this primer are for version 84/7 of DATAPLOT. Most (but not all) descriptions also hold for prior versions.

Neither the author nor any branch of the United States Government may be held liable for errors arising from the use of the DATAPLOT language or the implemented DATAPLOT system.

Suggestions and comments are welcome. Please forward them to

James J. Filliben
National Bureau of Standards
Administration Building, Room A-340
Washington, D.C. 20234
301-921-3651

Changes from Previous Versions

The National Technical Information Service (NTIS) has distributed 3 prior versions of DATAPLOT--

Version 82/3	FORTRAN 66 (General)
Version 82/7	FORTRAN 77 (General)
Version 83/5	FORTRAN 77 (Vax)

Version 84/7 will be released from NTIS shortly (July 1984), and will be primarily distinguished from earlier versions in that it will have the benefit of code updates (for certain uncovered bugs) and capability enhancements (for added analysis power).

The features and capabilities described in this manual are for version 84/7 of DATAPLOT. Most (but not all) descriptions also hold for the prior released versions (82/3 and 82/7).

Commands available in 84/7 but not in earlier versions include--

READ PARAMETER	for reading parameters from a file;
READ FUNCTION	for reading functions from a file;
LOOP	for looping;
IF	for conditional execution of a block of statements;
LIST	for listing a subprogram on a file.

The MACRO ON, MACRO OFF, and MACRO EXECUTE commands of previous versions are described in this manual as the CREATE ON, CREATE OFF, and CALL commands. The MACRO commands will still work in 84/7 , but the preferable commands are CREATE and CALL.

The ANGLE UNITS command of previous versions is described in this manual as the TRIG UNITS command--either will work in 84/7 .

The COMMENT command in previous versions (to write out descriptive text) is described in this manual as a sub-capability under the WRITE command, so that

```
COMMENT CALIBRATION ANALYSIS
```

and

```
WRITE "CALIBRATION ANALYSIS"
```

both have the same effect in 83/10.

The analytic differentiation sub-capability under the LET FUNCTION command has been reinstated for version 84/7, but was omitted from earlier versions.

New data analysis capabilities which have been added to the 84/7 version are

1) The BOX PLOT command has been generalized (via the FENCE command) so that values beyond the inner and outer fences may be indicated.

2) Robust (3RSR) smoothing and Hamming smoothing have been added.

3) Stem and Leaf diagrams have been added.

4) The CONTROL CHART command has been generalized to cover the unequal-sample size case.

James J. Filliben
May 1984

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What is DATAPLOT?

DATAPLOT is an interactive high-level (free-format English-like syntax) language with extensive capabilities in

1) Graphics (continuous or discrete);
2) Fitting (non-linear or linear);
3) General Data Analysis;
4) Mathematics.

DATAPLOT was developed originally in 1977 in response to data analysis problems encountered at the National Bureau of Standards. DATAPLOT may be run either in batch mode or interactively, although it was primarily designed for (and is most effectively used in) an interactive environment. DATAPLOT graphics may appear on many different types of output devices.

Capabilities

DATAPLOT has a broad scope of capabilities--

1) raw graphics (2-D, 3-D, color, single/multiple plots per page, etc.);

2) analysis graphics (plotting data, plotting functions);

3) presentation graphics (special fonts, Greek, math symbols, word charts, etc.);

4) diagrammatic graphics (diagrams, schematics, etc.);

5) graphical data analysis (box plots, probability plots, histograms, control charts, lag plots, EDA, residual analysis, etc.);

6) time series plots (autocorrelation plots, spectral plots, demodulation plots, etc.);

7) fitting (non-linear, multi-linear, polynomial, spline, etc.);

8) general data analysis (ANOVA, median polish, robust smoothing, ANOP, etc.);

9) statistical/probability capabilities (. 20 statistics, cdf's, ppf's, random numbers, etc.);

10) mathematics (roots, differentiation, integration, convolution, etc.);

11) subset analyses (as easy as full-set analyses);

12) extensive built-in Fortran-like library of math and probability functions.

Getting Into and Out of DATAPLOT

The procedure for accessing DATAPLOT varies from one computer to the next. For example, on a Univac computer, one enters

```
@DATAPLOT
```

On a Vax computer, one enters

```
DATAPLOT
```

Check with the local DATAPLOT service group to determine the local convention for accessing DATAPLOT. Upon entry into DATAPLOT, the DATAPLOT banner will appear, along with a version number, and dimension message about the current configuration, as in--

```
*****************************************************
*                    DATAPLOT                       *
*   INTERACTIVE GRAPHICAL DATA ANALYSIS LANGUAGE    *
*****************************************************
                                          VERSION 83/1

INTERNAL DATA STORAGE CAPACITY = 10,000 OBSERVATIONS
(1000 OBSERVATIONS PER VARIABLE   X   10 VARIABLES)
```

To exit from a DATAPLOT program, one enters any of the following--

```
EXIT
END
STOP
HALT
BYE
```

Getting Started with DATAPLOT

Suppose the analyst has the following 5 observations on the variables X and Y--

X	Y
1	1
2	3
3	15
4	18
5	30

Enter a DATAPLOT program to carry out the following 4 operations--

1) *Compute the mean of the Y data;*

2) *Plot Y versus X with titles and labels;*

3) *Carry out a least squares fit of Y on X with a linear model;*

4) *Generate a plot with the fitted values from the linear fit on top of the raw data.*

To do so, one first invokes DATAPLOT (e.g., by entering @DATAPLOT on UNIVAC computers, and whatever is appropriate on other computers). Upon invoking DATAPLOT, a DATAPLOT banner and a few lines of messages will appear on the screen.

One is now ready to enter the DATAPLOT program. A program to carry out the above 4 operations is as follows--

```
. STEP 0--READ IN THE DATA
.
READ X Y
1 1
2 3
3 15
4 18
5 30
END OF DATA
.
. STEP 1--COMPUTE THE MEAN
.
LET M = MEAN Y
.
. STEP 2--PLOT THE DATA
.
TITLE CALIBRATION ANALYSIS
YLABEL RESPONSE
XLABEL FORCE
PLOT Y X
.
. STEP 3--FIT THE DATA
.
FIT Y=A+B*X
.
. STEP 4--GENERATE A SUPERIMPOSED PLOT AFTER THE FIT
.
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
.
EXIT
```

All lines beginning with . (period) are non-executing comment lines and so DATAPLOT will ignore them; they are included here for clarity. There are 15 such lines in the above program. Ignore them or enter them at your discretion. The existence of such comment lines is more common in a DATAPLOT program to be stored in a file (and run later in toto) than in a DATAPLOT program to be entered line by line and run interactively.

The READ statement will read data into variables X and Y. the read is format-free and so spacing between data values on a line is unimportant (but at least one space between data values must exist--3 15 could not be writted as 315). Since there are only 5 data pairs, they are entered directly from the terminal (as opposed to reading the data from a file). The read terminates when an END of DATA line is entered.

LET M = MEAN Y computes the mean of the data in the variable Y, prints out the value, and stores this value in the internal DATAPLOT parameter M. DATAPLOT has over 20 summary statistics (MEAN, MEDIAN, STANDARD DEVIATION, CORRELATION, etc.) which may be similarly invoked via the LET command.

TITLE CALIBRATION ANALYSIS defines the title to appear above subsequent plots; YLABEL RESPONSE defines the vertical axis label to appear on subsequent plots; XLABEL FORCE defines the horizontal axis label to appear on subsequent plots. PLOT Y X actually generates the plot--Y will be plotted vertically and X horizontally. The plot will have a solid line (the default) connecting the data points. The pre-defined titles and labels will be automatically written out on the plot. The plot limits will be automatic and neat.

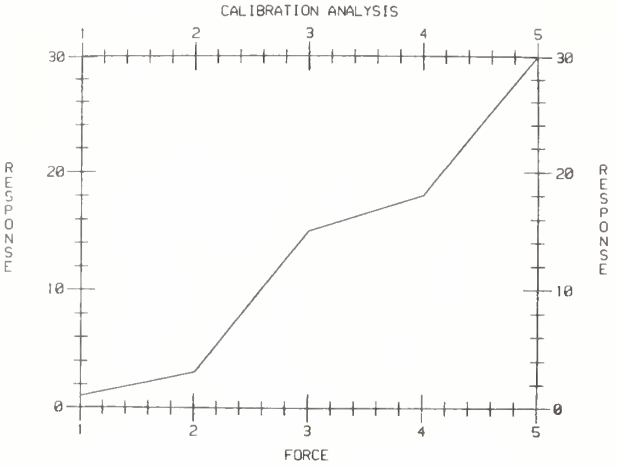
*FIT Y = A+B*X+C*X**2 carries out a least squares linear fit of Y on X. The coefficients and other results from the fit are be printed out. Predicted (= fitted) values from the fit are automatically placed in a variable PRED, and residuals from the fit are automatically placed in the variable RES. The above model (linear) is simple--DATAPLOT may carry out least squares fits for not only such polynomial and multi-linear models, but also for general non-linear models.*

CHARACTERS X BLANK specifies that the first trace on subsequent plots should have X's as the plot character and the second trace should have blank (= no) plot character. LINES BLANK SOLID specifies that the first trace on subsequent plots should have a blank (= no) connecting line, and the second trace should have a solid connecting line. PLOT Y PRED VERSUS X generates the superimposed plot of the raw data Y and predicted values PRED as a function of X. Due to the prior CHARACTERS and LINES commands, the first trace (Y versus X) has X's as characters and no connecting line ; the second trace (PRED VERSUS X) has no plot characters but solid connecting lines.

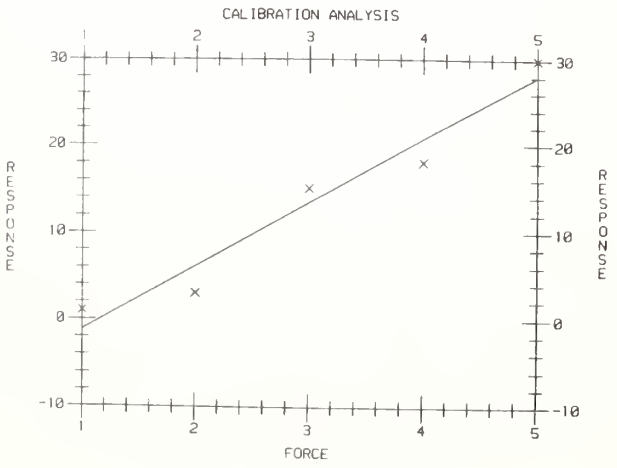
EXIT terminates the DATAPLOT run.

The output from the above DATAPLOT program is as follows--

```
THE MEAN OF THE        5 OBSERVATIONS          =    .13400000+002
THE COMPUTED VALUE OF THE PARAMETER M          =    .13400000+002
```




```
LEAST SQUARES NON-LINEAR FIT
     SAMPLE SIZE N =          5
     MODEL--Y=A+B*X
     NO REPLICATION CASE

 ITERATION  CONVERGENCE  RESIDUAL  *  PARAMETER
  NUMBER      MEASURE    STANDARD  *  ESTIMATES
                         DEVIATION *
-----------------------------------*-----------
    1--    .10000-001   .17000+002 *  .10000+001   .10000+001
    2--    .50000-002   .30714+001 * -.84844+001   .72951+001

     FINAL PARAMETER ESTIMATES              (APPROX. ST. DEV.)
     1  A                 -8.50001            ( 3.221    )
     2  B                  7.30000            ( .9713    )

     RESIDUAL    STANDARD DEVIATION =          3.0713732541
     RESIDUAL    DEGREES OF FREEDOM =             3
```



If the analyst were running on an alphanumeric terminal (e.g., Texas Instrument Silent 700) then the code should be preceded by a DISCRETE command which instructs DATAPLOT that the terminal is essentially non-continuous (has no ability to draw a continuous straight line from any point on the screen to any other point on the screen) and therefore the plots should be suitably modified. Also, the BLANK in

```
CHARACTERS X BLANK
```

should be replaced by some non-blank character, as in

```
CHARACTERS X P
```

The 2 plots will thus appear as--

```
                                CALIBRATION ANALYSIS
                    I---------I---------I---------I---------I
     .3000000+002 -                                         X
     .2855000+002 I
     .2710000+002 I
     .2565000+002 I
     .2420000+002 I
R    .2275000+002 -
E    .2130000+002 I
S    .1985000+002 I
P    .1840000+002 I                                    X
O    .1695000+002 I
N    .1550000+002 -                    X
S    .1405000+002 I
E    .1260000+002 I
     .1115000+002 I
     .9700000+001 I
     .8250000+001 -
     .6800000+001 I
     .5350000+001 I
     .3900000+001 I
     .2450000+001 I          X
     .1000000+001 -  X

                    I---------I---------I---------I---------I
                .1000+001 .2000+001 .3000+001 .4000+001 .5000+00
                                    FORCE
```

```
                                CALIBRATION ANALYSIS
                    I---------I---------I---------I---------I
     .3000000+002 -                                         X
     .2844000+002 I                                         P
     .2688000+002 I
     .2532000+002 I
     .2376000+002 I
R    .2220000+002 -
E    .2064000+002 I                                    P
S    .1908000+002 I
P    .1752000+002 I                                    X
O    .1596000+002 I
N    .1440000+002 -                    X
S    .1284000+002 I                    P
E    .1128000+002 I
     .9719998+001 I
     .8159997+001 I
     .6599997+001 -          P
     .5039997+001 I
     .3479997+001 I          X
     .1919997+001 I
     .3599966+000 I  X
    -.1200004+001 -  P

                    I---------I---------I---------I---------I
                .1000+001 .2000+001 .3000+001 .4000+001 .5000+001
                                    FORCE
```

4 Typical Problems

A computer language is a tool--a means of generating solutions to problems. Before delving into the details of the DATAPLOT language, let us first consider the types of problems that the scientist/engineer/ research scientist typically encounters. This will provide motivation for how the computer language (as a tool) was developed. All computer languages have their own areas of strength. The choice of problems below serve as a frame of reference for both reader and developer alike as to the type of problems that DATAPLOT considers "important" and for which it has been designed to be strong in.

1) A Graphics Problem--
An analyst has a data set consisting of (x,y) pairs. Plot the data. "Blow up" any intersting sub-regions of the plot.

2) A Non-Linear Fitting Problem--
An analyst has a data set consisting of (x,y) pairs. Read the data into the computer. Plot them. Carry out a non-linear fit for the model

$$y = \exp(-\alpha x)/(a+bx) \quad .$$

Generate a superimposed plot of raw data and predicted values from the fit. Generate a plot of residuals versus x. Generate a normal probability plot of the residuals.

3) A Data Analysis Problem--
An analyst has data consisting of a response variable and 3 independent variables (factors). Determine if the factors affect the response. Determine if there is interaction between the factors. Carry out an analysis of variance. Carry out a graphical analysis of variance.

4) A Mathematics Problem--
*An analyst wishes to examine the function x*exp(-x) + sin(x**2) over the interval 0 to 3. Plot the function over the interval. Determine any roots in the interval. Determine its definite integral over the interval.*

Several points are noteworthy--

1) Graphics as a Core Activity.
Note the graphics component that exists in all of the above problems--graphics is a key activity in both data analysis and mathematics.

2) Time.
These problems should all be solvable with less than 10 lines of code.

3) Number of Lines of Code.
These problems should all take less than 10 minutes to solve.

4) Interactive Analysis.
These problems should be solvable interactively so that in case some interesting tangent arises in the course of the solution, the analyst may immediately pursue it.

5) Graphics Quality.
Ideally, the graphics should be all continuous and of manuscript-quality if so desired.

6) Variety of Graphics Devices.
On the other hand, if the analyst is working at a discrete terminal or in batch, neither the logic of the analysis nor the entered plot commands should be any different.

7) Subset Analyses.
The analyst should not need to worry about whether the graphics, fitting, or data analysis is being carried out over the full data set or over any complicated subsets of the data. Carrying out analyses over subsets should not result in irrelevant (as far as the scientist is concerned) preliminary data extraction and manipulation. It should be as easy to carry out any (and all) graphics and analysis operations over a subset as it is to carry it out over the full set.

8) Sample Size.
The analyst should not need to worry about whether the data set consists of 7 data points or 700 data points--the number of data points is a nuisance parameter that the analyst should not need to concern himself with.

9) Data Format.
The analyst should not need to worry about how the data is formatted upon input--this also is an unimporant nuisance item.

10) Predicted Values and Residuals.
The analyst should not need to worry about predicted values and residuals from the fit--they should be automatically available for further analysis and plotting.

11) Scope of Capabilities.
The analyst should be able to fluidly glide from graphics to fitting to data analysis to mathematics activities with no interruption and within the context of the language.

12) Ease of Use.
The ultimate objective of the analyst is not in learning a computer language--it is in gaining insight into the problem at hand; thus the computer language should be natural, easy to learn, and easy to use. The language that the analyst uses should preserve the continuity of thought that is so important in scientific research.

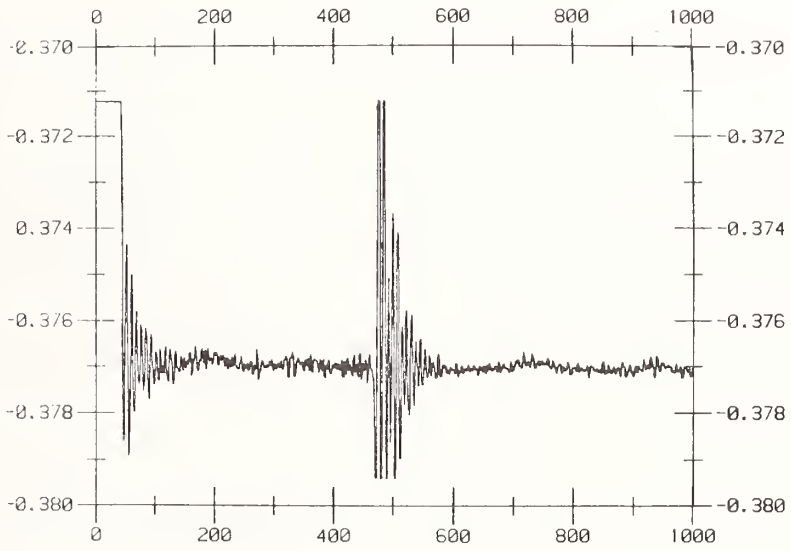
13) English-Syntax.
Ideally, the language should correspond as close as possible to the English-language and mathematical representation of the solution. This will allow the analyst to "think science" as opposed to "think computing" and will eliminate an unnecessary mapping from conceptual solution to computer-language solution.

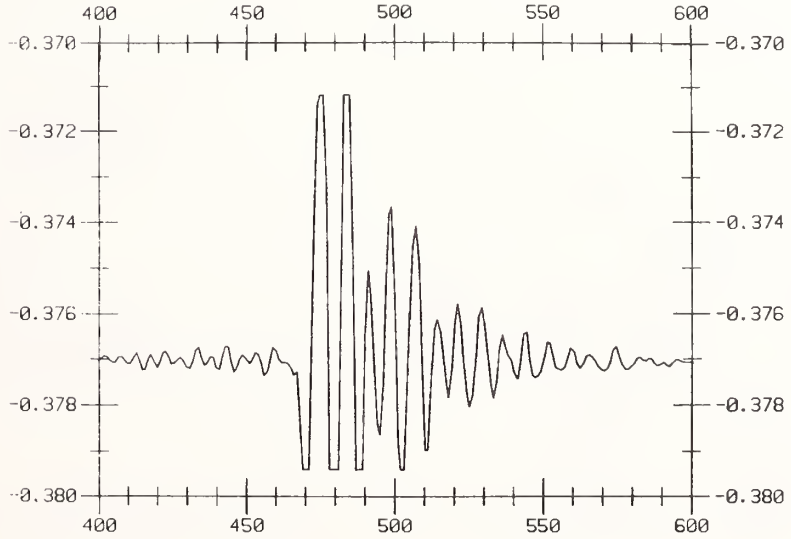
4 DATAPLOT Solutions

1. The Graphics Problem--
An analyst has a data set consisting of (x,y) pairs. Plot the data. "Blow up" any intersting sub-regions of the plot.

The DATAPLOT program and output is as follows--

```
READ FILE1. X Y
PLOT Y X
PLOT Y X SUBSET X 400 TO 600
```





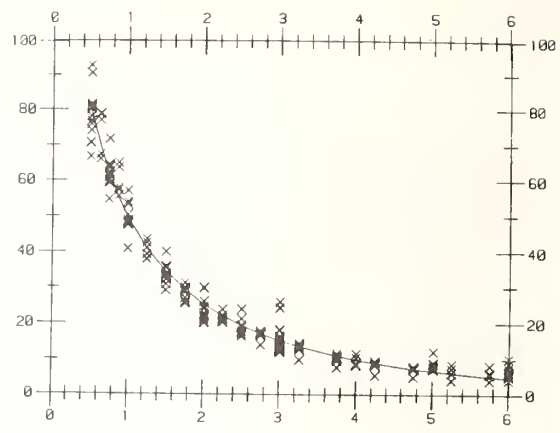
2. The Non-Linear Fitting Problem--
An analyst has a data set consisting of (x,y) pairs. Read the data into the computer. Plot them. Carry out a non-linear fit for the model

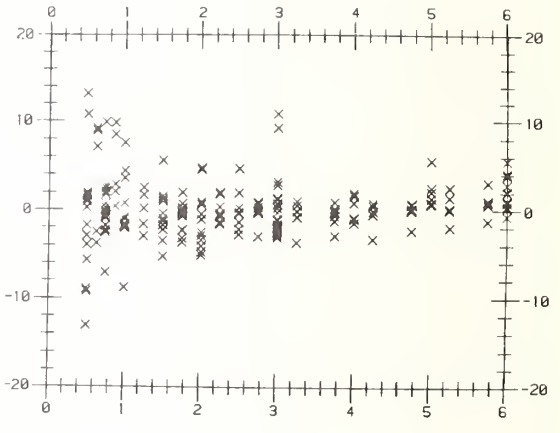
$$y = \exp(-\alpha x)/(a+bx) \quad .$$

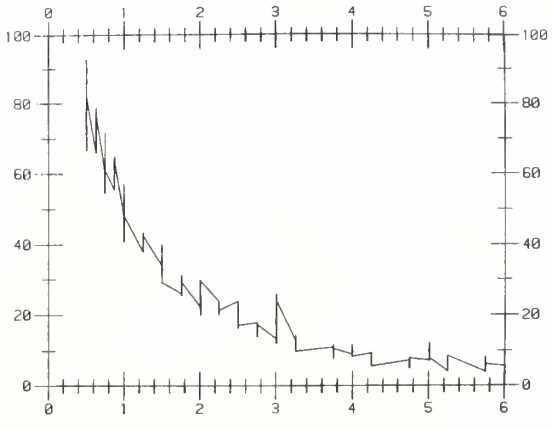
Generate a superimposed plot of raw data and predicted values from the fit. Generate a plot of residuals versus x. Generate a normal probability plot of the residuals.

The DATAPLOT program and output is as follows--

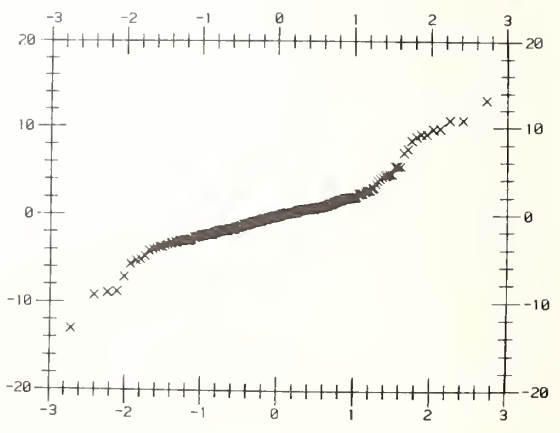
```
READ FILE2. X Y
PLOT Y X
.
LET A=0
LET B = 1
LET ALPHA=.1
FIT Y = EXP(-ALPHA*X)/(A+B*X)
.
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
NORMAL PROBABILITY PLOT RES
```







```
LEAST SQUARES NON-LINEAR FIT
      SAMPLE SIZE N =          214
      MODEL IS Y=EXP(-ALPHA*X)/(A+B*X)
      REPLICATION CASE
      REPLICATION STANDARD DEVIATION =       .3281762689+001
      REPLICATION DEGREES OF FREEDOM =           192
      NUMBER OF DISTINCT SUBSETS     =            22

ITERATION  CONVERGENCE  RESIDUAL   *  PARAMETER
 NUMBER      MEASURE    STANDARD   *  ESTIMATES
                        DEVIATION  *
-----  ---------------------------*-----------
    1--   .10000-001   .42568+002 *  .10000+000  .00000       .10000-001
    2--   .50000-002   .13287+002 *  .13193+000  .20057-002   .12365-001
    3--   .25000-002   .42349+001 *  .16578+000  .46193-002   .11885-001
    4--   .12500-002   .33646+001 *  .18896+000  .60624-002   .10578-001
    5--   .62500-003   .33617+001 *  .19052+000  .61357-002   .10521-001

      FINAL PARAMETER ESTIMATES              (APPROX. ST. DEV.)
      1  ALPHA                .190403          ( .2208-001)
      2  A                    .613287-002      ( .3492-003)
      3  B                    .105268-001      ( .8827-003)

      RESIDUAL     STANDARD DEVIATION =          3.3616723120
      RESIDUAL     DEGREES OF FREEDOM =           211
      REPLICATION STANDARD DEVIATION =           3.2817626894
      REPLICATION DEGREES OF FREEDOM =           192
      LACK OF FIT F RATIO =      1.5474 = THE  92.6461% POINT OF THE
      F DISTRIBUTION WITH      19 AND     192 DEGREES OF FREEDOM
```

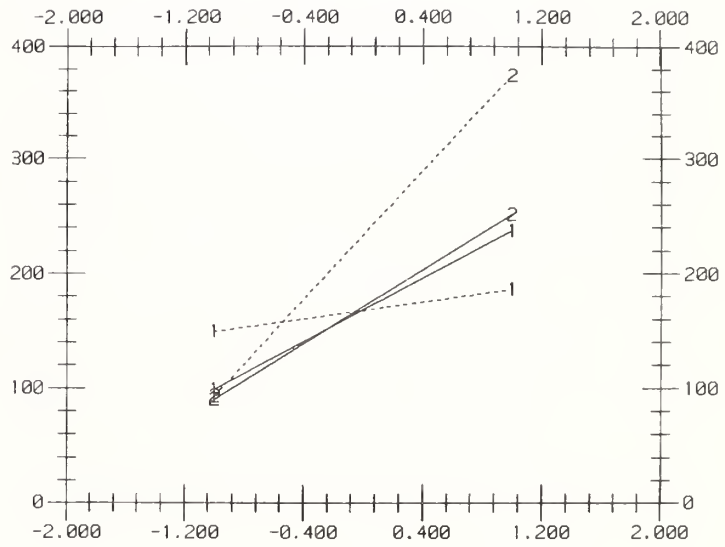


3. The Data Analysis Problem--
An analyst has data consisting of a response variable and 3 independent variables (factors). Determine if the factors affect the response. Determine if there is interaction between the factors. Carry out an analysis of variance. Carry out a graphical analysis of variance.

The DATAPLOT program and output is as follows--

```
READ FILE3. Y X1 X2 X3
ANOVA Y X1 X2 X3
.
LET TAG = X2+2*(X3-1)
CHARACTERS 1 1 2 2
LINES SOLID DOTTED SOLID DOTTED
PLOT Y X1 TAG
```

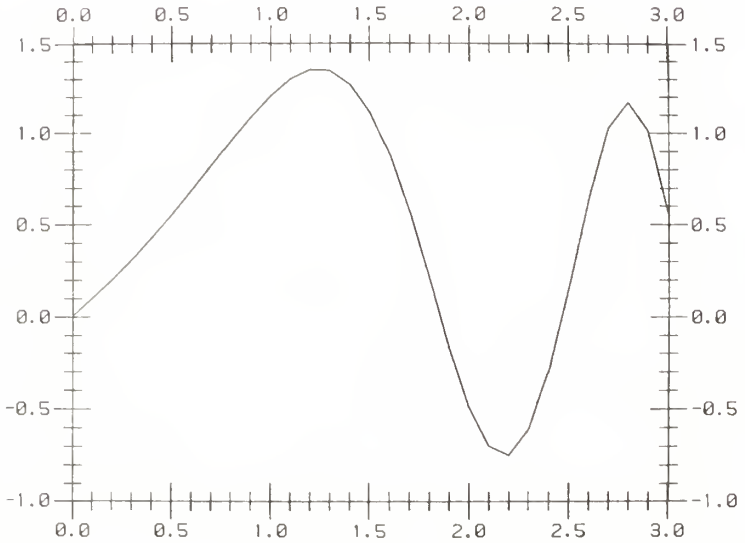
```
                ***********************************
                ***********************************
                **  3-WAY ANALYSIS OF VARIANCE   **
                ***********************************
                ***********************************

     NUMBER OF OBSERVATIONS              =         8
     NUMBER OF FACTORS                   =         3
     NUMBER OF LEVELS FOR FACTOR 1       =         2
     NUMBER OF LEVELS FOR FACTOR 2       =         2
     NUMBER OF LEVELS FOR FACTOR 3       =         2
     RESIDUAL     STANDARD DEVIATION     =     .65340454102+002
     RESIDUAL     DEGREES OF FREEDOM     =         4
     NO REPLICATION CASE
     NUMBER OF DISTINCT CELLS            =         8

                      *****************
                      *  ESTIMATION   *
                      *****************

     GRAND MEAN                          =     .18487500000+003
     GRAND STANDARD DEVIATION            =     .90256431500+002

              LEVEL-ID       N1       MEAN       EFFECT     SD(EFFECT)
-------------------------------------------------------------------------
FACTOR  1--   -1.00000        4.   107.75000   -77.12500    23.10134
        --    1.00000        4.   262.00000    77.12500    23.10134

FACTOR  2--   -1.00000        4.   169.25000   -15.62500    23.10134
        --    1.00000        4.   200.50000    15.62500    23.10134

FACTOR  3--   -1.00000        4.   167.75000   -17.12500    23.10134
        --    1.00000        4.   202.00000    17.12500    23.10134


        MODEL                  RESIDUAL STANDARD DEVIATION
-----------------------------------------------------------
CONSTANT              ONLY--          99.2564315796
CONSTANT & FACTOR  1 ONLY--          59.6891250610
CONSTANT & FACTOR  2 ONLY--         105.6881385880
CONSTANT & FACTOR  3 ONLY--         105.3697853088
CONSTANT & ALL 3 FACTORS --          65.3404541016

                      *************
                      *  TESTING  *
                      *************

              NUM. LEVELS    F STAT.          F CDF
-----------------------------------------------------
FACTOR  1--         2      11.14592280925    97.113%
FACTOR  2--         2        .45747328177    46.410%
FACTOR  3--         2        .54952422529    50.033%

     RESIDUAL     STANDARD DEVIATION =          65.34045410156
     RESIDUAL     DEGREES OF FREEDOM =                4
```



4. The Mathematics Problem--
*An analyst wishes to examine the function x*exp(-x) + sin(x**2) over the interval 0 to 3. Plot the function over the interval. Determine any roots in the interval. Determine its definite integral over the interval.*

The DATAPLOT program and output is as follows--

```
LET FUNCTION F = X*EXP(-X)+SIN(X**2)
PLOT F FOR X = 0 .1 3
LET R = ROOTS F WRT X FOR X = 0 TO 3
LET INT = INTEGRAL F WRT X FOR X = 0 TO 3
```




```
INTEGRAL EVALUATION
      FUNCTION--(X*EXP(-X)+SIN(X**2))
      SPECIFIED LOWER LIMIT OF INTEGRAL  =          .0000000000
      SPECIFIED UPPER LIMIT OF INTEGRAL  =         3.0000000000
      NUMBER OF VARIABLES OF INTEGRATION =                   1

NUMBER OF     *       VALUE OF
PARTITIONS    *       INTEGRAL
--------------*--------------------

       1      *    .1574414+001
       2      *    .1574414+001

INTEGRAL VALUE        =    .1574414+001

THE COMPUTED VALUE OF THE CONSTANT   INT      =    .1574414+001
```

```
ROOTS OF AN EQUATION
      FUNCTION--(X*EXP(-X)+SIN(X**2))
      ROOT VARIABLE                      = X
      SPECIFIED LOWER LIMIT OF INTERVAL =          .0000000000
      SPECIFIED UPPER LIMIT OF INTERVAL =         3.0000000000

      NUMBER OF ROOTS FOUND IN INTERVAL =        3

ROOT     1 =    .0000000
ROOT     2 =    .1853707+001
ROOT     3 =    .2464136+001

THE NUMBER OF VALUES GENERATED FOR THE VARIABLE R        =        3

THE FIRST         COMPUTED VALUE OF R        =    .0000000     (ROW     1)
THE LAST (    3TH) COMPUTED VALUE OF R       =    .2464136+001 (ROW     3)

THE CURRENT COLUMN FOR THE VARIABLE R        =        1
THE CURRENT LENGTH OF  THE VARIABLE R        =        3

THE COMPUTED VALUE OF THE CONSTANT   NROOTS   =    .3000000+001
```

Programming with DATAPLOT

DATAPLOT programs proceed sequentially from the beginning of the code to the end. The language is structured. There are no "Go-to"-type statements and no statement labels.

Like BASIC, FORTRAN, etc., DATAPLOT has a series of low-level commands which specify to the computer that certain elementary operations (such as reading, writing, looping, etc.) should be carried out.

In addition, however, DATAPLOT goes beyond BASIC and FORTRAN in that it allows the analyst to also make use of a set of high-level commands (such as PLOT, FIT, HISTOGRAM, etc.) which permit the analyst to carry out a wide variety of graphics (continuous or discrete), non-linear fitting, data analysis, and mathematical operations directly.

Like BASIC, DATAPLOT is an interpretive language. Although the language may be used in a semi-interactive mode (running pre-stored programs at a terminal), and a batch mode (running pre-stored programs with remote output on the batch high-speed printer), it was primarily designed for (and is most effectively used in) an interactive environment.

Because of the existence of commonly-used high-level graphical and analytical capabilities, the typical DATAPLOT program is short (e.g., 5 to 20 lines). Usually there is only a main program with no need of subprograms. If subprograms are desired, they are accessed via the CALL command.

Input and output in DATAPLOT is format-free. The READ and SERIAL READ command enter data into DATAPLOT, the WRITE (with PRINT as a synonym) command allows the writing of data (back to the terminal screen or out to a file/subfile).

The DATAPLOT command vocabulary consists of over 100 commands. The analyst may use any command at any time. A given program for a given application typically makes use of a small subset of DATAPLOT commands (10 to 15 commands). The 3 most important DATAPLOT commands are PLOT, FIT, and LET. Other commonly-used commands are CHARACTERS, LINES, TITLE, ...LABEL (as in YLABEL, XLABEL, X2LABEL, and X3LABEL), FONT, TEXT, ECHO, HARDCOPY, READ, WRITE, and STATUS.

The universal separator between words on a DATAPLOT command line is a blank (1 or more blanks). The comma is never used in any DATAPLOT command syntax; when in doubt, use a blank rather than a comma, as in

```
WRITE A B C
```

rather than

```
WRITE A,B,C
```

English-Syntax Language

DATAPLOT is an English-syntax language. Many of the command statements are identical to their English-language counterparts, for example,

PLOT
FIT
HISTOGRAM
NORMAL PROBABILITY PLOT
ANOVA
SMOOTH
BOX PLOT

Thus to generate a plot of the function sin(x)/x for the values starting with x = .1, at increments of .1, and ending with x = 12, one would enter

```
PLOT SIN(X)/X FOR X = .1 .1 12
```

*And if the analyst has data in variables Y and X and wishes to carry out a least squares fit of Y on X with the model y = a+b*exp(-c*x), one would enter*

```
FIT Y = A+B*EXP(-C*X)
```

And if the analyst has data in the variable X and wishes to form a new variable Y defined as the natural logarithm of X, one enters

```
LET Y = LOG(X)
```

The net result is that DATAPLOT programs are easy to write, easy to understand, and easy to update. This is particularly important for the analyst with no prior programming experience.

Free-Format Language

Command statements appear free-format in columns 1 to 80 of a program line.

*The usual separator between components of a command line is a blank (one or more blanks). Thus to generate a plot of X**2 over the interval of x values starting with x = -3, at increments of .1, and ending with x = +3, the following is incorrect--*

```
PLOTX**2FORX=-3.13
```

while the following is correct--

```
PLOT X**2 FOR X = -3 .1 3
```

*Note the spacing between PLOT, X**2, FOR, X, -3, .1, AND 3. The spacing here is 1 blank, but optionally could have been any number of blanks. The PLOT statement as given here starts in column 1, but optionally could have been any column.*

Packing of characters is permitted only in defining and using functions. Thus

```
PLOT 3+2*EXP(-X) FOR X = 0 .1 6
```

is correct, as is

```
PLOT 3 + 2 * EXP(-X) FOR X = 0 .1 6
```

and other variations.

If command statements are longer than 80 characters, then they may be extended onto the next line by appending ... at the end of the first line, as in

```
PRE-FIT Y = A + B*EXP(-C*X) FOR A = 10 1 20 ...
FOR B = 1 .1 2 FOR C = .5 .01 .6
```

Command statements longer than 2 full lines (160 characters) are not permitted.

Declaration-Free Language

The elements of the DATAPLOT language which the analyst may create, redefine, and operate on are

parameters = named constants
variables = named vectors
functions = named character strings

Names used for parameters/variables/functions may be up to 8 characters, must start with an alphabetic character, and may thereafter be any combination of the 26 alphabetic characters and the 10 numeric characters. Names which are longer than 8 characters may be used but only the first 8 characters are scanned and internally stored.

DATAPLOT is a declaration-free language--one need not pre-define parameter, variable, and function names in a separate section unto itself (as with ALGOL and PASCAL); in fact, one does not pre-define such elements at all--one simply introduces these elements along the way as needed by the program and as dictated by the analysis.

Once a name is defined (as a parameter, a variable, or a function), it remains that type throughout the DATAPLOT run (thus, for example, if X is used as a variable, it will remain a variable for the entire run). If the analyst chooses to change the use of a name (for example, to change a variable X to a function X) in the middle of a run, then the analyst must first delete the name (via the DELETE command, as in DELETE X), and then reuse the name in the desired fashion.

Structured Language

Program execution--whether in the main routine or within a subprogram)--always flows from top to bottom, and so DATAPLOT is by design a structured language. DATAPLOT does not have statement labels and therefore is a "GO-TO-less" language. In practice, because of the existence of higher-level graphics/analysis commands, and because of the DATAPLOT feature of being able to append subset and conditionality qualifiers at the end of any high-level graphics and analysis command, the need for such branching has been virtually eliminated. The net result is a structured, top-to-bottom language structure which greatly facilitates the writing and updating of programs.

Branching within a (sub)program is not permitted; branching between subprograms may be done via the CALL command, as in

CALL ANALYSIS.

where ANALYSIS. is the name of the (analyst-created) file where the subprogram resides (the period at the end of the file name tells DATAPLOT that ANALYSIS is the name of a mass storage file name as opposed to, for example, the name of a parameter, variable, or function).

Punctuation

*The universal separator for components in a DATAPLOT command line is the space (= blank). A blank between the words of a command line are important because DATAPLOT uses such spaces as a separator Spaces around relational operators (e.g., =, <, >=, etc.), arithmetic operators (+, -, *, /, and **), and within arithmetic expressions (e.g., B**2-4*A*C) may be included or excluded at the preference of the analyst. Readability considerations suggest that spaces be included around such operators and in such expressions.*

Commas serve no purpose in DATAPLOT and may at times be the cause of syntax errors. There are no commands which call for the use of commas in DATAPLOT; when in doubt, leave a space rather than a comma. Blanks and spaces within mathematical and functional expressions are solely for visual convenience--they may be included or excluded at the discretion of the analyst; as in

```
LET Y = A+B*EXP(-ALPHA+BETA*X)
LET Y = A + B*EXP(-ALPHA + BETA*X)
```

Command statements appear free-format in columns 1 to 80 of a program line. If a statement is longer than this, it may be continued onto the next line by appending a ... at the end of the first line. Statements longer than 2 full lines (160 characters) are not permitted.

DATAPLOT also expects no punctuation in data files which are read via the READ and SERIAL READ commands. Adjacent numbers on a line image may be free-format but should be separated by at least one blank. Commas between numbers will usually be ignored by DATAPLOT, but if error messages are generated because of them on a READ, the commas should be replaced by a blank via the local editor. Alphabetic information up at the beginning of a data file may be skipped over via the SKIP command, as in

```
SKIP 5
```

which will cause subsequent READ and SERIAL READ commands to skip over all information on line images 1 to 5 of the file. The ROW LIMITS command allows the analyst to focus only on specified line iamges of a file, as in

```
ROW LIMITS 6 100
```

The COLUMN LIMITS command allows the analyst to focus only on certain column limits in reading a file, as in

```
COLUMN LIMITS 1 50
```

which would be a way of omitting non-numeric (or numeric) information beyond column 50.

Language Components

The DATAPLOT language consists of the following components--

1) *commands;*
2) *arithmetic operators;*
3) *relational operators;*
4) *numbers;*
5) *parameters;*
6) *variables;*
7) *functions;*
8) *sub-commands under the LET command;*
9) *keywords;*
10) *in-line text sub-commands;*
11) *file and subfile references.*

Commands

There are 6 DATAPLOT command categories--

Graphics commands;
Analysis commands;
Diagrammatic Graphics commands;

Plot Control commands;
Support commands;
Output Device Commands.

The first 3 categories are of primary interest. The commands in these categories are all active in the sense that they all "do something"--a plot is generated, an analysis (e.g., an ANOVA or a least squares fit) is carried out, or a geometric figure (e.g., a box or circle) is drawn out on the screen. The commands in these categories could very well constitute an end in itself for the experimental objectives of the analyst.

On the other hand, the commands, in the last 3 categories are of secondary importance--they are rarely end objectives of an analysis; rather these commands typically play some intermediate role in assuring that the analyst carries out precisely the analysis as desired. Typical examples of such secondary commands are

1) *reading data in from a file (reading data in is never the end objective--it is only the first step in an analysis);*

2) *specifying that calculations should be carried out in degrees rather than radians for trigonometric calculations;*

3) *specifying the title and labels for succeeding plots;*

4) *specifying line types (e.g., dotted) for succeeding plots;*

5) *specifying the desired graphics output device (e.g., the Zeta plotter).*

Clearly such commands are not ultimate objectives in an analysis; on the other hand, the absence of such commands would severely handcuff the analyst in carrying out the desired analysis.

Graphics Commands

All commands in this category generate a plot. This category provides for the analyst a set of graphical analysis tools for plotting data and functions. the most important (and most heavily-used) command in this category is PLOT. Other frequently-used commands are HISTOGRAM and ... PROBABILITY PLOT (especially NORMAL PROBABILITY PLOT).

Graphics Commands

Command	*Description*	*Default*	*Example*
PLOT	*Generate plot of var &/or func*	*N/A*	*PLOT Y X*
3-D PLOT	*Generate 3-dimensional plot of var &/or func*	*N/A*	*3-D PLOT Z Y X*
... HISTOGRAM	*Generate histogram--cum, rel, or cum rel*	*N/A*	*HISTOGRAM Y*
... FREQUENCY PLOT	*Generate frequency plot--cum, rel, or cum rel*	*N/A*	*FREQUENCY PLOT Y*
PIE CHART	*Generate pie chart*	*N/A*	*PIE CHART Y*
PERCENT POINT PLOT	*Generate percent point plot*	*N/A*	*PERCENT POINT PLOT Y*
... PROBABILITY PLOT	*Generate probability plot (24 distributions)*	*N/A*	*NORMAL PROBABILITY PLOT Y*
... PPCC PLOT	*Generate prob plot corr coef plot (9 families)*	*N/A*	*WEIBULL PPCC PLOT*
... NORMALITY PLOT	*Generate normality plot (Box-Cox family only)*	*N/A*	*BOX-COX NORMALITY PLOT Y*
RUN SEQUENCE PLOT	*Generate run sequence plot*	*N/A*	*RUN SEQUENCE PLOT Y*
LAG ... PLOT	*Generate lag plot for a given lag number*	*N/A*	*LAG 1 PLOT Y*
... CORRELATION PLOT	*Generate auto- or cross-correlation plot*	*N/A*	*AUTOCORRELATION PLOT Y*
... SPECTRAL PLOT	*Generate auto-, cross-, etc spectral plot*	*N/A*	*SPECTRAL PLOT Y*
... PERIODOGRAM	*Generate auto- or cross-periodogram*	*N/A*	*PERIODOGRAM Y*
COMPLEX DEMODULATION ... PLOT	*Generate complex demodulation amp or phase plot*	*N/A*	*COMPLEX DEMODULATION PHASE PLOT Y*
BOX PLOT	*Generate box plot*	*N/A*	*BOX PLOT Y X*
I PLOT	*Generate I plot*	*N/A*	*I PLOT Y X*
... CONTROL CHART	*Generate mean, sd, or range control chart*	*N/A*	*MEAN CONTROL CHART Y X*

Analysis Commands

All commands in this category generate printed output. This category provides the analyst with a set of quantitative/statistical/mathematical tools which serve as an analytic complement to the graphical techniques of the prior category. The most important commands in this category are FIT and LET.

Analysis Commands

Command	*Description*	*Default*	*Example*
LET	*Define var & param; calc stat; roots/diff/int*	*N/A*	*LET Y=X**LAMBDA+EXP(-A*X**2)*
LET FUNCTION	*Define & operate on func; differentiate func*	*N/A*	*LET FUNCTION F1=A0/(1+B1*X**2)*
SUMMARY	*Compute summary statistics*	*N/A*	*SUMMARY Y*
... FIT	*Perform least squares linear or non-linear fit*	*N/A*	*FIT Y=A+B*EXP(-C*X)*
... PRE-FIT	*Perform pre-fit analysis for starting values*	*N/A*	*PRE-FIT X**A FOR A = 1 .1 2*
EXACT ... RATIONAL FIT	*Perform exact rational function fit*	*N/A*	*EXACT 1/2 RATIONAL FIT Y2 X2 Y X*
... SPLINE FIT	*Perform spline fit*	*N/A*	*CUBIC SPLINE FIT Y X*
... SMOOTH	*Perform smoothing of equi-spaced data*	*N/A*	*CUBIC SMOOTH Y*
ANOVA	*Perform analysis of variance*	*N/A*	*ANOVA Y X1 X2*
MEDIAN POLISH	*Perform analysis of variance*	*N/A*	*ANOVA Y X1 X2*

Diagrammatic Graphics Commands

The commands in this category are used for the superposition of text on any output, and for the construction of diagrams, schematics, and specialized charts. The most important commands in this category are FONT, HW, JUSTIFICATION, ERASE, MOVE, TEXT, and COPY.

Diagrammatic Graphics Commands

Command	*Description*	*Default*	*Example*
FONT	*Specify script font*	*N/A*	*FONT TRIPLEX ITALIC*
HEIGHT	*Specify height of letters*	*N/A*	*HEIGHT 10*
WIDTH	*Specify width of letters*	*N/A*	*WIDTH 7*
HW	*Specify height and width of letters*	*N/A*	*HW 10 7*
JUSTIFICATION	*Specify justification (left/center/right)*	*N/A*	*JUSTIFICATION CENTER*
CASE	*Specify script case (upper vs. lower)*	*N/A*	*CASE LOWER*
ERASE	*Erase current screen*	*N/A*	*ERASE*
COPY	*Copy the current screen onto local hardcopy*	*N/A*	*COPY*
RING BELL	*Ring bell*	*N/A*	*RING BELL 10*
CROSS-HAIR (or CH)	*Activate cross-hair*	*N/A*	*CROSS-HAIR A B*
TEXT	*Write out script text*	*N/A*	*TEXT GRAPHICS*
MOVE	*Move to given coordinates on the screen*	*N/A*	*MOVE 50 50*
DRAW	*Draw from present location to specified coor.)*	*N/A*	*DRAW 50 50 60 60*
POINT	*Draw a point*	*N/A*	*POINT 50 50*
ARROW	*Draw an arrow*	*N/A*	*ARROW 50 50 60 60*
TRIANGLE	*Draw a triangle*	*N/A*	*TRIANGLE 50 50 60 50 55 60*
BOX	*Draw a box*	*N/A*	*BOX 50 50 60 60*
HEXAGON	*Draw a hexagon*	*N/A*	*HEXAGON 50 50 60 50*
CIRCLE	*Draw a circle*	*N/A*	*CIRCLE 50 50 60 50*
SEMI-CIRCLE	*Draw a semi-circle*	*N/A*	*SEMI-CIRCLE 50 50 60 50*
ARC	*Draw an arc*	*N/A*	*ARC 50 50 60 50 70 40*
ELLIPSE	*Draw an ellipse*	*N/A*	*ELLIPSE 50 50 60 45 70 50*
OVAL	*Draw an oval*	*N/A*	*OVAL 50 50 60 45 70 50*
DIAMOND	*Draw a diamond*	*N/A*	*DIAMOND 50 50 60 45 70 50*
AMPLIFIER	*Draw an amplifier*	*N/A*	*AMPLIFIER 50 50 60 50*
CAPACITOR	*Draw a capacitor*	*N/A*	*CAPACITOR 50 50 60 50*
GROUND	*Darw a ground*	*N/A*	*GROUND 50 50 60 50*
INDUCTOR	*Draw an inductor*	*N/A*	*INDUCTOR 50 50 60 50*
RESISTOR	*Draw a resistor*	*N/A*	*RESISTOR 50 50 60 50*
AND	*Draw an and box*	*N/A*	*AND 50 50 60 50*
OR	*Draw an or box*	*N/A*	*OR 50 50 60 50*
NAND	*Draw a nand box*	*N/A*	*NAND 50 50 60 50*
NOR	*Draw a nor box*	*N/A*	*NOR 50 50 60 50*

Plot Control Commands

The commands in this category allow the analyst to specify the details of plots which are generated in the Graphics command category. The most important commands in this category are CHARACTERS, LINES, TITLE, and ...LABEL (especially YLABEL and XLABEL).

Command	Description	Default	Example
CHARACTERS	Specify plot character types	all blank	CHARACTERS A B CIRCLE STAR
CHARACTER SIZES	Specify size (height) for characters on plots	red	CHARACTERS SIZES 3 3 5 7
LINES	Specify plot line types	all solid	LINES SOLID DOT DASH DASH2
TITLE	Specify title at top of plot	no title	TITLE SPECTROMETRIC ANALYSIS
TITLE SIZE	Specify plot title size (height)	automatic	TITLE SIZE 4
...LABEL	Specify labels at sides & bottom of plot	no labels	YLABEL RESPONSE
...LABEL SIZE	Specify size (height) for labels on plots	red	X3LABEL COLOR BLUE
...MINIMUM	Specify minima for plot axes	automatic	YMINIMUM 250
...MAXIMUM	Specify maxima for plot axes	automatic	YMAXIMUM 300
...LIMITS	Specify limits (min and max) for plot axes	automatic	YLIMITS 250 300
BELL	Specify automatic plot bell (ON/OFF)	OFF = no bell	BELL ON
PRE-SORT	Specify automatic pre-plot sort (ON/OFF)	ON = pre-sorted	PRE-SORT OFF
SEQUENCE	Specify auto seq numbering for plots (ON/OFF)	OFF = no seq numb	SEQUENCE ON
...GRID	Specify plot grid lines (ON/OFF)	OFF = no grid lines	GRID OFF
...LOG	Specify axis scale as logarithmic (ON/OFF)	OFF = linear scale	YLOG ON
...FRAME	Specify plot frames (ON/OFF)	ON = frame	FRAME OFF
FRAME CORNER COORDINATES	Specify plot frame location and shape	15 20 90 90	CORNER COORDINATES 20 20 75 90
LEGEND ...	Specify plot legends	no legends	LEGEND 1 NO CATALYST
LEGEND ... COORDINATES	Specify plot legend positioning	20 85	LEGEND 1 COORDINATES 75 85
LEGEND ... SIZE	Specify size (height) for legends on plots	red	LEGEND 1 COLOR BLUE
ARROW ... COORDINATES	Specify location of arrows on plots	no default	ARROW 2 COORDINATES 29 80 50 50
BOX ... CORNER COORDINATES	Specify location of boxes on plots	no default	BOX 3 CORNER COORDINATES 5 5 9 9
SEGMENT ... COORDINATES	Specify location of line segments on plots	no default	SEGMENT 4 30 80 50 50
...TIC MARK	Specify tic marks on plots (ON/OFF)	ON = tic marks	TIC MARK OFF
...TIC MARK COORDINATES	Specify plot tic mark positioning	automatic	TIC MARK COORDINATES 1500 2500
...TIC MARK POSITION	Specify plot tic mark positioning	through the frame	TIC MARK POSITION INSIDE
...TIC MARK SIZE	Specify plot tic mark size	automatic	TIC MARK SIZE 2
...TIC MARK LABEL	Specify plot tic mark labelling (ON/OFF)	automatic	X1TIC MARK LABEL MALE FEMALE
...TIC MARK LABEL SIZE	Specify plot tic mark labelling size (height)	automatic	X1TIC MARK LABEL SIZE 2
EYE COORDINATES	Specify eye location for 3-dimensional plot	max + 5*range	EYE COORDINATES 20 20 50
ORIGIN COORDINATES	Specify reference origin for 3-dimensional plot	(xmin,ymin,zmin)	ORIGIN COORDINATES 50 200 200
PEDESTAL	Specify 3-d plot with pedestal (ON/OFF)	OFF = no pedestal	PEDESTAL ON
PEDESTAL SIZE	Specify size for pedestal on plots	red	PEDESTAL SIZE 2000
VISIBLE	Specify 3-d bkgrd lines visibility (ON/OFF)	ON = visible	VISIBLE OFF
CHARACTER COLORS	Specify colors for characters on plots	red	CHARACTER COLORS RED BLUE GREEN
LINE COLORS	Specify colors for lines on plots	red	LINE COLORS RED BLUE GREEN YELLOW
TITLE COLOR	Specify color for title on plots	red	TITLE COLOR ORANGE
...LABEL COLOR	Specify colors for labels on plots	red	XLABEL COLOR GREEN
...FRAME COLOR	Specify colors for frame on plots	red	FRAME COLOR RED
...TIC MARK COLOR	Specify color of tic marks on plots	red	TIC MARK COLOR BLUE
...TIC MARK LABEL COLOR	Specify color for tic mark labelling on plots	red	X1TIC MARK LABEL COLOR RED
BACKGROUND COLOR	Specify color of background on plots	blue	BACKGROUND COLOR GREEN
MARGIN COLOR	Specify color of margin on plots	blue	MARGIN COLOR GREEN
LEGEND ... COLOR	Specify color for legends on plots	all red	LEGEND 1 COLOR BROWN
ARROW ... COLOR	Specify colors for arrows on plots	red	ARROW 2 COLOR BLUE
SEGMENT ... COLOR	Specify colors for line segments on plots	red	SEGMENT 4 COLOR BLACK
BOX ... COLOR	Specify colors for box frame on plots	red	BOX 3 COLOR GREEN
PEDESTAL COLOR	Specify color of pedestal on 3d-plots	red	PEDESTAL COLOR GREEN

Support Commands

The commands in this category allow the analyst to carry out important secondary operations (such as input/output), and to specify a variety of settings which will allow an analysis to be tailored precisely to one's specifications. The most important commands in this category are READ, END OF DATA, WRITE, ECHO, EXIT, STATUS, and HELP.

Support Commands

Command	Description	Default	Example
READ	Read variables	Read from terminal	READ CALIB. Y X
SERIAL READ	Read variables serially	Read from terminal	SERIAL READ CALIB. Y X
WRITE	Write (terminal/mass storage) var, param, func	Write to terminal	WRITE CALIB2. Y X LAB PRED RES
SKIP	Specify number of header lines to skip for READ	0 = no lines	SKIP 5
ROW LIMITS	Specify row limts for READ and SERIAL READ	rows 1 to infinity	ROW LIMITS 50 100
COLUMN LIMITS	Specify column limts for READ and SERIAL READ	columns 1 to 132	COLUMN LIMITS 10 40
END OF DATA	Define end of data for READ and SERIAL READ	N/A	END OF DATA
ECHO	Specify auto echo of command lines (ON/OFF)	OFF = no echo	ECHO ON
FEEDBACK	Allow/suppress all feedback printing (ON/OFF)	ON = allow messages	FEEDBACK OFF
PRINTING	Allow/suppress all analysis printing (ON/OFF)	ON = printing	PRINTING OFF
RESET	"Zero-out" all var, param, func, etc	N/A	RESET
SAVE	Dump all var/param/func to mass storage	N/A	SAVE SCRATCH4.
RESTORE	Restore all saved var/param/func from mass stg	N/A	RESTORE SCRATCH4.
EXIT	Exit from DATAPLOT	N/A	EXIT
STATUS	Print status of all lines, char, var, param	N/A	STATUS
DIMENSION	Specify dimensions of internal data storage	10 var x 1000 obs	DIMENSION 20 VARIABLES
DELETE	Delete variables or elements of a variable	N/A	DELETE Y(5) X(5) LAB(5)
RETAIN	Retain variables or elements of a variable	N/A	RETAIN Y X MAT SUBSET LAB 4
NAME	Assign (equate) additional names to variables	N/A	NAME Y 1 X 2 LAB 3
COMMENT	Insert a comment line in code	N/A	COMMENT DILUTION ANALYSIS
.	Insert a comment line in code	N/A	. CARRY OUT ANALYSIS ON LAB 4
IMPLEMENT	Activate local change to DTPLT. implementation	As initialized	IMPLEMENT 3
PRE-ERASE	Specify auto pre-erase for plots (ON/OFF)	ON = pre-erase	PRE-ERASE ON
CREATE	Create a subprogram	N/A	CREATE PROG3.
END OF CREATE	End Creation of a subprogram	N/A	END OF CREATE
CALL	Execute a DATAPLOT subprgm from mass stg	N/A	CALL PROG3.
LOOP	Initiate a loop	N/A	LOOP FOR A = 2 .1 5
END OF LOOP	Terminate a loop	N/A	END OF LOOP
IF	Define start of conditionally-executed code	N/A	IF FOR A > 5
END OF IF	Define end of cond tionally-executed code	N/A	END OF IF
TRIGONOMETRIC UNITS	Specify trigonometric units	radians	TRIGONOMETRIC UNITS DEGREES
RADIANS	Specify radians for trig calculations (ON/OFF)	ON = radians	RADIANS ON
DEGREES	Specify degrees for trig calculations (ON/OFF)	OFF = radians	DEGREES ON
GRADS	Specify grads for trig calculations (ON/OFF)	OFF = radians	GRADS ON
CLASS ...LOWER	Spec. first class lower lim for HISTOGRAM, etc	xbar - 6*s	CLASS LOWER -150
CLASS ...UPPER	Spec. last class upper lim for HISTOGRAM, etc	xbar + 6*s	CLASS UPPER 150
CLASS ...WIDTH	Specify class width for HISTOGRAM, etc	0.3*s	CLASS WIDTH 10
DEMODULATION FREQUENCY	Specify frequency for complex demodulation	no default	DEMODULATION FREQUENCY .3
FILTER WIDTH	Specify filter width for SMOOTH	3	FILTER WIDTH 7
FIT CONSTRAINTS	Specify constraints for FIT & PRE-FIT	OFF = no constraint	FIT CONSTRAINTS A . 0 B = 5
FIT ITERATIONS	Specify upper bound on iterations for FIT	50	FIT ITERATIONS 30
FIT POWER	Specify fit criterion power for PRE-FIT & FIT	2 = least squares	FIT POWER 1
FIT STANDARD DEVIATION	Specify lower bound on res sd for FIT	.000005	FIT STANDARD DEVIATION .0001
KNOTS	Specify knots variable for SPLINE	OFF = no knots	KNOTS 10 20 40 80
WEIGHTS	Specify weights variable for FIT, PRE-FIT, etc	OFF = equi-weighted	WEIGHTS W

COMMUNICATIONS LINK	Specify link (phone, network, etc.) to host	the "local" link	COMMUNINCATIONS LINK NETWORK
BAUD RATE	Specify baud rate	9600	BAUD RATE 9600
HOST	Specify host computer	the "local" host	HOST VAX 11/780
CURSOR COORDINATES	Specify cursor coordinates after a command	Next line	CURSOR COORDINATES 5 5
CURSOR SIZE	Specify cursor size after a plot	1.5	CURSOR SIZE 3
ERASE DELAY	Specify delay factor for erase	1	ERASE DELAY 3
HARDCOPY DELAY	Specify delay factor for hardcopy	1	HARDCOPY DELAY 3
HELP	Print short documentation for a given command	List 7 categories	HELP PLOT
NEWS	Print general news from DATAPLOT service org	no default	NEWS
MAIL	Print message from DATAPLOT service org to user	no default	MAIL SMITH
BUGS	List known bugs	no default	BUGS
OPERATOR	Send a message to the host console operator	N/A	OPERATOR WHEN SCHEDULED REBOOT?
MESSAGE	Write message to DATAPLOT service organization	no default	MESSAGE CALL J. SMITH (EXT. 3862
TIME	Display (wall clock) time and elapsed run time	N/A	TIME
PROBE	Dump contents of underlying FORTRAN parameter	N/A	PROBE NUMCOL
SET	Set contents of underlying FORTRAN parameter	N/A	SET NUMCOL
TERMINATOR CHARACTER	Specify character to terminate commands	;	TERMINATOR CHARACTER #

Output Device Commands

The commands in this category deal with the specification of output devices. As with the previous category, the commands in this category are secondary in nature. The most important commands in this category are HARDCOPY, DISCRETE, BATCH, and TERMINAL.

Output Device Commands

Command	*Description*	*Default*	*Example*
TERMINAL	*Specify terminal model or power (ON/OFF)*	*TEKTRONIX 4014*	*TERMINAL TEKTRONIX 4027*
CONTINUOUS	*Specify continuity (ON/OFF) for terminal*	*ON*	*CONTINUOUS ON*
PICTURE POINTS	*Specify number of picture points for terminal*	*4096 BY 3024*	*PICTURE POINTS 72 24*
COLOR	*Specify color (ON/OFF) for terminal*	*OFF*	*COLOR ON*
DISCRETE	*Specify primary output--discr nw term (ON/OFF)*	*OFF = contin term*	*DISCRETE NARROW-WIDTH ON*
DISCRETE NARROW-WIDTH	*Specify primary output--discr nw term (ON/OFF)*	*OFF = contin term*	*DISCRETE NARROW-WIDTH ON*
BATCH	*Specify primary output--batch (ON/OFF)*	*OFF = contin term*	*BATCH ON*
DISCRETE WIDE-CARRIAGE	*Specify primary output--discr wc term (ON/OFF)*	*OFF = contin term*	*DISCRETE WIDE-CARRIAGE ON*
HARDCOPY	*Specify secondary output--local hdcpy (ON/OFF)*	*OFF = no hdcpy outp*	*HARDCOPY ON*
PENPLOTTER	*Specify secondary output--penplotter (ON/OFF)*	*OFF = no penpl outp*	*PENPLOTTER ON*
CALCOMP	*Specify secondary output--Calcomp (ON/OFF)*	*OFF = no Calcp outp*	*CALCOMP ON*
VERSATEC	*Specify secondary output--Versatec (ON/OFF)*	*OFF = no Vers outp*	*VERSATEC ON*
ZETA	*Specify secondary output--Zeta (ON/OFF)*	*OFF = no Zeta outp*	*ZETA ON*
DEVICE ... POWER	*Specify power (ON/OFF) for a device*	*ON for dev 1 (only)*	*DEVICE 2 POWER ON*
DEVICE ... MANUFACTURER	*Specify manufacturer for a device*	*ON for dev 1 (only)*	*DEVICE 2 MANUFACTURER FR-80*
DEVICE ... CONTINUOUS	*Specify continuous (ON/OFF) for a device*	*ON for dev 1 (only)*	*DEVICE 3 CONTINUOUS ON*
DEVICE ... PICTURE POINTS	*Specify number of picture points for a device*	*4096 by 3124*	*DEVICE 1 PICTURE POINTS 4096 30*
DEVICE ... COLOR	*Specify color (ON/OFF) for a device*	*ON for dev 1 (only)*	*DEVICE 1 COLOR ON*

Keywords

Keywords are reserved words which are not commands in themselves, but rather are special words which may appear at various points within a command line. Some keywords are built-in parameter names (such as PI, INFINITY, RESSD, etc.); some keywords are built-in variable names (such as PRED and RES); some keywords are components in other commands (such as VERSUS and AND for PLOT); some keywords are optional and powerful extensions to a variety of commands (such as SUBSET, EXCEPT, and FOR). The most important keywords are AND, VERSUS, SUBSET, EXCEPT, FOR, PRED, RES, and =.

Keywords

Command	Description	Default	Example
AND	Used with PLOT, etc for multi-trace plots	N/A	PLOT Y X AND
VERSUS	Used with PLOT, etc for multi-trace plots	N/A	PLOT Y1 Y2 Y3 VERSUS X
SUBSET	Qualifier denoting subset of interest	N/A	PLOT Y X SUBSET LAB 4
EXCEPT	Qualifier denoting excepted subset	N/A	FIT Y=A+X**B EXCEPT LAB 9
FOR	Qualifier denoting elts or var of interest	N/A	PLOT SIN(X) FOR X = 0 .1 6.3
I	Var denoting dummy index; used in FOR	N/A	LET Y(I) = X(I+20) FOR I = 1 1 20
TO	Specify interval of values within a variable	N/A	PLOT Y X SUBSET LAB 4 TO 9
PI	Parameter with value 3.1415926	3.1415926	LET Y = SIN(2*PI*F*T)
INFINITY	Param with value "infinity"	largest real value	DELETE Y X FOR Y = 50 TO IN
PRED	Var with predicted values from FIT, etc	N/A	PLOT Y PRED VERSUS X
RES	Var with residuals from FIT, ANOVA, etc	N/A	PLOT RES X
RESSD	Param with res sd from FIT, ANOVA, etc	N/A	PRINT RESSD
RESDF	Param with res deg of freedom from FIT etc	N/A	PRINT RESDF
REPSD	Param with replication sd from FIT, ANOVA, etc	N/A	PRINT REPSD
REPDF	Param with rep deg of freedom from FIT etc	N/A	PRINT REPDF
LOFCDF	Param with lack of fit cdf value from FIT, etc	N/A	PRINT LOFCDF
WRT	"With respect to"; used with LET for roots, etc	N/A	LET FUNCTION G=DERIVATIVE F WRT X
COEF	Var where FIT, ANOVA, etc coef stored	N/A	PRINT COEF
COEFSD	Var where FIT, ANOVA, etc coef sd stored	N/A	PRINT COEFSD
DEMODF	Param with updated complex demodulation freq	N/A	PRINT DEMODF
ON	Set a switch to "on" position	N/A	CALCOMP ON
OFF	Set a switch to "off" position	N/A	CALCOMP OFF
AUTOMATIC	Set a switch to "automatic" position	N/A	LIMITS AUTOMATIC
DEFAULT	Set a switch to "default" position	N/A	EYE COORDINATES DEFAULT
VERTICALLY	Rotate contents (but not frame) of plot	N/A	PLOT VERTICALLY X**2 FOR X=0 1 10
=	"Equal"; used in FIT, PRE-FIT, FOR, etc	N/A	FIT Y = A+B*LOG(-C*X)
<>	"Not equal to"	N/A	LET Y = 1/X SUBSET X <> 0
<	"Less than"	N/A	FIT Y = U+EXP(-A*X) SUBSET X < 2
<=	"Less than or equal to"	N/A	FIT Y = U+EXP(-A*X) SUBSET X <= 2
>	"Greater than"	N/A	DELETE Y X LAB SUBSET Y > 100
>=	"Greater than or equal to"	N/A	DELETE Y X LAB SUBSET Y >= 100
;	Terminator character for a command	N/A	PLOT Y PRED VS X; PLOT RES X
...	Continue any statement onto next line	N/A	FIT Y = A0 + A1/X + A2/... X**2 + A3/X**3

Arithmetic Operations

As with FORTRAN, the DATAPLOT language uses the following symbols for arithmetic operations--

```
+   addition
-   subtraction
*   multiplication
/   division
**  exponentiation
```

Also, operations are performed left to right with priorities defined in a fashion identical to FORTRAN--

```
1) exponentiation
2) multiplication and division
3) addition and subtraction
```

Also as in FORTRAN, the order of operations may be altered by use of parentheses--with operations in parentheses being performed first.

The 3 most important DATAPLOT commands are

```
PLOT
FIT
LET
```

These 3 commands also have the most common occurrence of arithmentic operations, as in

```
PLOT 10+X**2 FOR X = 1 1 10
```

which would generate a plot of 10 + X**2 for the values X = 1, at increments of 1, up to 10 (that is, X = 1, 2, ... 10).

```
FIT Y = A+B*LOG(C+X**2)
```

would carry out a non-linear fit of Y on X with the model A + B*LOG(C + X**2)

```
LET A = X*Y+Z**2
```

would compute the parameter or variable A from the parameters or variables X, Y, and Z. If X, Y, and Z were all parameters, then A would become a parameter. If any of the X, Y, or Z were variables, then A would become a variable.

It is also possible to use arithmetic operators in the definition of functions, as in,

```
LET FUNCTION F = X**2
LET FUNCTION G = 10*Y
LET FUNCTION H = A+F/G
```

which would result in the creation of the functions F, G, and H where F = X**2, G = 10*Y, and H = A+(X**2)/(10*Y) . Note that DATAPLOT would automatically provide the needed parentheses in the definition of H.

Relational Operations

DATAPLOT has 6 relational operators--

```
=          equality
<>         inequality

<          less than
<= or =<   less than or equal to

>          greater than
>= or =>   greater than or equal to
```

The spacing within such operators is important--using > = instead of >= will lead to a syntax error or possible erroneous results. Thus to generate a plot of Y versus X but with the plot restricted to those X and Y values for which the LAB variable is 7 or greater, the proper entry is

```
PLOT Y X SUBSET LAB >= 7
```

while

```
PLOT Y X SUBSET LAB > = 7
```

is incorrect.

Spacing around such relational operators is optional and at the analyst's discretion. The following are equivalent--

```
PLOT Y X SUBSET LAB >= 7
PLOT Y X SUBSET LAB>=7

FIT Y = A+B/X
FIT Y=A+B/X

LET Y = (X**LAMBDA)/(LAMBDA+1)
LET Y=(X**LAMBDA)/(LAMBDA+1)
```

Good programming practice and readability, however, suggest that relational operators be surrounded by a blank, as in

```
PLOT Y X SUBSET X < 100
```

rather than

```
PLOT Y X SUBSET X<100
```

Numbers

Numbers are unnamed scalars. They may appear in a variety of different kinds of commands; note the 20 and 50 in

```
BOX 20 20 50 50
```

note the 0, .1 and 10 in

```
PLOT SIN(X) FOR X = 0 .1 10
```

note the 2.5 in

```
LET Y = X+2.5
```

note the 2 in

```
FIT Y = A+B*X+C*X**2
```

With the exception of the FIT and PRE-FIT commands, the general rule in DATAPLOT is that anywhere a number appears in a command line, it could equally well have been replaced by a parameter, as in the following analogues to the above--

```
LET X1 = 20
LET Y1 = 20
LET X2 = 50
LET Y2 = 50
BOX X1 Y1 X2 Y2
```

```
LET START = 0
LET INC = .1
LET STOP = 10
PLOT SIN(X) FOR X = START INC STOP
```

```
LET A = 2.5
LET Y = X+A
```

The FIT and PRE-FIT commands are an exception because the command lines

```
LET D = 2
FIT Y = A+B*X+C*X**D
```

will not be treated in the same manner as

```
FIT Y = A+B*X+C*X**2
```

*In the first case, DATAPLOT will realize that D is a parameter and so (like all parameters appearing in a fit) will determine the least squares estimate for the parameter D along with the other parameters A, B, and C. However, in the second case (FIT Y = A+B*X+C*X**2), DATAPLOT will note the scalar number 2 and fit for the parameters A, B, and C only. Be aware of this distinction in carrying out fits and pre-fits.*

All numbers are stored internally in DATAPLOT as single precision floating point. If the analyst wishes to specify a decimal number, as in

```
LET Y = X**2.378
```

then the decimal point and trailing decimal digits should of course be included. However, if the number happens to be an integer, then the analyst has the choice of including or excluding the trailing decimal point, and including or excluding any trailing zeros--thus the following are all equivalent--

```
LET Y = X**2
LET Y = X**2.
LET Y = X**2.0
LET Y = X**2.00
```

All such expressions will be stored and processed internally by DATAPLOT in an identical fashion--the analyst gains nothing by including the trailing decimal point and zeros. Simplicity dictates that the first form be used, but if the analyst prefers to use other forms, the results will be identical.

*To define numbers with large exponents (for example, 7.4 raised to the 15th power), the analyst should use the ** (exponentiation) operator directly, as in*

```
LET A = 7.4**15
```

The E format (as occurs in FORTRAN) is not permitted; thus

```
LET A = 7.4E15
```

is not a valid DATAPLOT command.

Negative exponents are handled in a similar fashion, as in

```
LET B = 7.4**(-15)
```

Parameters
LET

A parameter is a named scalar and may be defined via the LET command, as in

```
LET A = 17.26
LET B = 3.97
LET C = -5.38
LET D = 2.4*10**(-8)
LET E = B**2-4*A*C
LET F = MEAN X
```

Two internally-provided parameters which the analyst may use are

```
PI
INFINITY
```

PI has the value 3.14159265; INFINITY has the value of the largest floating point number which the user 's computer may store (that is, INFINITY = machine infinity). PI and INFINITY may be used at any time and like any other user-defined parameter, for example,

```
PLOT (1/SQRT(2*PI))*EXP(-0.5*X**2) FOR X = -3 .1 3

FIT Y = A+B*X**C EXCEPT X 100 TO INFINITY
```

Be wary of the use of PI in FIT and PRE-FIT expressions; like all parameters, DATAPLOT will attempt to determine least squares estimates for it. Thus rather than use

```
FIT Y = AMP * SIN(2*PI*F*X)
```

one should explicitly use

```
FIT Y = AMP * SIN(2*3.14159265*F*X)
```

With the exception of the above-mentioned FIT and PRE-FIT exclusion, parameters may be substituted anywhere in which numbers appear. For example, suppose the analyst wished to override the usual plot frame coordinates and specify that all succeeding plots have lower left corner at (20,50) and for the plot to be 30 units wide and 30 units high (that is, have the upper right corner at (50,80). This may be done explicitly by

```
FRAME CORNER COORDINATES 20 50 50 80
```

or alternatively

```
LET X1 = 20
LET Y1 = 50
LET X2 = 50
LET Y2 = 80
FRAME CORNER COORDINATES X1 Y1 X2 Y2
```

or

```
LET X1 = 20
LET Y1 = 50
LET X2 = X1+30
LET Y2 = Y1+30
FRAME CORNER COORDINATES X1 Y1 X2 Y2
```

This capability of substituting parameters for numbers is especially convenient for diagram-construction on terminals which have built-in hardware for inputting screen coordinates via cross-hair, light-pen, or equivalent. Suppose it is desired to draw a line between 2 points on the screen which the analyst will interactively specify via the cross-hair. One way is to

1) raise the cross-hair (via CROSS-HAIR);

2) position it to the first point (via the thumbwheels);

3) input and print the coordinates (via hitting any key (on Tektronix terminals), or by hitting some predesignated key (on other terminls);

4) raise the cross-hair (via CROSS-HAIR);

5) position it to the second point (via the thumbwheels);

6) print the coordinates (via hitting any key);

7) draw the line (via, for example, DRAW 20.4 35.3 78.4 80.5).

An easier way which avoids the handling of absolute numbers and replaces it with the handling of symbolic parameter names is

1) raise the cross-hair (via CROSS-HAIR X1 Y1);

2) position it to the first point (via the thumbwheels);

3) copy the coordinates into X1 and Y1 (via hitting any key);

4) raise the cross-hair (via CROSS-HAIR X2 Y2);

5) position it to the second point (via thumbwheels);

6) copy the coordinates into X2 and Y2 (via hitting any key);

7) draw the line (via DRAW X1 Y1 X2 Y2).

Variables

LET, READ, and SERIAL READ

A variable is a named vector (a named single-dimension array), and may be defined via the LET, READ, and SERIAL READ commands, as in

```
LET Y = SEQUENCE 1 1 10
LET Z = PATTERN 1 2 3 FOR I = 1 1 9
LET U = NORMAL RANDOM NUMBERS FOR I = 1 1 100
LET X2 = X**2-LOG(Y)
LET Y2 = SQRT(X+Y**3)
```

or

```
READ X Y
1 1
2 4
3 9
4 16
5 25
END OF DATA
```

or

```
SERIAL READ X Y
1 1 2 4 3 9 4 16 5 25
END OF DATA
```

Variables are the most commonly-handled component in DATAPLOT, as in

```
PLOT Y X
FIT Y = A+B*LOG(X+C)
LET X2 = LOG(X)
```

Names for variables, parameters, and functions may be of any length, but since only the first 8 characters are scanned and internally stored, no 2 names should be identical for the first 8 characters. Names must start with an alphabetic character, but may be any combination of alphabetic and numeric characters thereafter. It is the author's personal practice (which shows up throughout this manual) to follow the usual mathematical custom of using characters toward the end of the alphabet (X's, Y's, Z's, etc.) to represent variables, of using characters toward the beginning of the alphabet (A's, B's, C's, etc.) to represent parameters, and of using characters in the vicinity of F (e.g., F's, G's, H's, etc.) to represent functions. Note, however, that this is personal preference and not a DATAPLOT requirement.

Functions
LET FUNCTION

A function is a named character string, and may be defined via the LET FUNCTION command, as in

```
LET FUNCTION F = EXP(-0.5*X**2)
LET FUNCTION G = SIN(2*PI*W*T)
LET FUNCTION H = F+LOG(G)
LET FUNCTION F2 = DERIVATIVE F WRT X
```

Functions may be concatenated and built-up piece-by-piece, as in

```
LET FUNCTION NUM = EXP(-ALPHA*X)
LET FUNCTION DENOM = A+B*X
LET FUNCTION RATIO = NUM/DENOM
```

which is equivalent to

```
LET FUNCTION RATIO = EXP(-ALPHA*X)/(A+B*X)
```

Functions may be defined before (or after) the parameters and variables contained in them are created, as in the following example involving a variable transformation--

```
LET FUNCTION F = X**2
.
SERIAL READ X
1 2 3
END OF DATA
.
LET Y = F
```

This last statement (LET Y = F) is equivalent to

```
LET Y = X**2
```

and will (upon execution) result in the Y variable having the values 1, 4, and 9.

A more common example of functions being defined prior to use is in fitting--

```
LET FUNCTION F1 = A1+B1*SQRT(X)
LET FUNCTION F2 = A2+B2*LOG(X)
.
READ X Y
1 1
2 1.5
3 2
4 2.3
5 2.5
END OF DATA
.
FIT Y = F1
FIT Y = F2
```

Evaluating Functions
LET

The LET FUNCTION command and the LET command carry out 2 distinctly different operations-- the LET FUNCTION command allows the analyst to create functions; the LET command allows the analyst to carry out function evaluations.

*For example, suppose it is desired to evaluate the function sqrt(1-0.3*x**2) over the region x = 0 (.01) 1. This may be done in a number of ways; the most direct way is*

```
LET X = SEQUENCE 0 .01 1
LET Y = SQRT(1-0.3*X**2)
WRITE X Y
PLOT Y X
```

The first LET command makes use of the SEQUENCE sub-capability of the LET command to create the variable X with a sequence of 101 values in it-- .00, .01, .02,. .03, ..., .99, 1.00. The second LET command creates a variable Y (also with 101 elements) which has the desired function evalution values in it. The WRITE command generates a list of X and Y values. The PLOT command will generate a plot of Y (vertically) versus X (horizontally).

A second way to evaluate the function would be

```
LET X = SEQUENCE 0 .01 1
LET FUNCTION F = SQRT(1-0.3*X**2)
LET Y = F
WRITE X Y
PLOT Y X
```

*As before, the first LET statement would create the variable X with the specified sequence of 101 values. The LET FUNCTION command would then create the function F consisting of the following 16 characters--SQRT(1-0.3*X**2) . Note that the LET FUNCTION does not carry out a function evaluation--it merely creates a function. The LET Y = F command would then recognize F as a pre-defined function, replace the name F with the specified 16-character string, and carry out the function evaluation. As before, the WRITE command prints out the results of the function evaluation and the PLOT command plots out the results of the function evaluation.*

Note that if our ultimate objective is to simply plot the function (rather than creating variables containing evaluated values of the function), then the above code could be shortened directly to

```
PLOT SQRT(1-0.3*X**2) FOR X = 0 .01 1
```

or

```
LET FUNCTION F = SQRT(1-0.3*X**2)
PLOT F FOR X = 0 .01 1
```

Sub-commands Under the LET Command
Statistics, Mathematics, Random Numbers, Manipulation
LET

The LET command is the single most powerful command in DATAPLOT. The most important capability of the LET command is carrying out function evaluations and variable transformations. Such evaluations/transformations are general--any Fortran-like expression may be used.

In addition, the LET command may also be used by the analyst to carry out a broad spectrum of statistical, mathematical, and manipulative operations. These operations are specified by inclusion of sub-commands under the LET command. These sub-commands fall into 4 general categories--

1. *Computing Statistics*
2. *Performing Mathematical Operations*
3. *Generating Random Numbers*
4. *Miscellaneous*

SUB-COMMANDS UNDER THE LET COMMAND

Computing Statistics on a Variable
(Input is a variable; output is a parameter)

Description	*Sub-Command*	*Example*
Compute sample size (number of observations)	*SIZE (or NUMBER)*	*LET A = SIZE Y*
Compute sample mean	*MEAN*	*LET A = MEAN Y*
Compute sample median	*MEDIAN*	*LET A = MEDIAN*
Compute sample midrange	*MIDRANGE*	*LET A = MIDRANGE Y*
Compute sample midmean	*MIDMEAN*	*LET A = MIDMEAN Y*
Compute sample range	*RANGE*	*LET A = RANGE Y*
Compute sample standard deviation	*STANDARD DEVIATION*	*LET A = STANDARD DEVIATION Y*
Compute sample variance	*VARIANCE*	*LET A = VARIANCE Y*
Compute sample relative standard deviation	*RELATIVE STANDARD DEVIATION*	*LET A = RELATIVE STANDARD DEVIATION Y*
Compute standard deviation of the mean	*STANDARD DEVIATION OF THE MEAN*	*LET A = STANDARD DEVIATION OF THE MEAN Y*
Compute sample third central moment	*THIRD CENTRAL MOMENT*	*LET A = THIRD CENTRAL MOMENT*
Compute sample skewness (stand. 3rd cent. mom.)	*SKEWNESS*	*LET A = SKEWNESS Y*
Compute sample fourth central moment	*FOURTH CENTRAL MOMENT*	*LET A = FOURTH CENTRAL MOMENT Y*
Compute sample kurtosis (stand. 4th cent. mom.)	*KURTOSIS*	*LET A = KURTOSIS Y*
Compute sample minimum	*MINIMUM*	*LET A = MINIMUM Y*
Compute sample maximum	*MAXIMUM*	*LET A = MAXIMUM Y*
Compute sample lower quartile	*LOWER QUARTILE*	*LET A = LOWER QUARTILE Y*
Compute sample upper quartile	*UPPER QUARTILE*	*LET A = UPPER QUARTILE Y*
Compute sample lower hinge	*LOWER HINGE*	*LET A = LOWER HINGE Y*
Compute sample upper hinge	*UPPER HINGE*	*LET A = UPPER HINGE Y*
Compute sample autocovariance	*AUTOCOVARIANCE*	*LET A = AUTOCOVARIANCE Y*
Compute sample autocorrelation	*AUTOCORRELATION*	*LET A = AUTOCORRELATION Y*
Compute sample covariance	*COVARIANCE*	*LET A = COVARIANCE Y X*
Compute sample correlation	*CORRELATION*	*LET A = CORRELATION Y X*
Compute sample rank covariance	*RANK COVARIANCE*	*LET A = RANK COVARIANCE Y X*
Compute sample rank correlation	*RANK CORRELATION*	*LET A = RANK CORRELATION Y X*

Performing Mathematical Operations on a Variable
(Part 1—Input is a variable; output is a parameter)

Description	Sub-Command	Example
Compute sum of elements in a variable	SUM	LET A = SUM Y
Compute product of elements in a variable	PRODUCT	LET A = PRODUCT Y
Compute integral of elements in a variable	INTEGRAL	LET A = INTEGRAL Y X

Performing Mathematical Operations on a Variable
(Part 2—Input is a variable; output is a variable)

Description	Sub-Command	Example
Compute cumulative sums of elts in a var	CUMULATIVE SUM	LET Y2 = CUMULATIVE SUM Y
Compute cumulative products of elts in a var	CUMULATIVE PRODUCT	LET Y2 = CUMULATIVE PRODUCT Y
Compute cumulative integrals of elts in a var	CUMULATIVE INTEGRAL	LET Y2 = CUMULATIVE INTEGRAL Y X
Compute sequential differences of elts in a var	SEQUENTIAL DIFFERENCE	LET Y2 = SEQUENTIAL DIFFERENCE Y
Sort the elements in a variable	SORT	LET Y2 = SORT Y
Rank the elements in a variable	RANK	LET Y2 = RANK Y
Code the elements in a variable	CODE	LET Y2 = CODE Y
Compute convolution of elts in 2 var	CONVOLUTION	LET Y2 = CONVOLUTION Y X

Performing Mathematical Operations on a Function

Description	Sub-Command	Example
Compute roots of a function	ROOTS	LET Y2 = ROOTS EXP(-X)-SIN(X) WRT X FOR X=0 TO
Compute derivative of a function	DERIVATIVE	LET A = DERIVATIVE SQRT(EXP(-X**2) WRT X FOR X=
Compute definite integral of a function	INTEGRAL	LET A = INTEGRAL EXP(-X**2) WRT X FOR X = -3 TC

Generating Random Numbers

Description	Sub-Command	Example
Generate normal N(0,1) random numbers	NORMAL RANDOM NUMBERS	LET Y = NORMAL RANDOM NUMBERS FOR I = 1 1 50
Generate uniform (0,1) random numbers	UNIFORM RANDOM NUMBERS	LET Y = UNIFORM RANDOM NUMBERS FOR I = 1 1 50
Generate logistic random numbers	LOGISTIC RANDOM NUMBERS	LET Y = LOGISTIC RANDOM NUMBERS FOR I = 1 1 50
Generate double exponential rand numb	DOUBLE EXPONENTIAL RANDOM NUMBERS	LET Y = DOUBLE EXPONENTIAL RANDOM NUMBERS FOR I = 1 1 50
Generate Cauchy random numbers	CAUCHY RANDOM NUMBERS	LET Y = CAUCHY RANDOM NUMBERS FOR I = 1 1 50
Generate Tukey lambda random numbers	TUKEY LAMBDA RANDOM NUMBERS	LET Y = TUKEY LAMBDA RANDOM NUMBERS FOR I = 1 1 50
Generate semi-circular random numbers	SEMI-CIRCULAR RANDOM NUMBERS	LET Y = SEMI-CIRCULAR RANDOM NUMBERS FOR I = 1 1 50
Generate triangular random numbers	TRIANGULAR RANDOM NUMBERS	LET Y = TRIANGULAR RANDOM NUMBERS FOR I = 1 1 50
Generate lognormal random numbers	LOGNORMAL RANDOM NUMBERS	LET Y = LOGNORMAL RANDOM NUMBERS FOR I = 1 1 50
Generate halfnormal random numbers	HALFNORMAL RANDOM NUMBERS	LET Y = HALFNORMAL RANDOM NUMBERS FOR I = 1 1 50
Generate t random numbers	T RANDOM NUMBERS	LET Y = T RANDOM NUMBERS FOR I = 1 1 50
Generate chi-squared random numbers	CHI-SQUARED RANDOM NUMBERS	LET Y = CHI-SQUARED RANDOM NUMBERS FOR I = 1 1 50
Generate F random numbers	F RANDOM NUMBERS	LET Y = F RANDOM NUMBERS FOR I = 1 1 50
Generate exponential random numbers	EXPONENTIAL RANDOM NUMBERS	LET Y = EXPONENTIAL RANDOM NUMBERS FOR I = 1 1 50
Generate gamma random numbers	GAMMA RANDOM NUMBERS	LET Y = GAMMA RANDOM NUMBERS FOR I = 1 1 50
Generate beta random numbers	BETA RANDOM NUMBERS	LET Y = BETA RANDOM NUMBERS FOR I = 1 1 50
Generate Weibull random numbers	WEIBULL RANDOM NUMBERS	LET Y = WEIBULL RANDOM NUMBERS FOR I = 1 1 50
Generate extr value type 1 rand numb	EXTREME VALUE TYPE 1 RANDOM NUMBERS	LET Y = EXTREME VALUE TYPE 1 RANDOM NUMBERS FOR I=1 1 50
Generate extr value type 2 rand numb	EXTREME VALUE TYPE 2 RANDOM NUMBERS	LET Y = EXTREME VALUE TYPE 2 RANDOM NUMBERS FOR I=1 1 50
Generate Pareto random numbers	PARETO RANDOM NUMBERS	LET Y = PARETO RANDOM NUMBERS FOR I = 1 1 50
Generate binomial random numbers	BINOMIAL RANDOM NUMBERS	LET Y = BINOMIAL RANDOM NUMBERS FOR I = 1 1 50
Generate geometric random numbers	GEOMETRIC RANDOM NUMBERS	LET Y = GEOMETRIC RANDOM NUMBERS FOR I = 1 1 50
Generate Poisson random numbers	POISSON RANDOM NUMBERS	LET Y = POISSON RANDOM NUMBERS FOR I = 1 1 50
Generate negative binomial random numb	NEGATIVE BINOMIAL RANDOM NUMBERS	LET Y = NEGATIVE BINOMIAL RANDOM NUMBERS FOR I = 1 1 50
Generate a random permutation	RANDOM PERMUTATION	LET Y = RANDOM PERMUTATION FOR I = 1 1 50

Miscellaneous

Description	Sub-Command	Example
Generate a sequence within a var	SEQUENCE	LET Y = SEQUENCE 1 .1 10
Generate a patterned seq within a var	PATTERN	LET Y = PATTERN 1 2 3 4 5 FOR I = 1 1 60
Extract distinct elements from a var	DISTINCT	LET Y = DISTINCT X

For category 1 (Computing Statistics), the input is always a variable and the output is always a parameter. For example, if Y is a variable, then

LET A = MEAN Y

computes the mean of the data in the variable Y and places the result into the parameter A.

For category 2 (Mathematical Operations), there are 3 sub-categories--

2.1) input = variable;
output = parameter;

2.2) input = variable;
output = variable;

2.3) input = function;
output = parameter or variable;

An example of sub-category 2.1 is the SUM operation; if Y is a variable, then

LET A = SUM Y

computes the sum of all the elements in the variable Y, and places that sum into the parameter A.

An example of sub-category 2.2 is the CUMULATIVE SUM operation; if Y is a variable, then

LET Y2 = CUMULATIVE SUM Y

computes the cumulative sum (= partial sum) of the elements in the variable Y, and places the resulting cumulative sums into corresponding elements of the variable Y2; thus

Y2(1) = Y(1)
Y2(2) = Y(1) + Y(2)
Y2(3) = Y(1) + Y(2) + Y(3)
etc.

An example of sub-category 2.3 is the ROOTS operation; if F is a function, then

LET Y = ROOTS F WRT X FOR X = 0 TO 10

determines all of the roots of the function X in the interval 0 to 10 and places those roots (if any found) into the elements of Y. If no roots are found, then Y3 will not be formed; if 1 root is found, then Y3 will be a parameter; if 2 or more roots are found, then Y3 will be a variable.

For category 3 (Computing Random Numbers), the FOR qualification at the end of the command statement tells DATAPLOT not only how many random numbers to generate but also where (into what elements of the variable) to place the random numbers. Thus

LET Y = NORMAL RANDOM NUMBERS FOR I = 1 1 50

generates 50 normal N(0,1) random numbers, and places these 50 numbers into the first 50 elements of the variable Y.

If the analyst enters

LET Y = NORMAL RANDOM NUMBERS FOR I = 101 1

then this instructs DATAPLOT to generate enough random numbers so as to fill

element 101
at increments of 1
up to element 200

of the variable Y (that is, elements 101, 102, 103, 104, ..., 198, 199, 200 of the variable Y); a total of 100 random numbers are generated.

If the analyst enters

LET Y = NORMAL RANDOM NUMBERS FOR I = 101 1

then this instructs DATAPLOT to generate enough random numbers so as to fill

element 101
at increments of 10
up to element 200

of the variable Y (that is, elements 101, 111, 121, 131, ..., 181, 191, of the variable Y); a total of 10 random numbers are generated.

Random numbers may be generated for distributions and distributional families. Note the distinction between a distribution and a distributional family. A distribution has only one prototype shape for the probability density function; this probability density function may be displaced or may be squeezed/expanded due to different location/scale parameters, but nevertheless, there is only one prototype shape for this function. Examples of distributions are

Normal (= Gaussian)
Uniform
Logistic
Double Exponential (= LaPlace)
Cauchy
Semi-Circular
Triangular

Lognormal
Halfnormal

Exponential
Extreme Value Type 1

On the other hand, a distributional family represents not just 1 distribution, but rather a set of distributions. Each different distribution has its own prototype probability density function which changes depending on the value of the shape/tail length parameter for the family. Examples of distributional families are

Tukey lambda

t (= Student's t)
Chi-squared
F

Gamma
Beta
Weibull
Extreme Value Type 2
Pareto

Binomial
Geometric
Poisson
Negative Binomial

When generating random numbers from a distribution, such as

```
LET Y = NORMAL RANDOM NUMBERS FOR I = 1 1 50
```

then the one command line is sufficient. On the other hand, when generating random numbers from a member of a distributional family, then an additional command line is needed so as to specify what member of the family the random numbers are being drawn from. For example, to generate random numbers from the t distribution, the entry

```
LET Y = T RANDOM NUMBERS FOR I = 1 1 50
```

would be incomplete because we have not specified which member of the t family is desired. To rectify this, we precede the above statement with an additional statement which defines the desired NU value, as in

```
LET NU = 5
LET Y = T RANDOM NUMBERS FOR I = 1 1 50
```

or

```
LET NU = 20
LET Y = T RANDOM NUMBERS FOR I = 1 1 50
```

The shape/tail length parameters which need to be defined for the various distributions are

Tukey lambda	LAMBDA
t (= Student's t)	NU
Chi-squared	NU
F	NU1 AND NU2
Gamma	GAMMA
Beta	ALPHA AND BETA
Weibull	GAMMA
Extreme Value Type 2	GAMMA
Pareto	GAMMA
Binomial	N AND P
Geometric	P
Poisson	LAMBDA
Negative Binomial	K AND P

As an aside, note that DATAPLOT allows probability plots to be generated for the same extensive set of distributions and distributional families as enumerated above for random numbers. For distributions, only a single command is needed, as in

```
NORMAL PROBABILITY PLOT Y
```

which generates a normal probability plot of the data in the variable Y; but for distributional families, an additional command is needed to specify the desired member of the family, as in

```
LET NU = 20
T PROBABILITY PLOT Y
```

which generates a t probability plot (with NU = 20) of the data in Y.

For category 4 (Miscellaneous), the input depends on the operation, but the output is a variable. For example,

```
LET Y = SEQUENCE 70 .1 80
```

generates a sequence of numbers

starting with 70
at increments of .1
and stopping with 80.

A total of 101 numbers are generated-- 70, 70.1, 70.2, 70.3, ..., 79.8, 79.9, 80. These 101 values are placed in the first 101 elements of the variable Y.

Built-in Library Functions
LET, LET FUNCTION, PLOT, 3D-PLOT, FIT, and PRE-FIT

*General FORTRAN-like expressions are allowable in the LET, LET FUNCTION, PLOT, 3D-PLOT, FIT, and PRE-FIT commands. These expressions may include any general FORTRAN-like combination of +, -, *, /, and ** operations, as well as any mixture of the following built-in library functions. In all of the following expressions, the X, Y, etc. in the arguments may be DATAPLOT parameters, variables, or functions.*

Examples of usage of such functions are

```
LET Y = EXP(-X)/(2+6*X)
```

which if X is a variable (parameter) will form a corresponding variable (parameter) as given by the function expression.

```
LET FUNCTION F = LOG(2*X)/(EXP(SQRT(X)))
```

defines a function F as given by the expression.

```
PLOT SQRT(1-0.5*X**2) FOR X = 0 .1 1
```

generates a plot of the function at the points 0, at increments of .1, and stopping at 1 (that is, at the points 0, .1, .2, ..., .8, .9, 1).

```
3D-PLOT EXP(-X**2-Y**2) FOR X = -2 .2 2 FOR Y = -2 .2 2
```

generates a 3-dimensional plot of the bivariate surface as given by the function and evaluated at the X points -2, at increments of .2, and stopping at 2; and at the Y points -2, at increments of .2, and stopping at 2. The plot will be a cross-hatched surface. The analyst should have previously entered (via the EYE COORDINATES command) the position of the analyst's eye in viewing the surface, as in EYE COORDINATES 10 11 5.

```
FIT Y = EXP(-ALPHA*X)/(A+B*X)
```

carries out a non-linear fit according to the function.

```
PRE-FIT Y = LOG(A+B*X) FOR A = 1 1 10 FOR B = 1 .1 2
```

carries out a pre-fit according to the function, with the pre-fit carried out over the lattice of points specified by A = 1, 2, 3, ..., 9, 10 and B = 1, 1.1, 1.2, ..., 1.8, 1.9, 2.

The built-in library functions include

1) *General Functions;*
2) *Trigonometric Functions;*
3) *Probability Functions.*

The general mathematical functions include various FORTRAN-library entries, plus Chebychev, Bessel, octal-decimal conversions, etc.

The trigonometric functions are much more extensive than the usual FORTRAN library. The DATAPLOT library includes all circular functions, all inverse circular functions, all hyperbolic functions, and all inverse hyperbolic functions.

The probability functions include cumulative distribution functions, probability density functions, and percent point functions (= inverse cumulative distribution functions) for 4 common distributions/distributional families, namely--

Normal
t
Chi-squared
F

Such functions are useful for hypothesis testing.

General Functions--

escription	Function	Example
bsolute value	ABS(X)	LET Z = A + B*EXP(ABS(X) + C)
quare root	SQRT(X)	LET Z = A + B*EXP(SQRT(X) + C)
xponential	EXP(X)	LET Z = A + B*EXP(EXP(X) + C)
ogarithm (natural)	LN(X)	LET Z = A + B*EXP(LN(X) + C)
ogarithm (natural)	LOG(X)	LET Z = A + B*EXP(LOG(X) + C)
ogarithm (base 10)	LOG10(X)	LET Z = A + B*EXP(LOG10(X) + C)
ogarithm (base 2)	LOG2(X)	LET Z = A + B*EXP(LOG2(X) + C)
ign	SIGN(X)	LET Z = A + B*EXP(SIGN(X) + C)
nteger portion	INT(X)	LET Z = A + B*EXP(INT(X) + C)
ractional portion	FRACT(X)	LET Z = A + B*EXP(FRACT(X) + C)
odulo	MOD(X,Y)	LET Z = A + B*EXP(MOD(X,Y) + C)
inimum	MIN(X,Y)	LET Z = A + B*EXP(MIN(X,Y) + C)
aximum	MAX(X,Y)	LET Z = A + B*EXP(MAX(X,Y) + C)
ositive difference-- x-min(x,y)	DIM(X,Y)	LET Z = A + B*EXP(DIM(X,Y) + C)
ctal to decimal conversion	OCTDEC(X)	LET Z = A + B*EXP(OCTDEC(X) + C)
ecimal to octal conversion	DECOCT(X)	LET Z = A + B*EXP(DECOCT(X) + C)
rror function	ERF(X)	LET Z = A + B*EXP(ERF(X) + C)
omplementary error function	ERFC(X)	LET Z = A + B*EXP(ERFC(X) + C)
amma function	GAMMA(X)	LET Z = A + B*EXP(GAMMA(X) + C)
og (to the base e) Gamma function	LOGGAMMA(X)	LET Z = A + B*EXP(LOGGAMMA(X) + C)
hebychev polynomial of the first kind and order 0	CHEB0(X)	LET Z = A + B*EXP(CHEB0(X) + C)
hebychev polynomial of the first kind and order 1	CHEB1(X)	LET Z = A + B*EXP(CHEB1(X) + C)
hebychev polynomial of the first kind and order 2	CHEB2(X)	LET Z = A + B*EXP(CHEB2(X) + C)
hebychev polynomial of the first kind and order 3	CHEB3(X)	LET Z = A + B*EXP(CHEB3(X) + C)
hebychev polynomial of the first kind and order 4	CHEB4(X)	LET Z = A + B*EXP(CHEB4(X) + C)
hebychev polynomial of the first kind and order 5	CHEB5(X)	LET Z = A + B*EXP(CHEB5(X) + C)
hebychev polynomial of the first kind and order 6	CHEB6(X)	LET Z = A + B*EXP(CHEB6(X) + C)
hebychev polynomial of the first kind and order 7	CHEB7(X)	LET Z = A + B*EXP(CHEB7(X) + C)
hebychev polynomial of the first kind and order 8	CHEB8(X)	LET Z = A + B*EXP(CHEB8(X) + C)
hebychev polynomial of the first kind and order 9	CHEB9(X)	LET Z = A + B*EXP(CHEB9(X) + C)
hebychev polynomial of the first kind and order 10	CHEB10(X)	LET Z = A + B*EXP(CHEB10(X) + C)
essel function of the first kind and order 0	BESS0(X)	LET Z = A + B*EXP(BESS0(X) + C)
essel function of the first kind and order 1	BESS1(X)	LET Z = A + B*EXP(BESS1(X) + C)

Trigonometric Functions--

Description	Function	Example
Sine	SIN(X)	LET Z = A + B*EXP(SIN(X) + C)
Cosine	COS(X)	LET Z = A + B*EXP(COS(X) + C)
Tangent	TAN(X)	LET Z = A + B*EXP(TAN(X) + C)
Cotangent	COT(X)	LET Z = A + B*EXP(COT(X) + C)
Secant	SEC(X)	LET Z = A + B*EXP(SEC(X) + C)
Cosecant	CSC(X)	LET Z = A + B*EXP(CSC(X) + C)
Arcsine	ARCSIN(X)	LET Z = A + B*EXP(ARCSIN(X) + C)
Arccosine	ARCCOS(X)	LET Z = A + B*EXP(ARCCOS(X) + C)
Arctangent	ARCTAN(X)	LET Z = A + B*EXP(ARCTAN(X) + C)
Arccotangent	ARCCOT(X)	LET Z = A + B*EXP(ARCCOT(X) + C)
Arcsecant	ARCSEC(X)	LET Z = A + B*EXP(ARCSEC(X) + C)
Arccosecant	ARCCSC(X)	LET Z = A + B*EXP(ARCCSC(X) + C)
Hyperbolic Sine	SINH(X)	LET Z = A + B*EXP(SINH(X) + C)
Hyperbolic Cosine	COSH(X)	LET Z = A + B*EXP(COSH(X) + C)
Hyperbolic Tangent	TANH(X)	LET Z = A + B*EXP(TANH(X) + C)
Hyperbolic Cotangent	COTH(X)	LET Z = A + B*EXP(COTH(X) + C)
Hyperbolic Secant	SECH(X)	LET Z = A + B*EXP(SECH(X) + C)
Hyperbolic Cosecant	CSCH(X)	LET Z = A + B*EXP(CSCH(X) + C)
Hyperbolic Arcsine	ARCSINH(X)	LET Z = A + B*EXP(ARCSINH(X) + C)
Hyperbolic Arccosine	ARCCOSH(X)	LET Z = A + B*EXP(ARCCOSH(X) + C)
Hyperbolic Arctangent	ARCTANH(X)	LET Z = A + B*EXP(ARCTANH(X) + C)
Hyperbolic Arccotangent	ARCCOTH(X)	LET Z = A + B*EXP(ARCCOTH(X) + C)
Hyperbolic Arcsecant	ARCSECH(X)	LET Z = A + B*EXP(ARCSECH(X) + C)
Hyperbolic Arccosecant	ARCCSCH(X)	LET Z = A + B*EXP(ARCCSCH(X) + C)

Probability Functions--

Description		Function	Example
Normal N(0,1)	cumulative distribution function	NORCDF(X)	LET Z = A + B*EXP(NORCDF(X) + C)
t	cumulative distribution function	TCDF(X,NU)	LET Z = A + B*EXP(TCDF(X) + C)
Chi-squared	cumulative distribution function	CHSCDF(X,NU)	LET Z = A + B*EXP(CHSCDF(X) + C)
F	cumulative distribution function	FCDF(X,NU1,NU2)	LET Z = A + B*EXP(FCDF(X) + C)
Normal N(0,1)	probability density function	NORPDF(X)	LET Z = A + B*EXP(NORPDF(X) + C)
t	probability density function	TPDF(X,NU)	LET Z = A + B*EXP(TPDF(X) + C)
Chi-squared	probability density function	CHSPDF(X,NU)	LET Z = A + B*EXP(CHSPDF(X) + C)
F	probability density function	FPDF(X,NU1,NU2)	LET Z = A + B*EXP(FPDF(X) + C)
Normal N(0,1)	percent point function	NORPPF(X)	LET Z = A + B*EXP(NORPPF(X) + C)
t	percent point function	TPPF(X,NU)	LET Z = A + B*EXP(TPPF(X) + C)
Chi-squared	percent point function	CHSPPF(X,NU)	LET Z = A + B*EXP(CHSPPF(X) + C)
F	percent point function	FPPF(X,NU1,NU2)	LET Z = A + B*EXP(FPPF(X) + C)

Creating Parameters, Variables, and Functions

LET, LET FUNCTION, READ, and SERIAL READ

A parameter is a named scalar and may be defined via the LET command, as in

```
LET A = 17.26
LET B = 3.97
LET C = -5.38
LET D = 2.4*10**(-8)
LET E = B**2-4*A*C
LET F = MEAN X
```

A variable is a named vector (a named single-dimension array), and may be defined via the LET, READ, and SERIAL READ commands, as in

```
LET Y = SEQUENCE 1 1 10
LET Z = PATTERN 1 2 3 FOR I = 1 1 9
LET U = NORMAL RANDOM NUMBERS FOR I = 1 1 100
LET X2 = X**2-LOG(Y)
LET Y2 = SQRT(X+Y**3)
```

or

```
READ X Y
1 1
2 4
3 9
4 16
5 25
END OF DATA
```

or

```
SERIAL READ X Y
1 1 2 4 3 9 4 16 5 25
END OF DATA
```

A function is a named character string, and may be defined via the LET FUNCTION command, as in

```
LET FUNCTION F = EXP(-0.5*X**2)
LET FUNCTION G = SIN(2*PI*W*T)
LET FUNCTION H = F+LOG(G)
LET FUNCTION F2 = DERIVATIVE F WRT X
```

Functions may be concatenated and built-up piece-by- piece, as in

```
LET FUNCTION NUM = EXP(-ALPHA*X)
LET FUNCTION DENOM = A+B*X
LET FUNCTION RATIO = NUM/DENOM
```

which is equivalent to

```
LET FUNCTION RATIO = EXP(-ALPHA*X)/(A+B*X)
```

Copying Parameters, Variables, and Functions

LET

Copying parameters, variables, and functions is just a special case of more general operations involving the creation of parameters, variables, and functions.

Parameters may be copied via the LET command, as in

```
LET B = A
LET C = A
```

If A in the above examples is a parameter, then B and C will become parameters with the same value as A.

Variables may be copied with the LET command, as in

```
LET Y = X
LET Z = X
```

If X in the above examples is a variable, then Y and Z will become variables with the same values as X.

Functions may be copied via the LET FUNCTION command, as in

```
LET FUNCTION G = F
LET FUNCTION H = F
```

If F in the above examples is a function, then G and H will become functions with the same character string as F.

Deleting Parameters, Variables, and Functions
DELETE

The DELETE command will cause parameters, variables, and functions to be deleted. The form for the delete command is

```
DELETE   list of parameters, variables,
         and/or function names
```

Thus, to delete parameters A and B, variables X and Y, and functions F and G, one could enter

```
DELETE A
DELETE B
DELETE X
DELETE Y
DELETE F
DELETE G
```

or simply

```
DELETE A B X Y F G
```

Note that the DELETE command may be used in conjunction with SUBSET/EXCEPT/FOR qualifications to accomplish a partial or selected delete of elements within variables (partial deleting of parameters and functions may not be done). Whenever a partial delete of a variable is done, then the undeleted elements in the variable are automatically "packed" into the first available elements of the variable. For example,

```
DELETE X Y SUBSET LAB 4
```

would delete all elements in X and Y corresponding to LAB 4 (and pack all remaining elements of X and Y). Note that X and Y would end up with the same number of elements, but the LAB variable would be unchanged and so would be longer and "out of alignment" with the new X and Y. To circumvent this, one could have entered

```
DELETE X Y LAB SUBSET LAB 4
```

which would carry out the delete, and result in the variables X, Y, and LAB all having the same (shortened) length. The DELETE may be used with any general SUBSET/EXCEPT/FOR qualification. In particular,

```
DELETE X Y FOR I = 1 1 20
```

would delete elements 1 through 20 of variables X and Y. The net result is that element 21 would shift up and become element 1, element 22 would become element 2, etc.

Specific elements of a variable may be deleted by explicit referencing of the element; for example,

```
DELETE X(4) Y(10) Z(30)
```

which would delete the 4-th element of X, the 10-th element of Y, and the 30-th element of Z. Immediately after the deletion is done, the remaining elements in the variable are packed. To delete successive elements in the same variable, the analyst should delete the higher elements first and then proceed to the lower elements. Thus to delete elements 2, 7, and 15 of variable X, one should enter

```
DELETE X(15) X(7) X(2)
```

which is equivalent to

```
DELETE X(15)
DELETE X(7)
DELETE X(2)
```

rather than

```
DELETE X(2) X(7) X(15)
```

which is equivalent to

```
DELETE X(2)
DELETE X(7)
DELETE X(15)
```

Because of the successive packing after each deletion, the latter code would not yield the desired results-- the former code should be used. (Note that one need not heed this caution when one uses the SUBSET/EXCEPT/FOR qualification for deleting elements).

A practical example of when the deletion of specific elements would be useful is when the analyst has a variable Y, and suspects (perhaps via a lag-1 plot) that the i-th element of Y was related to the (i-1)st element of Y, in such a fashion that a first-order autoregressive model would be appropriate. To carry this out one could enter

```
LET Y1 = Y
LET N = NUMBER Y
DELETE Y1(1)
DELETE Y(N)
FIT Y = A0+A1*Y1
```

The above code would

1) *Copy Y into Y1*
   (the elements of Y remain unaffected);

2) *Determine the number of elements in Y*
   (place this into the parameter N);

3) *Delete the first element of Y1*
   (and shift all remaining elements up 1);
   note that Y1 now has N-1 elements;

4) *Delete the last element of Y*
   (so that Y also has N-1 elements);

5) *Carry out a least squares linear fit of Y on Y1; thus yielding a first-order autoregressive fit.*

Partial deletion of variables may also be done via the RETAIN command. The form is the same, but the RETAIN command will retain only those elements specified, and delete all others. As with the DELETE command, the remaining elements are "packed" into the first available elements after the deletion is done. Thus

```
RETAIN X Y FOR I = 10 1 20
```

would delete all elements in X and Y except those from 10 to 20. These 11 elements would then be shifted up to become elements 1 to 11 of the new, shortened variables X and Y. The new length of X and Y would be 11.

Assigning Multiple Names to a Variable

NAME

The NAME command allows the analyst to attach more than 1 name to a variable. For example, suppose a variable X existed, to attach an additional name (X2, say) to X, one would enter

```
NAME X2 X
```

The net effect is that the name X2 would be attached to the name X, and either of the 2 names could be used at any time after that to refer to the same variable. Note that

```
NAME X2 X
```

is different than

```
LET X2 = X
```

The latter would in fact create a second variable X2 and fill it with values of the variable X. This second variable X2 is distinct from X (and takes up additional space in the internal DATAPLOT data storage area).

One may use the NAME command to attach as many different names as desired to an existing variable. To check what names are currently attached to a variable, the analyst should enter the STATUS command.

Renaming variables is not commonly done but does have application when used in conjunction with subprograms. Suppose, for example, that one has constructed a general subprogram that is residing in a file ANALYSIS, and which is written in general terms so as to operate on variables Y and X, such as

```
PLOT Y X
SUMMARY Y
FIT Y = A+B*X
CHARACTER X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

How can one use this subprogram if the variables in the main program are called something other than X and Y? This is done via the NAME command, for example,

```
READ DAY1. PRES1 VOL1
NAME X PRES1
NAME Y VOL1
TITLE CALIBRATION 1
CALL ANALYSIS.
.
READ DAY2. PRES2 VOL2
NAME X PRES2
NAME Y VOL2
TITLE CALIBRATION 2
CALL ANALYSIS.
.
READ DAY3. PRES3 VOL3
NAME X PRES3
NAME Y VOL3
TITLE CALIBRATION 3
CALL ANALYSIS.
```

The above code would

1) read data from file DAY1 into the variables PRES1 and VOL1;

2) assign the additional name X to PRES1;

3) assign the additional name Y to VOL1;

4) specify the title (of future plots) to be CALIBRATION 1

5) invoke the subprogram residing in file ANALYSIS so as to carry out an analysis;

6) read data from file DAY2 into the variables PRES2 and VOL2;

7) assign the additional name X to PRES2;

8) assign the additional name Y to VOL2;

9) specify the title (of future plots) to be CALIBRATION 2

10) invoke the subprogram residing in file ANALYSIS so as to carry out an analysis;

11) read data from file DAY3 into the variables PRES3 and VOL3;

12) assign the additional name X to PRES3;

13) assign the additional name Y to VOL3;

14) specify the title (of future plots) to be CALIBRATION 3

15) invoke the subprogram residing in file ANALYSIS so as to carry out an analysis.

Creating Data Internally
LET, READ, and SERIAL READ

The most common way to create data in DATAPLOT is to simply read it in via the READ and SERIAL READ commands. Such data is usually read from an external mass storage file. Occasions arise, however, where it is convenient to create data internal to a DATAPLOT program. For example, in carrying out a spline fit, it is required to specify a variable containing the knot positions. The LET command may be used directly to create elements of a variable. For example,

```
LET X(1) = 20
LET X(2) = 55
LET X(3) = 23.66
```

will result in the first element of the variable X being set to the value 20, the second element of the variable X being set to 55, and the third element of the variable X being set to 23.66. Other related forms for this use of the LET command are shown in the following program--

```
LET A = 23
LET X(4) = A
LET X(5) = X(2)
LET X(6) = A+SQRT(2.4)
LET J = 7
LET K = 3
LET X(J) = Y(K)
```

The above code will

1) define a parameter A with the value 23;

2) set the fourth element of the variable X equal to A (which currently has value 23);

3) set the fifth element of the variable X to the same value as the second element of the variable X;

4) set the sixth element of the variable X equal to A+SQRT(2.4)--note that A has the value 23;

5) set the parameter J = 7;

6) set the parameter K = 3;

7) set the J-th element of the variable X to the same value as the K-th element of the variable Y-- note that J and K currently have the values 7 and 3, respectively.

Note that if an element appears on the right side of the assignment statement, it must not be part of an arithmentic expression; thus

```
LET A = X(2)
LET B = X(5)
LET X(10) = A + B**2
```

are legal, but

```
LET X(10) = X(2) + X(5)**2
```

will result in an error message.

The SEQUENCE sub-form of the LET command allows the analyst to create a variable consisting of a sequence of numbers. The general form is

```
LET  variable  =  SEQUENCE  start  increment  stop
      name                  value              value
```

as in

```
LET X = SEQUENCE 1 1 10
```

which would result in the creation of a variable X with the 10 values--1, 2, ..., 9, 10. The command

```
LET Y = SEQUENCE 0 .1 20
```

creates the variable Y with 201 values--0, .1, .2, ..., 19.9, 20.

```
LET Z = SEQUENCE 10 -.1 -10
```

creates the variable Z with 201 values--10, 9.9, 9.8, ..., -9.9, -10.

```
LET START = 1
LET INC = .01
LET STOP = 2
LET U = SEQUENCE START INC STOP
```

creates the parameters START, INC, and STOP, and then creates the variable U with 101 values--1, 1.01, 1.02, ..., 1.99, 2.

The PATTERN sub-form of the LET command allows the analyst to create a variable consisting of a pattern of numbers. The general form is

```
LET  variable  =  PATTERN  sequence of values
      name
```

as in

```
LET X = PATTERN 1 2 3 4 5 6 7 8 9 10
```

which would result in the creation of a variable X with the 10 values--1, 2, ..., 9, 10. The command

```
LET Y = PATTERN 1 2 3
```

creates the variable Y with 3 values--1, 2, and 3.

```
LET Z = PATTERN 1 1 1 2 2 2 3 3 3
```

creates the variable Z with 9 values--1, 1, 1, 2, 2, 2, 3, 3, and 3. To repeat patterns, one simply augments the PATTERN sub-form with a FOR qualification; for example,

```
LET X = PATTERN 1 2 3 FOR I = 1 1 12
```

creates a variable X with 12 values-- 1, 2, 3, 1, 2, 3, 1, 2, 3, 1, 2, 3.

```
LET Z = PATTERN 1 1 1 2 2 2 3 3 3 FOR I = 1 1 18
```

creates a variable Z with 18 values--1, 1, 1, 2, 2, 2, 3, 3, 3, 1, 1, 1, 2, 2, 2, 3, 3, 3. The use of the PATTERN command arises in connection with forming a variable (if not already available) for defining individual traces in a multi-trace plot, and in defining a variable for carrying out ANOVA and graphical ANOVA.

To generate random numbers internally, the analyst uses the RANDOM NUMBERS subform of the LET command. The general form is

```
LET    variable = distribution  RANDOM NUMBERS FOR I = start   increment     stop
         name         name                              value                 value
```

The distribution name identifies the distribution from which random numbers are to be drawn. The FOR qualification at the end of the command tells DATAPLOT into which elements of the variable the random numbers are to be placed. Thus

```
LET X = NORMAL RANDOM NUMBERS FOR I = 1 1 100
```

will generate 100 normal random numbers and place them into elements 1 to 100 of variable X.

```
LET X = NORMAL RANDOM NUMBERS FOR I = 1 2 50
LET X = CAUCHY RANDOM NUMBERS FOR I = 2 2 50
```

will generate 25 normal random numbers and place them into elements 1, 3, 5, ..., 49 of variable X, and then generate 25 Cauchy random numbers and place them into elements 2, 4, 6, ..., 48, 50 of variable X. To specify particular members of a distributional family, specify the distributional parameter value prior to use of the RANDOM NUMBER sub-form, as in

```
LET NU = 5
LET X = T RANDOM NUMBERS FOR I = 1 1 30
```

which will generate 30 random numbers from the t distribution with nu = 5 degrees of freedom.

```
LET GAMMA = 2.57
LET X = WEIBULL RANDOM NUMBERS FOR I = 1 1 200
```

will generate 200 random numbers from the Weibull distribution with gamma = 2.57.

The final 2 ways to create data internally in a DATAPLOT program involve the use of READ and SERIAL READ commands. If one excludes the specification of a mass storage file/subfile, then the data may be specified immediately in the program as in

```
READ X
20
55
23.66
END OF DATA

SERIAL READ X
20 55 23.66
END OF DATA
```

Both of the above will create a variable X with the 3 values--20, 55, and 23.66.

Files and Subfiles

The DATAPLOT commands which may contain file/subfile specifications are--

READ	read data from a file;
SERIAL READ	read sequential data from a file;
WRITE	write data out to a file;
CREATE	dynamically create a subprogram;
CALL	execute a subprogram;
SAVE	save all internal DATAPLOT settings;
RESTORE	restore all internal DATAPLOT settings.

The DATAPLOT convention in designating files and subfiles is as follows--

1) qualifier;
2) qualifier-file separator (an asterisk);
3) file name;
4) file name-subfile name separator (a period);
5) subfile name.

The qualifier is typically a user identifier, a project identifier, or simply an extended file name. The qualifier allows the computer to distinguish between 2 files which nominally have the same name. For example, if analyst SMITH has a file called DATA, and analyst JONES has a file called DATA, then to distinguish between these 2 files called DATA, the analyst may be required to enter SMITH*DATA or JONES*DATA, respectively, as in

```
READ SMITH*DATA. X Y
```

```
READ JONES*DATA. X Y
```

Qualifier names may be up to 12 characters. On some computer systems, the qualifier name is optional; on others, it is required. If optional, and if omitted, then the computer system usually substitutes a default qualifier name that was defined by the user at the time of log-on. For example, on some computers, analyst SMITH may be able to enter

```
READ DATA. X Y
```

as a shorter form of

```
READ SMITH*DATA. X Y
```

The qualifier separator tells DATAPLOT that the qualifier name is finished, and the file name is starting. The separator is typically 1 character in length. At NBS, the separator character is * (an asterisk). Other computers may choose to some other separator besides *. For example, on VAX systems, the separator is usually].

The file name is up to 12 characters. The period at the end of the file name tells DATAPLOT that the file name is finished and the subfile name (if existent) is starting. The period must be appended to all file names in all relevant DATAPLOT commands regardless of whether the system allows subfiles or not. The period is important because it tells DATAPLOT that the entry is a file name as opposed to a variable name. For example, in the READ command, if DATAPLOT encounters

```
READ A. B C
```

then it expects to read from file A and to read the first 2 numbers on each line image of file A into variables B and C. On the other hand, if DATAPLOT encounters

```
READ A B C
```

then the absence of a file name is a signal to DATAPLOT that the data will be read in from the terminal where the first 3 numbers on each line image will be placed into the variables A, B, and C, as in

```
READ A B C
1 1 1
2 4 8
3 9 27
4 16 64
END OF DATA
```

Even though such ambiguity does not exist in other commands, such as

```
SAVE DATA.
```

(which will allow all internal DATAPLOT switch settings to be saved to the file DATA because the DATAPLOT run has to be interrupted for some reason) the DATAPLOT convention (for consistency's sake) is to have all file names appended with a period in all commands; thus

```
SAVE DATA.
```

is correct, while

```
SAVE DATA
```

is incorrect.

Some computer systems allow subfile structure--that is, allow files to be logically subdivided into smaller units which may be treated as logical entities unto themself. For example, UNIVAC systems allow such subfiles, while some computers may not allow subfiles. If the computer system allows subfile structure, then DATAPLOT allows such names to be up to 12 characters, as in

READ DATA.CALIBRATION7 X Y

which would instruct DATAPLOT to read from subfile CALIBRATION7 of file DATA, and to read the first 2 values on each line image into variables X and Y.

The above allowances (12 characters for qualifiers, 12 characters for file names, and 12 characters for subfile names) are DATAPLOT allowances; these limits may be overridden by restrictions on name length imposed by the computer system itself (for example, some may allow only 8 characters for names). The user should check with local system personnel to determine if such restrictions exist.

Input/Output

DATAPLOT input/output is carried out via the following 3 commands--

READ
SERIAL READ
WRITE

All reading and writing is format-free. There are no format statements in DATAPLOT.

The READ and SERIAL READ have 4 auxiliary commands which may at times be of use to the analyst in reading data into DATAPLOT--

SKIP
ROW LIMITS
COLUMN LIMITS
END OF DATA

Reading in Columns of Data

READ

The most common method of inputting data into DATAPLOT is via the READ command. The general form for the READ command is

```
READ    file name. (optional)    list of variable
                                      names
```

In the following examples, data will be read from the terminal (as part of the program)--

```
READ X
READ X Y
READ X Y Z
READ Y1 Y2 Y3 Y4 Y5 Y6 X
READ RESPONSE TEMP VOLUME PRESSURE LAB
```

In the following examples, data will be read from file A. (the period at the end of the file name (A. as opposed to A) is important--it tells DATAPLOT that A is a file and not a variable). The period at the end of the file name is used in the NBS implementation--other implementations may have other punctuation to indicate a file (for example, a slash /). Some punctuation must be used, however, in order for DATAPLOT to distinguish file names from variable names. Check the local DATAPLOT service organization for file indicators at your installation.

```
READ A. X
READ A. X Y
READ A. X Y Z
READ A. Y1 Y2 Y3 Y4 Y5 Y6 X
READ A. RESPONSE TEMP VOLUME PRESSURE LAB
```

The input data file must be an editable file. In particular, such a file may not be a binary file that would (for example) result from a FORTRAN program which uses a formatless write, as in

```
WRITE(7)(X(I),Y(I),I=1,1000)
```

Such a FORTRAN write statement results in a packed, binary output file which is efficiently generated, but nevertheless uneditable. Such a file may not serve as input into DATAPLOT.

Some computers allow subfile structures. Thus in the following examples, data will be read from subfile B of file A--

```
READ A.B X
READ A.B X Y
READ A.B X Y Z
READ A.B Y1 Y2 Y3 Y4 Y5 Y6 X
READ A.B RESPONSE TEMP VOLUME PRESSURE LAB
```

A specific example of reading data in from the terminal itself (or the program itself) is as follows--

```
READ X Y
1 1
2 4
3 9
4 16
5 25
END OF DATA
```

Note that in this case, the read will continue until a line image is encountered which has the END OF DATA command.

If that same data set were to be read from a file A., then the command would be

```
READ A. X Y
```

where the file A. would consist of the following 6 line images--

```
1 1
2 4
3 9
4 16
5 25
END OF DATA
```

or equivalently the following 5 lines--

```
1 1
2 4
3 9
4 16
5 25
```

The reason that the above 2 file structures are equivalent is the DATAPLOT convention that the read from a file (or subfile) will continue until

1) an END OF DATA line image is encountered;
2) an end of file is encountered;

(whichever comes first). The 6-line representation of the data in the file A. is actually redundant (the END OF DATA line image is superfluous) but no harm was done and the result of the read will be the same in both cases.

DATAPLOT input is format-free. Numbers on a line should be separated by at least one space. Missing values on a data file should be converted (e.g., by a local editor) into some numeric value (e.g., -9999) which may subsequently be easily "weeded out" (via SUBSET and EXCEPT qualifications) after being read into DATAPLOT, as in

```
READ A.B X Y
DELETE X Y SUBSET X < -9000
DELETE X Y SUBSET Y < 9000
FIT Y = A+B*EXP(-C*X)
PLOT Y PRED VERSUS X
PLOT RES X
```

If there are more variables specified in the READ statement than there are data values on the line image, as in

```
READ X Y Z U
1 1 1
2 4 8
3 9 27
END OF DATA
```

then an error message will be generated. If there are fewer variables specified than there are data values, as in

```
READ X Y
1 1 1
2 4 8
3 9 27
END OF DATA
```

then only as many data values per line image will be read as there are variables specified (2 in this case), and remaining data values on each line image will be ignored. Thus in the example, the variable X will end up with values 1 2, and 3; and the variable Y will end up with the values 1, 4, and 9. The values 1, 8, and 27 will be ignored.

Data may be in usual floating point representation, as in

```
1.234
-23.6489
26.00054
```

or exponential format, as in

```
1.234+4
1.234E+4
```

Note that the E format is permitted for data on a file/subfile (because such a file is commonly the output from a previously-run FORTRAN program).
(On the other hand, it is recalled that E format is not permitted in any form of the LET command; thus LET A = 1.234E+4 is illegal).

Trailing zeros and the decimal point in integers may be omitted, as in

```
1.0
1.
1
```

Note the following features of reading data into DATAPLOT--

1) data on succeeding line images do not have to be neatly lined up one under the other--the read is free-format;

2) the analyst does not need to be concerned with pre-specifying the number of line images--the READ will continue until an END OF DATA statement is encountered or until an end of file is encountered.

The READ command will generate a feedback message indicating the first line image that was read, the last line image that was read, the number of line images read, and the number of variables read.

Reading from multiple data files may be carried out. Suppose file A. consisted of 5 line images--

```
11
12
13
14
15
```

and file B. consisted of 3 line images--

```
21
22
23
```

then what will be the effect of the following 2 statements--

```
READ A. X
READ B. X
```

The first READ will fill the first 5 locations of X with 11 to 15. The second READ will fill the first 3 locations of X with 21 to 23. The net effect after both reads is that the variable X will contain the following 5 observations--

```
21
22
23
14
15
```

The rule is that all READs always start at the top of a variable unless otherwise directed. This allows variables to be partially overwritten which may (at times) be what the analyst intended. However, the more usual case is that the analyst would like to have data from various files concatenated one behind the other. This may be done by use of SUBSET/EXCEPT/FOR qualifications attached onto the end of the READ statment. For example,

```
READ A. X
READ B. X FOR I = 6 1 8
```

will have what effect? The first READ will (as before) fill the first 5 locations of X with 11 through 15. The second READ tells DATAPLOT to read from file B., but to place the read values internally in the variable X starting with location 6, at increments of 1, up to location 8--thus the 3 data values will be read into locations 6, 7, and 8 of variable X. After both reads, the variable X will contain the following 8 observations--

11
12
13
14
15
21
22
23

With the FOR qualification, we can direct data anywhere we like within a variable (or variables). It is a valuable tool for data entry.

The SUBSET/EXCEPT qualifications on the end of the READ statement behave similarly. They work with variables that have already been defined (via READ, LET, etc.). For example, suppose the analyst already had a variable called LAB which has 15 values (say)--

1
2
1
2
1
2
1
2
1
2
1
2
1
2
1

What would be the effect of the following statement?

READ A. X SUBSET LAB 1

The effect is that the 5 data values (11 through 15) of file A. would be read in, but these data values would not be placed into the first 5 locations of variable X, rather, they would be placed in the first available locations as defined in the SUBSET qualification (SUBSET LAB 1). Since the internal variable LAB has value 1 for locations 1, 3, 5, 7, 9, 11, 13, and 15, then the net effect is that the 5 data values that were read in would be placed in locations 1, 3, 5, 7, and 9 of variable X. What would be in locations 2, 4, 6, etc.? These locations will remain unaffected by the READ, and so they will contain whatever values they had before the READ. (Note that all values in DATAPLOT's internal data area have a default sign-on value of negative machine infinity.) Much more complicated SUBSET/EXCEPT/FOR constructs may be formed, although in practice these complicated constructs are rarely needed--especially for input.

Reading Data in Sequentially
SERIAL READ

All of the comments and conventions for the READ command also hold for the SERIAL READ command except for the following important difference--whereas the READ command only reads a fixed number of data values per line image, the SERIAL READ allows the analyst to read all the data values on a line image. The motivation for this is that some analysts prefer to place data on a file/subfile in a serial fashion (multiple values of a variable on each line image), as opposed to the more common parallel fashion (only 1 value of each variable on each line image). To amplify the difference between READ and SERIAL READ, consider the following--

Suppose the file A. consisted of the following 4 line images--

```
11 12 13 14 15 16
21 22 23 24
31 32
41 42
```

The command

```
READ A. X
```

would result in X having 4 values--11, 21, 31, and 41. The command

```
SERIAL READ A. X
```

would result in X having 14 values--11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 31, 32, 41, and 42.

Further, if instead of reading 1 variable we had read 2 variables, as in

```
READ A. X Y
```

then X would have 4 values--11, 21, 31, and 41; and Y would have 4 values--12, 22, 32, and 42; but the command

```
SERIAL READ A. X Y
```

would result in X having 7 values--11, 13, 15, 21, 23, 31, and 41; and Y having 7 values--12, 14, 16, 22, 24, 32, and 42.

And if instead, we had read in 3 variables, as in

```
READ A. X Y Z
```

then this would have resulted in an error message because lines 3 and 4 contains no Z value; whereas, the command

```
SERIAL READ A. X Y Z
```

would result in variable X having 5 values--11, 14, 21, 24, and 41; variable Y having 5 values--12, 15, 22, 31, and 42; and variable Z having 4 values--13, 16, 23, and 32.

Reading in Parameters
READ PARAMETER

The READ PARAMETER command allows the analyst to read in one or more parameters. The READ PARAMETER command will cause exactly one line image to be read and scanned. Thus

```
READ PARAMETER ZZZ. A B C
```

will cause the next line image of the file ZZZ to be read and scanned, and the first 3 numbers on this line image will be placed into the DATAPLOT parameters A, B, and C. If more than 3 numbers exist on the line, then the remaining numbers will be ignored. If less than 3 numbers exist on the line, then as many parameters as numbers will be formed and the remaining parameters will be ignored.

If no file name is entered, as in

```
READ PARAMETER A B C
```

then the next line image from the terminal (or program) will be used, and so

```
READ PARAMETER A B C
11 12 13
```

will result in creating 3 internal parameters A, B, C, and assigning the value 11 to parameter A, the value 12 to parameter B, and the value 13 to parameter C.

Note that only the next single line is scanned for parameters. This convention was imposed for simplicity, and is no constraint in practice because the analyst may enter multiple READ PARAMETER statements if multiple lines of parameters exist. Thus

```
READ PARAMETER ZZZ. A B C
READ PARAMETER ZZZ. D E F G H
```

with the next 2 lines of file ZZZ. consisting of

```
23.6   -55   212
3400 26.97   85.88   0.0056   10
```

will result in the prescribed 8 parameters being properly defined.

Reading in Functions
READ FUNCTION

The READ FUNCTION command allows the analyst to read in a function. The READ FUNCTION command will cause exactly one line image to be read and scanned. Thus

```
READ FUNCTION ZZZ. F
```

will cause the next line image of the file ZZZ to be read and scanned, and the text on that line to be placed into the DATAPLOT function F. Leading and internal blanks are preserved, but trailing blanks are ignored.

If no file name is entered, as in

```
READ FUNCTION F
```

then the next line image from the terminal (or program) will be used, and so

```
READ FUNCTION F
EXP(-X**2)
```

*will result in the internal function F being created which has the 10-character contents EXP(-X**2).*

Note that only 1 function may be read at a time, and only 1 line is scanned for such a function. Such conventions were imposed for simplicity, and they hardly serve as any constraint on the analyst since functions may be freely concatenated inside DATAPLOT via the LET FUNCTION command. Thus

```
READ FUNCTION ZZZ. F
READ FUNCTION ZZZ. G
LET FUNCTION H = F+G
```

with the next 2 lines of file ZZZ. consisting of

```
EXP(-X**2)
SIN(X)/SQRT(LOG(X))
```

will result in function F being defined as

```
EXP(-X**2)
```

the function G being defined as

```
SIN(X)/SQRT(LOG(X))
```

and the function H being defined as

```
EXP(-X**2)+SIN(X)/SQRT(LOG(X))
```

Writing Out Parameters, Variables, and Functions
WRITE

The WRITE command may be used to write out parameters, variables, or functions. The general form for the WRITE command is

WRITE file/subfile name (optional) list of names

To write information back to the terminal, one omits the file/subfile name and just enters the list of parameter/variable/function names to be printed, as in

```
WRITE X
WRITE A B
WRITE A B C
WRITE X Y Z U
WRITE Y X G PRED RES REPSD REPDF
```

The list of names may be in arbitrary order--parameter names, variable names, and function names may be mixed at will. To write to a file, one enters the file name immediately after WRITE, as in

```
WRITE A. X
WRITE A. A B
WRITE A. A B C
WRITE A. X Y Z U
WRITE A. Y X G PRED RES REPSD REPDF
```

which would write out the designated parameter/variable/function names to file A. The period following the file name A. is important--it is that punctuation which tells DATAPLOT that A. is a file name as opposed to a parameter/variable/function name. The period at the end of the file name is the convention used with the NBS implementation--check locally for what the punctuation is that defines the end of a file name at your implementation. The WRITE command may also be used to write out strings, comments, and headings. The general form for this purpose is

```
WRITE "string to be written out"
```

as in

```
WRITE "LABORATORY 4 ANALYSIS"
```

which would print the line

```
LABORATORY 4 ANALYSIS
```

on the next available line. This is useful for headings as in

```
READ A. X Y
ERASE
WRITE "STRONTIUM ANALYSIS"
FIT Y = A+B/(C+X)
COPY
```

which would

1) read in data;
2) erase the screen;
3) print out the line STRONTIUM ANALYSIS
4) carry out a non-linear fit;
5) copy the screen contents to hardcopy.

The WRITE command may be used with a SUBSET/EXCEPT/FOR qualification to write out interesting subsets of the data. For example, if X and Y were variables,

```
WRITE X Y
```

would write out all values of X and Y; but

```
WRITE X Y FOR I = 11 1 20
```

would write out only elements 11 to 20 of variables X and Y; while

```
WRITE X Y SUBSET LAB 4
```

would write out only those elements of X and Y for which the LAB variable has the value 4; and

```
WRITE X Y SUBSET Y > 100
```

would write out all values of X and Y for which Y > 100 (which is useful for listing those data lines corresponding to outliers). Any general complicated SUBSET/EXCEPT/FOR qualification may be appended to the WRITE statement.

Skipping Over Lines in a Read SKIP

The SKIP command sets an internal switch which indicates how many lines should be skipped in a file/subfile before the reading of data. The default setting is 0 (= no lines to be skipped). To change the setting, enter

```
SKIP number
```

where the number indicates the desired number of lines at the beginning of the file which are to be skipped over (= ignored) for any subsequent reads (via READ, SERIAL READ, or READ FUNCTION). This command is usually used to skip over heading and other non-numeric information at the beginning of a data file. Thus if the file A. consisted of the following 6 lines--

```
CALIBRATION STUDY
LABORATORY A
11
21
31
END OF DATA
```

and if one entered

```
SKIP 1
READ A. X
```

then an error message would result (because no numeric information is on line 2. If one entered

```
SKIP 2
READ A. X
```

then the variable X would end up with the 3 values 11, 21, and 31. If one entered

```
SKIP 3
READ A. X
```

then the variable X would end up with only 2 values-- 21 and 31.

Note that as with all underlying DATAPLOT settings, once the SKIP setting is made, it remains in effect for the duration of the run, or until overridden by another SKIP command.

Restricting a Read to Certain Rows ROW LIMITS

The SKIP command allows one to skip over lines at the beginning of a file. The ROW LIMITS command is similar but it gives the analyst the ability to ignore lines at both the beginning and the end of a file. The general form for the command is

```
ROW LIMITS number number
```

where the first number is the first line number of the data file to be read, and the second number is the last number of the data file to be read. The default values for the row limits switch are 1 and infinity. Thus if the file A. consisted of

```
11
21
31
41
51
```

and if one entered

```
ROW LIMITS 2 4
READ A. X
```

then the variable X would end up with 3 values-- 21, 31, and 41.

The ROW LIMITS command adds a third rule to the list of those governing when a READ will stop; the 3 rules are

1) if an END OF DATA line is encountered;
2) if an end of file is encountered;
3) if the row limits maximum is encountered.

Restricting a Read to Certain Columns
COLUMN LIMITS

The COLUMN LIMITS command allows the analyst to focus on a certain region within a line image. The general form for the command is

```
COLUMN LIMITS number number
```

where the column numbers indicate the start and stop columns for the data image scan. Thus if the data file consists of the following 3 lines

```
11      12      13
21      22      23
31      32      33
```

where the first number on each line starts in column 1, the next number on each line starts in column 11, and the third number on each line starts in column 21, then

```
COLUMN LIMITS 10 15
READ X
```

would result in the variable X having 3 values--12, 22, and 32.

Terminating a Read
END OF DATA

The usual termination for a READ, SERIAL READ, or READ FUNCTION command is when a line image is encountered which has

```
END OF DATA
```

or

```
END DATA
```

on it. This is true regardless of whether or not the END OF DATA line image is in the data file (which is the usual practice) or is in the program itself, as in

```
READ X
11
21
31
END OF DATA
```

If the analyst is reading from a data file/subfile, then the usual procedure is for the analyst to append an extra line image to the file/subfile consisting of

```
END OF DATA
```

via the local editor.

In addition to an END OF DATA line image being encountered, there are 2 other ways in which a read may be terminated--

1) *when the end of the file or subfile being read is encountered;*

2) *when the pre-specified row limits maximum has been attained.*

These last 2 procedures may be used without using an END OF DATA statement.

The general rule of thumb is, therefore, that a READ or SERIAL READ will continue processing data from a file until one of the following 3 conditions is met--

1) *an END OF DATA line image is encountered;*

2) *an end of file or subfile is reached;*

3) *a row limits maximum is attained.*

The read will terminate as soon as any one of these 3 conditions is satisfied.

Looping
LOOP

Most DATAPLOT programs do not need loops. In FORTRAN (for example) the use of loops is commonly used for intermediate calculations en route to the final output. In DATAPLOT, however, the existence of numerous high-level graphics and analysis commands frequently obviates the need for such intermediate looping.

To initiate a loop in DATAPLOT, use the LOOP command. The general syntax is

```
LOOP   FOR   parameter   =   start   increment   stop
               name          value                value
```

The loop parameter will be a parameter in the usual DATAPLOT sense. As the loop is being executed, the parameter value will be successively changed (depending on start, increment, and stop values). The

```
END OF LOOP
```

or

```
END LOOP
```

commands will terminate the loop. This parameter value is global and may be used by any calculation or specification within the loop. Thus

```
LOOP FOR I = 1 1 10
WRITE I
END OF LOOP
```

will result in the sequence 1, 2, 3, ..., 9, 10 being printed out.

```
LOOP FOR L = 1 1 5
PLOT Y X SUBSET LAB L
END OF LOOP
```

will result in 5 distinct plots being generated--

1) a plot of Y versus X but restricted to those values for which the LAB variable = 1;

2) a plot of Y versus X but restricted to those values for which the LAB variable = 2;

3) a plot of Y versus X but restricted to those values for which the LAB variable = 3;

4) a plot of Y versus X but restricted to those values for which the LAB variable = 4;

5) a plot of Y versus X but restricted to those values for which the LAB variable = 5.

Note that

```
LOOP FOR D = 1 1 10
FIT Y = A+B*X SUBSET DAY D
LET A2(D) = A
LET B2(D) = B
LET S(D) = RESSD
END OF LOOP
```

will carry out 10 linear fits of Y on X--each fit being restricted to values of the DAY variable = to 1, then 2, then 3, etc. Further, for each fit, the value of the fit parameter A will be copied into the D-th element of variable A2, the value of the fit parameter B will be copied into the D-th element of the variable B2, and the value of the fit residual standard deviation parameter RESSD (automatically provided by DATAPLOT) will be copied into the D-th element of the variable S.

```
FEEDBACK OFF
ERASE
LOOP FOR IX1 = 10 10 80
LET IY1=IX1
LET IX2=IX1+10
LET IY2=IX2
BOX IX1 IY1 IX2 IY2
END OF LOOP
```

will generate a sequence of boxes along the lower left to upper right diagonal of the screen.

As is usual, the start value, increment, and stop value may be either numbers or parameters. Thus

```
LOOP FOR L = 1 1 5
PLOT Y X SUBSET LAB L
END OF LOOP
```

and

```
LET A = 1
LET B = 1
LET C = 5
LOOP FOR L = A B C
PLOT Y X SUBSET LAB L
END OF LOOP
```

are equivalent.

If one does use parameters for specifying the loop, then these parameters may be altered within the loop--this capability is at times used in conjunction with the IF qualification of the LET command so as to prematurely terminate a loop when a certain condition is arrived at. For example,

```
LET ALPHAMAX = 10
LOOP FOR ALPHA = .1 .1 ALPHAMAX
LET INT = INTEGRAL X**ALPHA WRT X FOR X = 0 TO 1
LET ALPHAMAX = -INFINITY IF INT < .05
END OF LOOP
```

will terminate itself as soon as a value of ALPHA is arrived at in which the integral of X**ALPHA (over the domain 0 to 1) is less than .05.

The checking of the loop parameters is done at the beginning of the loop. It is possible for a loop not to be executed at all (if the increment is positive and the stop value is smaller than the start value; or if the increment is negative and the stop value is larger than the start value); thus

```
LET STOP = -1
LOOP FOR A = 1 1 STOP
PRINT A
END OF LOOP
```

would result in the loop not being executed.

Loops may be nested 7 deep. Thus to generate plots of Y versus X for each combination of variables OP (with 3 levels), LAB (with 5 levels), and DAY (5 levels), one could enter

```
LOOP FOR O = 1 1 3
LOOP FOR L = 1 1 4
LOOP FOR D = 1 1 5
PLOT Y X SUBSET OP O SUBSET LAB L SUBSET DAY D
END OF LOOP
END OF LOOP
END OF LOOP
```

To have the 60 plots automatically hardcopied as they are being generated, and to have them automatically numbered (1 to 60), one could enter

```
HARDCOPY
SEQUENCE
LOOP FOR O = 1 1 3
LOOP FOR L = 1 1 4
LOOP FOR D = 1 1 5
PLOT Y X SUBSET OP O SUBSET LAB L SUBSET DAY D
END OF LOOP
END OF LOOP
END OF LOOP
```

To have them hardcopied, sequenced, and also to have them properly labeled with the current operator, lab, and day value, one could use the VALU( ) sub-command in conjunction with the ...LABEL command, as follows--

```
HARDCOPY
SEQUENCE
LOOP FOR O = 1 1 3
LOOP FOR L = 1 1 4
LOOP FOR D = 1 1 5
XLABEL OPERATOR = VALU( )O
X2LABEL LAB = VALU( )L
X3LABEL DAY = VALU( )D
PLOT Y X SUBSET OP O SUBSET LAB L SUBSET DAY
END OF LOOP
END OF LOOP
END OF LOOP
```

Any valid DATAPLOT command can be executed within the context of a loop. A particularly important command is the CALL command which allows a subprogram to be referenced. Thus for more complicated applications, it may be of interest to set up a loop in the main program and then specify a desired set of operations in a subprogram, as in

```
LOOP FOR O = 1 1 3
LOOP FOR L = 1 1 4
LOOP FOR D = 1 1 5
CALL A.
END OF LOOP
END OF LOOP
END OF LOOP
```

where subprogram A might consist of

```
XLABEL OPERATOR = VALU( )O
X2LABEL LAB = VALU( )L
X3LABEL DAY = VALU( )D
PLOT Y X SUBSET OP O SUBSET LAB L SUBSET DA
```

Conditionally Executing Statements
SUBSET, EXCEPT, FOR, and IF

Conditional execution of statements is handled in 2 different ways in DATAPLOT--

1) the augmentation of SUBSET/EXCEPT/FOR qualifications at the end of any graphics or analysis command (this is used when the the conditionality is based on values within variables);

2) the use of the IF command in conjunction with the END OF IF (or END IF) command (this is used when the conditionality is based on values of parameters).

Method 1 is the most popular and is the most straightforward way of conditionally executing commands. It is a DATAPLOT feature that any graphics command or any analysis command may be conditionally executed (that is, have its execution restricted to a certain subset of data, or have its execution contingent on the value of certain variables) by simply appending the qualification to the end of the command line. As far as the analyst is concerned, the primary general objective is to generate a plot, carry out a fit, carry out an analysis of variance, etc., whereas the restriction of such an activity to a specific subset is, in a sense, an afterthought. This being the case, the DATAPLOT structure is to have the DATAPLOT command (PLOT, FIT, ANOVA, etc.) appear first and foremost on the line, and then to simply append the qualification to the end of the line. Thus it is easy and natural to extend

```
PLOT Y X
FIT Y = A+B*LOG(X)
ANOVA Y X1 X2 X3
```

to

```
PLOT Y X SUBSET LAB 4
FIT Y = A+B*LOG(X) SUBSET X . 50 EXCEPT X = 140
ANOVA Y X1 X2 FOR I = 1 1 40
```

The specified subset is extracted before the command is executed. If the subset is empty, then the command will not be executed.

Method 2 is a much less popular way of conditionally executing statements, but does have occasional application. To conditionally execute a "chunk" of DATAPLOT code, one may use the IF command in combination with the END OF IF (or END IF) command. The general form for the IF command is

IF parameter or number — relative operator — parameter or number

where the relational operators are

=	equality
<>	inequality
<	less than
<= or =<	less than or equal to
>	greater than
>= or =>	greater than or equal to

The conditionality specification is done in terms of parameter values (as opposed to variable values in the SUBSET/EXCEPT qualification). For example, suppose a variable X has 100 values in it and it is desired to determine the maximum value in X. The easiest way to do this in DATAPLOT is to simply enter

```
LET MAX = MAXIMUM X
```

However, for purposes of illustration of the use of the IF command, one could achieve the same result via the following statements--

```
LET MAX = -INFINITY
LOOP FOR I = 1 1 100
LET XI=X(I)
IF XI > MAX
LET MAX = X(I)
END OF IF
END OF LOOP
```

It is clear that the second method is an extremely inefficient method for computing the parameter MAX.

As a second example, suppose it is desired to determine that combination of A and B (over a specified lattice of values) for which the L1 fit of A+LOG(B+X) is achieved. The easiest way to carry this out in DATAPLOT is

```
FIT POWER 1
PRE-FIT A+LOG(B+X) FOR A = 1 1 10 FOR B = 100 10 200
```

At the end of the PRE-FIT, the optimal values will reside in the parameters A and B. An alternate (and much longer) way of doing the same is

```
LET MIN = INFINITY
LOOP FOR A = 1 1 10
LOOP FOR B = 100 10 200
.
LET PRED = A+LOG(B+X)
LET RES = Y-PRED
LET RES2 = ABS(RES)
LET SUMAD = SUM RES2
.
IF SUMAD < MIN
LET A2 = A
LET B2 = B
END OF IF
.
END OF LOOP
END OF LOOP
```

At the end of execution of this code, the optimal values of A and B will reside in the parameters A2 and B2.

IF statements may be nested up to 7 deep, as in

```
IF A > 10
IF B = 7
IF C <= 100
WRITE A B C
END OF IF
END OF IF
END OF IF
```

The parameters A, B, and C will be scanned; only if the 3 specified conditions are satisfied will the WRITE occur.

Any valid DATAPLOT statment may occur within the context of the IF set of statements. A particularly powerful entry is the CALL statement which allows subprograms to be executed. Thus, for example, to conditionally execute (only if the residuals standard deviation RESSD from some fit is less than .1) a subprogram XYZ, one could enter

```
IF RESSD < .1
CALL XYZ.
END OF IF
```

The END OF IF may optionally be written as END IF, thus the above code may also be written as

```
IF RESSD < .1
CALL XYZ.
END IF
```

The IF capability in DATAPLOT is a low-level capability (no one does IF as an end objective in itself). Conditionally executing a chunk of code is an elementary capability of any computer language. In DATAPLOT, due to the existence of high-level capabilities, and due to the SUBSET/EXCEPT/FOR qualification capability, the IF capability is only lightly used.

Calling Subprograms
CALL

The typical DATAPLOT program consists only of a main program. The existence of higher-level capabilities (e.g., PLOT, FIT, LET, etc.) often precludes complicated nesting of subprograms. However, subprograms may be included in DATAPLOT as needed.

Subprograms are completely independent programs in their own right and must be placed in separate mass storage files (or subfiles). Such subprograms are accessed via the CALL command and are identified by the name of the mass storage file (or subfile) in which the subprogram resides, as in

```
CALL XYZ.
```

(which would execute the subprogram residing in file XYZ), or

```
CALL XYZ.ABC
```

(which would execute the subprogram residing in the subfile ABC of the file XYZ). As with all DATAPLOT commands which involve file/subfile usage, the trailing period after the file name is important--it tells DATAPLOT that the name is a file name. Further, for those computer systems which allow logical subfiles within files, the period also serves as a separator between file name and subfile name.

When the last line of the subprogram in the file is executed, it returns to the main program to the statement immediately following the CALL statement. The name of the subprogram is taken to be the name of the file where the subprogram resides. Modularity is strictly adhered to in that only 1 subprogram may exist in any given file/subfile. There is no necessity for internal identification of the subprogram (e.g., there is (as would be the case in FORTRAN, BASIC, and ALGOL) no need for a SUBPROGRAM, SUBROUTINE, or PROCEDURE statement as the first line of the subprogram). Nor is there any need to terminate the various subprograms with a terminator statement (e.g., RETURN). In fact, the existence of EXIT (or END, STOP, HALT, or BYE) will cause the DATAPLOT run to be terminated--thus EXIT (and its synonyms) is usually reserved for the last line of the main program. All parameter, variable, and function names are global--names defined in the main program may be used and modified in subprograms (and vice versa). Subprograms may in turn call other subprograms. The maximum number of nested subprograms is 7 (including the main program). Subprograms may not be recursive--that is, a subprogram may not call itself.

The 4 most important ways in which subprogram usage arises is as follows--

1) Unconditional calls
2) Conditional calls
3) Unconditional loops
4) Conditional loops

For example--

1) Unconditional calls
   In this case, a subprogram is called once and only once. For example,

```
CALL SIGMA.
```

   would cause subprogram SIGMA to be unconditionally called once and only once.

2) Conditional calls
   This calls a subprogram exactly once and only under certain conditions. For example,

```
IF A > 4
CALL SIGMA.
END OF IF
```

   would cause subprogram SIGMA to be called only if the current value of the parameter A exceeds 4, but not to call SIGMA otherwise.

3) Unconditional loops
   In this case, a subprogram is called multiple times. For example,

```
LOOP FOR B = 1 1 10
CALL SIGMA.
END OF LOOP
```

   would cause subprogram SIGMA to be unconditionally called 10 times (for B = 1, 2, ..., 9, 10).

4) Conditional loops
   In this case, a subprogram is called for a number of times that depends on calculations that occur within the subprogram being called. For example,

```
LOOP FOR B = 1 1 C
CALL SIGMA.
END OF LOOP
```

   (where the parameter C is pre-defined but may also be redefined within the subprogram being called)
   would cause subprogram SIGMA to be called a variable number of times depending on how C is redefined within the loop.

As one would expect, execution of a pre-stored main program may be initiated in an identical fashion as one would execute a subprogram, namely via the CALL command. Thus, for example, if the analyst has signed onto DATAPLOT, and if a pre-stored main program resides in a file called A, then execution of the main program could start with the entry of the statement

```
CALL A.
```

Creating Subprograms
CREATE

The most common and most efficient method for creating DATAPLOT subprograms is via the local editor. That is, before the analyst enters DATAPLOT, he/she enters into a file/subfile with the local editor and creates a DATAPLOT program and any needed DATAPLOT subprograms. There is no substitute for an excellent local editor-- the analyst is encouraged to use such an editor for creating DATAPLOT programs and subprograms.

One the other hand, it is at times convenient to be able to create a DATAPLOT subprogram "on the fly" while one is executing a DATAPLOT program. A prime example of this is in the construction of diagrammatic graphics in which one makes an interactive pass at forming the diagram, stores the commands that were used en route, and then executes these commands as a block in a semi-interactive mode.

If one is running DATAPLOT interactively, one may automatically store the entered interactive command lines into a file by use of the

CREATE

command. For example, to instruct DATAPLOT that all subsequently keyed-in commands should be in a file XYZ as they are being entered, the analyst would enter

CREATE XYZ.

To terminate the creation of the file XYZ, the analyst enters

END OF CREATE

or

END CREATE

To execute the contents of XYZ, one would enter

CALL XYZ.

Listing Subprograms
LIST

The LIST command may be used to list the contents of any file or subfile. Usually such a capability is taken advantage of when the file/subfile contains a subprogram, but it may also be used when the file contains data. The usual convention about periods following the file name is followed. Thus to list the contents of the file XYZ, one enters

LIST XYZ.

If the local computer system may have subfiles of files, then to list subfile ABC of file XYZ, one enters

LIST XYZ.ABC

The LIST command only lists files/subfiles--it does not execute the contents of such files/subfiles.

Restricting Plots and Analyses to Subsets
SUBSET, EXCEPT, and FOR

The DATAPLOT keywords

SUBSET
EXCEPT
FOR

may be appended to the end of any DATAPLOT graphics or analysis command. They allow the analyst to specify precisely the desired subset (any subset) which the plot/analysis should be restricted to. The rules for using SUBSET/EXCEPT/FOR are straightforward; we mention them briefly here and then demonstrate them by example. When the SUBSET qualification is used, it is always followed by a variable name. Any variable whatsoever may be used to define the subset--one which is used in the plot/analysis statement, such as

```
PLOT Y X SUBSET X 100 TO 200
PLOT Y X SUBSET Y 10 TO 30
```

or one not explicitly involved in the plot/analysis statement, as in

```
PLOT Y X SUBSET LAB 4 TO 6
PLOT Y X SUBSET OPERATOR 3
```

After the variable specification, one may have one of the following 4 syntaxes--

1) *a single number;*

2) *a series of numbers*

3) *a number followed by TO followed by another number;*

4) *a relational operator (=, <>, <=, <, >=, or >) followed by a single number.*

A single number indicates that the subset is restricted to that specific value and no others, as in

```
PLOT Y X SUBSET LAB 4
```

which will restrict the plot to values in Y and X corresponding to values in the LAB variable which equal 4.

A series of numbers indicates that the subset is restricted to those specific values and no others, as in

```
PLOT Y X SUBSET LAB 4 5 9
```

which will restrict the plot to values of Y and X corresponding to LAB values of 4, 5, and 9.

A number followed by TO followed by another number indicates that the subset is restricted to all values in the interval specified by the 2 numbers, inclusively, as in

```
PLOT Y X SUBSET LAB 4 TO 9
```

which will restrict the plot to values of Y and X corresponding to all LAB values between 4 and 9, inclusively.

A relational operator followed by a single number indicates that the subset is restricted to that specific interval, as in

```
PLOT Y X SUBSET LAB >= 3
```

which will restrict the plot to values in Y and X corresponding to values in the LAB variable greater than or equal to 3.

```
PLOT Y X SUBSET LAB = 3
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable equal to 3 (and so will have the same effect as PLOT Y X SUBSET LAB 3 as discussed earlier).

```
PLOT Y X SUBSET LAB <> 3
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable not equal to 3.

SUBSET qualifications may be strung together in a more complicated fashion. Each individual SUBSET specification may have any of the above 4 valid syntaxes. The final subset will be the intersection of the individual subsets. Thus

```
PLOT Y X SUBSET LAB 4 SUBSET OPERATOR 7
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable equal to 4 and (simultaneously) values in the OPERATOR variable equal to 7. The use of many SUBSET specifications strung together allows the analyst to easily focus on any particular subset desied. Thus

```
PLOT Y X SUBSET LAB 4 5 9 SUBSET OPERATOR 7 TO 14 SUBSET Y < 1000
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable equal to 4, 5, or 9, and (simultaneously) values in the OPERATOR variable equal to 7 to 14, and (simultaneously) values in the Y variable less than 1000.

In addition to direct subset specification via SUBSET, there is also a need at times for the subset to be defined via negation. DATAPLOT handles such a need via the EXCEPT qualification. For simplicity and consistency, the rules for using EXCEPT are identical to the rules for using SUBSET; thus

```
PLOT Y X EXCEPT LAB 3
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable not equal to 3.

```
PLOT Y X EXCEPT LAB 3 4 7 EXCEPT OPERATOR 10 TO 15 EXCEPT Y > 1000
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable not equal to 3, 4, or 7, and (simultaneously) values in the OPERATOR variable not equal to 10 to 15, and (simultaneously) values in the Y variable not greater than 1000.

At times the analyst may need to define subsets by a combination of specifying what is in the subset and what is not in the subset. DATAPLOT handles this by allowing the analyst to freely mix SUBSET and EXCEPT qualifications; thus

```
PLOT Y X SUBSET LAB 3 TO 20 EXCEPT LAB 4
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable from 3 to 20 with the exception of LAB 4.

```
PLOT Y X SUBSET LAB 3 4 7 EXCEPT OPERATOR 10 TO 15 EXCEPT Y > 1000
```

will restrict the plot to values in Y and X corresponding to values in the LAB variable equal to 3, 4, or 7, and (simultaneously) values in the OPERATOR variable not equal to 10 to 15, and (simultaneously) values in the Y variable not greater than 1000.

At times the analyst finds it convenient to specify a subset based not on the magnitudes and values of numbers in variables but rather on the element position in the variable. For example, suppose the analyst wishes to PLOT Y versus X but to do so for only every other element in the variables Y and X. How may this be done? DATAPLOT accounts for this case via the use of the FOR qualification. The FOR qualification (which may be appended to any DATAPLOT graphics/analysis command) has the general form

```
FOR dummy index = start increment stop
```

And so to plot Y versus X for elements 1, 3, 5, ..., 499, one enters

```
PLOT Y X FOR I = 1 2 500
```

To plot Y versus X for elements 10, 20, 30, ..., 490, 500, one enters

```
PLOT Y X FOR I = 10 10 500
```

In the above example, we have used the dummy index I; this is the most common choice for the FOR qualification, although any name could have been entered. The effect of using I is that this name will become a DATAPLOT parameter. At the end of the execution of the statement

```
PLOT Y X FOR I = 10 10 500
```

the parameter I will have the value 500 in it. One may not string successive FOR qualifications together at the end of a statement--only one FOR qualification is permitted. One may not mix FOR qualifications together with SUBSET and EXCEPT qualifications.

Note that in the above description of SUBSET, EXCEPT, and FOR, we referred in many places to the use of numbers, for example one form for the SUBSET qualification is to have a number followed by TO followed by another number, and the form for the FOR qualification is to have a start number, an increment number, and a stop number. Note that all statements involving numbers are equally valid for DATAPLOT parameters; that is, any SUBSET/EXCEPT/FOR qualification having numbers in it may equally well have pre-defined parameters in it. Although this feature is only rarely used, it does give the analyst additional generality if needed. For example,

```
LET A = 3
LET B = 7
PLOT Y X SUBSET X A B
```

is exactly equivalent to

```
PLOT Y X SUBSET X 3 7
```

and

```
LET START = 5
LET INCREMENT = 5
LET STOP = 300
PLOT Y X FOR I = START INCREMENT STOP
```

is exactly equivalent to

```
PLOT Y X FOR I = 5 5 300
```

As mentioned earlier, one may use any variable as the subset variable; occasions arise in which it makes good sense to use one of the variables in the plot (e.g., X or Y) as a subset variable, thus

```
PLOT Y X SUBSET X > 100
```

will restrict the plot to values in Y and X corresponding to values in the X variable greater than 100; while

```
PLOT Y X SUBSET Y < 1000
```

will restrict the plot to values in Y and X corresponding to values in the Y variable less than 1000 (which, for example, may be of use in regenerating a plot with outliers removed).

In addition to the variables that the analyst has created, the subset specification variable may also be the automatically-generated variables PRED (= predicted values) and RES (= residuals) which result from any DATAPLOT fitting, spline fitting, smoothing, Anova, Median polish, etc. operation. Note how the use of the RES variable as the subset variable may be a valuable tool for the data analyst in carrying out residual analysis. For example, suppose that the analyst has carried out a fit, say, via

```
FIT Y = A+B*EXP(-C*X)
```

and suppose the analyst has generated the usual superimposed plot of raw data and predicted values via

```
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
```

and suppose further that the analyst has generated the usual residual plot via

```
PLOT RES X
```

Now suppose that the analyst is interested in generating a listing of X, Y, PRED, and RES values for all the data; this is easily done via

```
PRINT X Y PRED RES
```

Now finally suppose that the analyst noted on the residual plot that there was a patch of residuals which were larger than others (this was the region of poorest fit) and suppose the analyst was interested in printing out those X, Y, PRED, and RES values only for this region of poor fit. Such a listing would be of use in exactly specifying the X values which had the poorest fit. For sake of definiteness, suppose the analyst was interested in such a printing for all values corresponding to residuals in excess of 10 units. How may such a printing be generated? Very easily, namely by entering

```
PRINT X Y PRED RES SUBSET RES > 10
```

A final note to this section reinforces the fact that SUBSET/EXCEPT/FOR qualifications may be used with any graphics/analysis command. Of particular importance are the various forms of the PLOT command. We have already seen how

```
PLOT Y X
```

may be restricted to become

```
PLOT Y X SUBSET LAB 4 TO 8
```

Note also that the powerful 3-argument form

```
PLOT Y X TAG
```

(which plots Y versus X but generates an individual trace for each distinct value of the TAG variable) may be also be restricted as in

```
PLOT Y X TAG SUBSET LAB 4 TO 8
```

Further, the same is true for the VERSUS form--

```
PLOT Y1 Y2 Y3 Y4 Y5 Y6 VERSUS X
```

(which is handy for generating multi-trace plots) may be similarly restricted, as in

```
PLOT Y1 Y2 Y3 Y4 Y5 Y6 VERSUS X SUBSET LAB 4 TO 8
```

The DATAPLOT convention for subset extraction is a flexible, powerful, time-saving tool for the scientist/researcher. Its use allows the analyst to easily probe into interesting subsets of the data--so as to detect anomalous behavior in such subsets and so as to determine if conclusions and models which hold for the full set are equally valid for the individual subsets.

In-line Text Sub-commands
TITLE, ...LABEL, LEGEND, and TEXT

The entries in this section are not commands in themselves; rather, they are sub-commands which may appear in-line in the text-oriented DATAPLOT commands--TITLE, ...LABEL, LEGEND, and TEXT. The sub-commands are "flagged" for DATAPLOT by the existence of open and closed parentheses following each sub-command, as in

```
TEXT ALPH()BETA()GAMM()
```

which would write out the Greek characters alpha, beta, and gamma. The most important of these sub-commands are LC, UC, SUB, SUP, INTE, VALU, and the Greek alphabet.

The sub-commands in this section are not applicable for the Tektronix font, but are applicable for all of the 7 "fancy script" fonts. Thus before use of any of the in-line text sub-commands, the analyst should inform DATAPLOT (via the FONT command) that the default Tektronix font is being overridden and another font is being used, as in

```
FONT TRIPLEX
TEXT ALPH()BETA()GAMM()
```

The VALU sub-command is especially important. It allows the analyst to substitute parameter values in titles, labels, legends, and text strings. For example,

```
LET LAB = 7
TEXT ANALYSIS FOR LABORATORY VALU()LAB
```

would result in the following line appearing--

```
ANALYSIS FOR LABORATORY 7
```

The VALU() sub-command will print out the value of the parameter which immediately follows the () of VALU(). In the example above, this parameter was LAB; this parameter had a value of 7.

General Operations

Sub-command	*Description*	*Example*
UC	*upper case*	*TEXT UC( )ABC*
CAP	*upper case*	*TEXT CAP( )ABC*
CAPS	*upper case*	*TEXT CAPS( )ABC*
LC	*lower case*	*TEXT LC( )ABC*
SUB	*subscript*	*TEXT ABCSUB( )DEF*
UNSB	*un-subscript*	*TEXT ABCSUB( )DEFUNSB( )GHI*
SUP	*superscript*	*TEXT ABCSUP( )DEF*
UNSP	*un-superscript*	*TEXT ABCSUP( )DEFUNSP( )GHI*
VALU	*substitute value of parameter*	*TEXT VALU( )A*

Greek Characters

Sub-command	*Description*	*Example*
ALPH	*alpha*	*TEXT ALPH( )*
BETA	*beta*	*TEXT BETA( )*
GAMM	*gamma*	*TEXT GAMM( )*
DELT	*delta*	*TEXT DELT( )*
EPSI	*epsilon*	*TEXT EPSI( )*
ZETA	*zeta*	*TEXT ZETA( )*
ETA	*eta*	*TEXT ETA( )*
THET	*theta*	*TEXT THET( )*
IOTA	*iota*	*TEXT IOTA( )*
KAPP	*kappa*	*TEXT KAPP( )*
LAMB	*lambda*	*TEXT LAMB( )*
MU	*mu*	*TEXT MU( )*
NU	*nu*	*TEXT NU( )*
XI	*xi*	*TEXT XI( )*
OMIC	*omicon*	*TEXT OMIC( )*
PI	*pi*	*TEXT PI( )*
RHO	*rho*	*TEXT RHO( )*
SIGM	*sigma*	*TEXT SIGM( )*
TAU	*tau*	*TEXT TAU( )*
UPSI	*upsilon*	*TEXT UPSI( )*
PHI	*phi*	*TEXT PHI( )*
CHI	*chi*	*TEXT CHI( )*
PSI	*psi*	*TEXT PSI( )*
OMEG	*omega*	*TEXT OMEG( )*

Mathematical Symbols

Sub-command	*Description*	*Example*
PART	*partial derivative*	*TEXT PART( )*
INTE	*integral*	*TEXT INTE( )*
CINT	*circular integral*	*TEXT CINT( )*
SUMM	*summation*	*TEXT SUMM( )*
PROD	*product*	*TEXT PROD( )*
INFI	*infinity*	*TEXT INFI( )*
+-	*+ or -*	*TEXT +-( )*
-+	*- or +*	*TEXT -+( )*
TIME	*times*	*TEXT TIME( )*
DOTP	*dot product*	*TEXT DOTP( )*
DEL	*vector product*	*TEXT DEL( )*
DIVI	*division*	*TEXT DIVI( )*
LT	*less than*	*TEXT LT( )*
GT	*greater than*	*TEXT GT( )*
LTEQ	*less than or equal to*	*TEXT LTEQ( )*
GTEQ	*greater than or equal to*	*TEXT GTEQ( )*
NOT=	*not equal*	*TEXT NOT=( )*
APPR	*approximately equal to*	*TEXT APPR( )*
EQUI	*equivalence*	*TEXT EQUI( )*
VARI	*varies*	*TEXT VARI( )*
TILD	*tilde*	*TEXT TILD( )*
CARA	*carat*	*TEXT CARA( )*
PRIM	*prime*	*TEXT PRIM( )*
RADI	*radical*	*TEXT RADI( )*
LRAD	*large radiacal*	*TEXT LRAD( )*
SUBS	*subset*	*TEXT SUBS( )*
SUPE	*superset*	*TEXT SUPE( )*
UNIO	*union*	*TEXT UNIO( )*
INTR	*intersection*	*TEXT INTR( )*
ELEM	*is an element of*	*TEXT ELEM( )*
THEX	*there exists*	*TEXT THEX( )*
THFO	*therefore*	*TEXT THFO( )*

Miscellaneous Symbols

Sub-command	*Description*	*Example*
SPAC	*Space*	*TEXT SPAC()*
SP	*Space*	*TEXT SP()*
LAPO	*left apostrophe*	*TEXT LAPO()*
RAPO	*right apostrophe*	*TEXT RAPO()*
LBRA	*left bracket*	*TEXT LBRA()*
RBRA	*right bracket*	*TEXT RBRA()*
LCBR	*left curly bracket*	*TEXT LCBR()*
RCBR	*right curly bracket*	*TEXT RCBR()*
LELB	*left elbow*	*TEXT LELB()*
RELB	*right elbow*	*TEXT RELB()*
RACC	*right accent*	*TEXT RACC()*
LACC	*left accent*	*TEXT LACC()*
BREV	*breve*	*TEXT BREV()*
RQUO	*right quote*	*TEXT RQUO()*
LQUO	*left quote*	*TEXT LQUO()*
NASP	*nasp*	*TEXT NASP()*
IASP	*inverted nasp*	*TEXT IASP()*
RARR	*right arrow*	*TEXT RARR()*
LARR	*left arrow*	*TEXT LARR()*
UARR	*up arrow*	*TEXT UARR()*
DARR	*down arrow*	*TEXT DARR()*
PARA	*paragraph*	*TEXT PARA()*
DAGG	*dagger*	*TEXT DAGG()*
DDAG	*double dagger*	*TEXT DDAG()*
VBAR	*vertical bar*	*TEXT VBAR()*
DVBA	*double vertical bar*	*TEXT DVBA()*
LVBA	*long vertical bar*	*TEXT LVBA()*
HBAR	*horizontal bar*	*TEXT HBAR()*
LHBA	*long horizontal bar*	*TEXT LHBA()*
BAR	*bar*	*TEXT BAR()*

Defaults, Restrictions, and Settings

Plot Control--

Operation	Default	Command
Automatic pre-erase (before plots)	on	PRE-ERASE
Automatic bell (before plots)	on	BELL
Automatic hardcopy (after plots)	off	HARDCOPY
Automatic sequence numbers on plots	off	SEQUENCE
Plot characters	all blank	CHARACTERS
Line types	all solid	LINES
Title and labels	all blank	TITLE and ...LABEL
Maximum number of characters in title	100	---
Maximum number of characters (each label)	100	---
Plot scale	linear	...LOG
Grid lines	off	...GRID
Axis limits	neat--float with data	...LIMITS
Frame lines	all 4 appear	...FRAME
Frame corner coordinates	(15,20) and (85,85)	FRAME CORNER COORDINATES
Tic marks	on all 4 frames	...TICS
Tic mark labels	on all 4 frames	...TIC LABELS
Tic mark position	through frame	...TIC POSITION
Legends	all blank	LEGEND ...
Maximum number of legends	100	---
Maximum number of characters (all legends)	500	---
Arrows	all off	ARROW ...
Maximum number of arrows	100	---
Line segments	all off	SEGMENT ...
Maximum number of line segments	100	---
Boxes	all off	BOX ...
Maximum number of boxes	100	---
Font (for all titles, labels, legends, etc.)	Tektronix	FONT
Size for plot characters	3 (= 3% screen height)	CHARACTER SIZE
Size for plot lines	3 (= 3% screen height)	LINE SIZE
Size for plot tics	3 (= 3% screen height)	TIC SIZE
Size for plot titles	3 (= 3% screen height)	TITLE SIZE
Size for plot lables	3 (= 3% screen height)	...LABEL SIZE
Size for plot legends	3 (= 3% screen height)	LEGEND ... SIZE
Color for plot characters	red	CHARACTER COLOR
Color for plot lines	red	LINE COLOR
Color for plot frames	red	FRAME COLOR
Color for plot tics	red	TIC COLOR
Color for plot tic labels	red	TIC LABEL COLOR
Color for plot titles	red	TITLE COLOR
Color for plot lables	red	...LABEL COLOR
Color for plot legends	red	LEGEND ... COLOR
Color for plot arrows	red	ARROW ... COLOR
Color for plot segments	red	SEGMENT ... COLOR
Color for plot boxes	red	BOX ... COLOR
Color for background (= inside frame line)	blue	BACKGROUND COLOR
Color for margin (= outside frame line)	blue	MARGIN COLOR
3d origin where x0 = min x data y0 = min y data z0 = min z data	(x0,y0,z0)	ORIGIN COORDINATES
3d frame lines	on	FRAME
3d eye coordinates where xe = max x + 3*(max x - min x) ye = max y + 3*(max y - min y) ze = max z + 3*(max z - min z)	(xe,ye,ze)	EYE COORDINATES
3d pedestal	off	PEDESTAL
color for 3d pedestal	red	PEDESTAL COLOR
Maximum number of plot points per plot	1000	---
Maximum number of superimposed plots	no limit	---

Diagrammatic Graphics--

Operation	Default	Command
Font	Tektronix	FONT
Case	upper case	CASE
Justification	left-justified	JUSTIFICATION
Height	3 (= 3% screen height)	HEIGHT
Width	2 (= 2% screen width)	WIDTH
Color of Background	blue	BACKGROUND COLOR
Color of text and figures	red	LINE COLOR

Output Devices--

Operation	Default	Command
Terminal	Tektronix 4014	TERMINAL MANUFACTURER
Horizontal picture points	1024	PICTURE POINTS
Vertical Picture points	781	PICTURE POINTS
Output device # 1	terminal	---
Terminal color status	off (= non-color)	COLOR
Terminal continuity status	on	CONTINUOUS
Maximum number of output devices	5	---
Status of device 1	on	---
Status of devices 2 to 5	off	ZETA, CALCOMP, VERSATEC
Status of penplotter	off	PENPLOTTER
Status of hardcopy unit	off	HARDCOPY

Data--

Operation	Default	Command
Maximum number of variables	10	DIMENSION
Maximum number of observations per variable	1000	DIMENSION
Maximum total internal data storage	10000	---
Automatically-provided variables	PRED and RES	---
Automatically provided parameters	PI and INFINITY	---
Maximum number of variable/parameter/function names (total)	200	---
Maximum number of characters (total for all functions)	1000	---
Maximum number of characters in FIT model	200	---
Maximum number of parameter names in FIT model	100	---
Maximum number indpendent variables in FIT	5	---

Support--

Operation	Default	Command
Trigonmetric units	radians	ANGLE UNITS
Baud rate	1200	BAUD RATE
Text angle	0 degrees (= horiz.)	ANGLE
Echo	off	ECHO
Bell (at time of plot)	on	BELL
Host	Univac 1100 Exec 8	HOST
Cut-off standard deviation for FIT	0.000005	FIT STANDARD DEVIATION
Cut-off number of iterations for FIT	50	FIT ITERATIONS
Default fit criterion power for PRE-FIT	2 (= least squares)	FIT POWER
Degree of internal calculations	single precision	---
Feedback messages from commands	on	FEEDBACK
Print output from analysis commands	on	PRINTING
Number of lines to be skipped on READ/SERIAL READ	0	SKIP
Row limits for READ/SERIAL READ	1 to infinity	ROW LIMITS
Column limits for READ/SERIAL READ	1 to 132	COLUMN LIMITS
Command terminator charactor	; or corriage return	TERMINATOR CHARACTER

General--

Operation	Default	Command
Maximum number of characters per terminal line	80	---
Maximum number of lines per command	2	---
Continuation indicator (at end of line)	...	---
Command terminator indicator	; or carriage return	TERMINATOR CHARACTER

Machine Constants (Example 1--Univac 1100/82)--

Operation	Default	Command
Standard input unit	5	SET
Standard output unit	6	SET
Number of bits per character	9	---
Number of characters per word	4	---
Number of bits per word	36	---
Machine infinity	0.1701412**39	SET

Machine Constants (Example 2--Vax 11/780)--

Operation	Default	Command
Standard input unit	5	SET
Standard output unit	6	SET
Number of bits per character	8	---
Number of characters per word	4	---
Number of bits per word	32	---
Machine infinity	xxx	SET

File/Subfile Nomenclature--

Operation	Default	Command
Qualifier-file separator (Example 1--Univac 1100/82)	*	---
File-subfile separator (Example 1--Univac 1100/82)	.	---
Qualifier-file separator (Example 2--Vax 11/780)	]	---
File-subfile separator (Example 2--Vax 11/780)	.	---

File/Subfile Structure--

Purpose	Unit Number	Name	File or Subfile	Command
Message	21	DPMESF	file only	MESSAGE
News	22	DPNEWF	file only	NEWS
Mail	23	DPMAIF	file only	MAIL
Help	24	DPHELF	file only	HELP
Bug	25	DPBUGF	file only	BUG
Query	26	DPQUEF	file only	QUERY
Log	27	DPLOGF	off	---
Read	31	user-defined	file or subfile	READ and SERIAL READ
Write	32	user-defined	file or subfile	WRITE
Macro	33	user-defined	file or subfile	CREATE and CALL
Save	34	user-defined	file or subfile	SAVE and RESTORE
Scratch	41	DPSCRF	file only	---
Data	42	DPDATF	file only	---
Plot	43	DPPL1F	file only	---
Plot 2	44	DPPL2F	file only	---

Dumping Status Information
STATUS

The status of the most important internal DATAPLOT settings may be printed out via the STATUS command. This command has no arguments, one simply enters

STATUS

The following is an example of the type of output which would result from entering the STATUS command--

```
**************************************************
*               STORAGE INFORMATION              *
**************************************************
* NUMBER OF ...      *   USED  * UNUSED  * MAXIMUM *
**************************************************
* VARIABLES (COLUMNS)*      6  *      4  *     10  *
* OBS PER VARIABLE   *     98  *    902  *   1000  *
* OBS (TOTAL)        *   6000  *   4000  *  10000  *
* FUNC CHAR (TOTAL)  *     13  *    987  *   1000  *
* VAR/PAR/FUNC NAMES *     23  *    177  *    200  *
**************************************************
```

SET INDEX	PLOT LINE TYPE	PLOT LINE COLOR	PLOT CHARACTER TYPE	PLOT CHARACTER COLOR	PLOT CHARACTER SIZE
1	BLAN	RED	X	RED	1.000
2	SOLI	RED	BLAN	RED	1.000
3	SOLI	RED	X	RED	1.000
4	SOLI	RED	X	RED	1.000
5	SOLI	RED	X	RED	1.000
6	SOLI	RED	X	RED	1.000
7	SOLI	RED	X	RED	1.000
8	SOLI	RED	X	RED	1.000
9	SOLI	RED	X	RED	1.000
10	SOLI	RED	X	RED	1.000

```
X-AXIS PLOT MINIMUM =  -.17014118+039
X-AXIS PLOT MAXIMUM =   .17014118+039
Y-AXIS PLOT MINIMUM =  -.17014118+039
Y-AXIS PLOT MAXIMUM =   .17014118+039

VARIABLE       1 (WITH       98 ELEMENTS) HAS THE FOLLOWING NAMES:   TIME    X

VARIABLE       2 (WITH       98 ELEMENTS) HAS THE FOLLOWING NAMES:   STRAIN  Y

VARIABLE       3 (WITH       98 ELEMENTS) HAS THE FOLLOWING NAMES:   STRESS

VARIABLE       4 (WITH        3 ELEMENTS) HAS THE FOLLOWING NAMES:   STRESS2

VARIABLE       5 (WITH        1 ELEMENTS) HAS THE FOLLOWING NAMES:   S2
VARIABLE       6 (WITH        1 ELEMENTS) HAS THE FOLLOWING NAMES:   C2

PARAMETER PI         HAS THE FOLLOWING VALUE:      .3141593+001
PARAMETER INFINITY   HAS THE FOLLOWING VALUE:      .1701412+039
PARAMETER NSTRESS2   HAS THE FOLLOWING VALUE:      .3000000+001
PARAMETER K          HAS THE FOLLOWING VALUE:      .1000000+001
PARAMETER ST         HAS THE FOLLOWING VALUE:      .3000000+003
PARAMETER A          HAS THE FOLLOWING VALUE:      .1591170+000
PARAMETER B          HAS THE FOLLOWING VALUE:     -.6243119-001
PARAMETER C          HAS THE FOLLOWING VALUE:      .1450866-002
PARAMETER REPSD      HAS THE FOLLOWING VALUE:      .0000000
PARAMETER REPDF      HAS THE FOLLOWING VALUE:      .0000000
PARAMETER RESSD      HAS THE FOLLOWING VALUE:      .2687022-002
PARAMETER RESDF      HAS THE FOLLOWING VALUE:      .3400000+002

FUNCTION  G        --A+B*EXP(-C*X)
```

The STATUS output has 3 sections--

1) storage;
2) plot control;
3) parameter/variable/function.

The storage section prints out information concerning the internal DATAPLOT arrays which have been used by the analyst. For the above example, the storage section indicates the following--

1) The maximum number of variables allowed is 10 (else use the DIMENSION command); 6 variables have been defined (TIME, STRAIN, STRESS, STRESS2, S2, and C2), and 10-6 = 4 variables remain to be defined;

2) The maximum number of observations per variable allowable is 1000 (else use the DIMENSION command); The longest (out of the 6 variables) has 98 observations; 1000-98 = 902 observations remain to be defined.

3) The total internal storage capacity is 10000 observations. The used storage is 6 variables x 1000 observations per variable = 6000 observations; the available storage available is 10000-6000 = 4000 observations.

4) The sum of the number of all characters in all DATAPLOT functions may not exceed 1000. For this run, 13 characters have been used (in the function G below); hence 1000-13 = 987 are available for further use by other functions.

5) The sum of the number of parameter names + variable names + function names may not exceed 200. For this run, 23 names have been defined--

   1) 6 user-defined variable names (TIME, STRAIN, STRESS, STRESS2, S2, and C2);

   2) 2 additional variable names (X and Y) that have been equated to TIME and STRAIN, respectively by use of the NAME command;

   3) 2 DATAPLOT-provided variables PRED (for predicted values) and RES (for residuals); these variables are not listed in the STATUS output because their storage is separate from that of the 10 variables and 10000 total observation limit of the analyst. PRED and RES are used anytime a PRE-FIT, FIT, EXACT RATIONAL FIT, SPLINE FIT, SMOOTH, ANOVA, or MEDIAN POLISH command is executed.

   4) 12 parameter names (INFINITY, PI, NSTRESS2, K, ST, A, B, C, REPSD, REPDF, RESSD, RESDF); of these 12 parameter names, PI and INFINITY are pre-defined by DATAPLOT and contain the value of the mathematical constant pi and the machine single-precision maximum. The 4 parameters REPSD, REPDF, RESSD, and RESDF are also internally-computed by DATAPLOT whenever any PRE-FIT, FIT, EXACT RATIONAL FIT, SPLINE FIT, SMOOTH, ANOVA, OR MEDIAN POLISH is done-- they contain the values

      1) REPSD = replication standard deviation;

      2) REPDF = replication degrees of freedom;

      3) RESSD = residual standard deviation;

      4) RESDF = residual degrees of freedom;

      The remaining parameters (NSTRESS2, K, ST, A, B, and C) are user-defined parameters.

   5) 1 function name (G).

The plot control section indicates information relevant to the generation of plots. For the example above, the STATUS output indicates--

1) The line types are all solid, except for the first line type which is blank (that is, no line);

2) All line colors are red (this is relevant only if one has a color terminal);

3) The character types are all X's, except for the second character which is blank (that is, no character);

4) All character colors are red (this is relevant only if one has a color terminal);

5) All character sizes are 1.0 (that is, 1% of total screen height);

6) the x-axis minimum is set at -infinity and the x-axis maximum is set at +infinity; these infinity values instruct DATAPLOT to have the plotted horizontal axis limits be neat and float with the data;

7) the y-axis minimum is set at -infinity and the y-axis maximum is set at +infinity; these infinity values instruct DATAPLOT to have the plotted vertical axis limits be neat and float with the data;

The parameter/variable/function section provides details about used parameters, variables, and functions. For the example above--

1) variable 1 has 98 observations and may be referred to by either the name TIME or X;

2) variable 2 has 98 observations and may be referred to by either the name STRAIN or Y;

3) variable 3 has 98 observations and has the name STRESS;

4) variable 4 has 3 observations and has the name STRESS2;

5) variable 5 has 1 observation and has the name S2;

6) variable 6 has 1 observation and has the name C2;

7) parameter PI has the value 3.141593;

*8) parameter INFINITY has the value .1701412**39;*

9) parameter NSTRESS2 has the value 3;

10) parameter K has the value 1;

11) parameter ST has the value 3;

12) parameter A has the value .1591170;

13) parameter B has the value -0.06243119;

14) parameter C has the value 0.001450866;

15) parameter RESSD has the value 0;

16) parameter RESDF has the value 0;

17) parameter REPSD has the value 0.002687022;
thus the residual standard deviation from the last fit-type operation was 0.002687022;

18) parameter REPDF has the value 34;
thus the residual degrees of freedom from the last fit-type operation was 34;

*19) function G has the character string A+B*EXP(-C*X) .*

Dumping On-Line Documentation
HELP

To print on-line documentation from within a DATAPLOT run, one uses the HELP command. The DATAPLOT HELP command may be followed by any one of the following 3 types of entries--

1) no entry at all, as in
   HELP

2) a DATAPLOT Command Category entry, as in
   HELP GRAPHICS

3) A DATAPLOT command name, as in
   HELP PLOT

These 3 cases will now be discussed individually.

If the analyst enters the HELP command alone with no trailing entry, as in

```
HELP
```

then the following will be printed at the terminal--

```
DATAPLOT IS AN INTERACTIVE GRAPHICS LANGUAGE.
THERE ARE 7 DATAPLOT COMMAND CATEGORIES--

    GRAPHICS
    ANALYSIS
    DIAGRAMMATIC GRAPHICS

    PLOT CONTROL
    SUPPORT
    OUTPUT DEVICE

    KEYWORDS

FOR A LISTING OF COMMANDS WITHIN A CATEGORY,
ENTER   HELP   FOLLOWED BY THE CATEGORY NAME,
AS IN--HELP GRAPHICS
       HELP ANALYSIS
       HELP PLOT CONTROL
```

The above is the list of the 7 general DATAPLOT command categories--

1) Graphics
2) Analysis
3) Diagrammatic Graphics
4) Plot Control
5) Output Device
6) Support
7) Keywords

If one enters HELP followed by any of the 7 command category names, as in

```
HELP GRAPHICS
HELP ANALYSIS
HELP DIAGRAMMATIC GRAPHICS
```

then a list of all DATAPLOT command names within that category will be printed. For example, if one enters

```
HELP GRAPHICS
```

then the following output will appear at the terminal--

```
THE DATAPLOT GRAPHICS COMMAND CATEGORY
CONSISTS OF THE FOLLOWING 18 COMMANDS--

    BOX PLOT
    COMPLEX DEMODULATION ... PLOT
    ... CONTROL CHART
    ... CORRELATION PLOT
    ... FREQUENCY PLOT
    ... HISTOGRAM
    ... HOMOSCEDASTICITY PLOT
    LAG ... PLOT
    ... NORMALITY PLOT
    PERCENT POINT PLOT
    ... PERIODOGRAM
    PIE CHART
    PLOT
    ... PPCC PLOT
    ... PROBABILITY PLOT
    RUN SEQUENCE PLOT
    ... SPECTRAL PLOT
    3-D PLOT

FOR ADDITIONAL INFORMATION ABOUT A
PARTICULAR COMMAND,
ENTER   HELP   FOLLOWED BY THE COMMAND NAME,
AS IN--HELP BOX PLOT
       HELP COMPLEX DEMODULATION ... PLOT
       HELP ... PROBABILITY PLOT
```

If one enters HELP followed by a command name, as in

```
HELP PLOT
HELP FIT
HELP LET
```

then summary, usage, default, and examples information will be printed out about that particular command. For example, if one entered

```
HELP PLOT
```

then the following output would result--

```
PLOT

    PURPOSE--GENERATE A PLOT

    EFFECT          --A PLOT IS GENERATED
    VISIBLE EFFECT--A PLOT IS GENERATED
    DEFAULT         --NOT APPLY
    EXAMPLES        --PLOT Y X
                      PLOT SIN(X) FOR X = 0 .1 5
                      PLOT Y PRED VERSUS X
```

Such on-line documentation is a useful feature which saves the analyst from a time-consuming look-up in a hardcopy manual. The HELP output

is not meant to be all-inclusive and comprehensive; rather, it is meant to summarize salient points pertaining to commands.

At times it is convenient to divert the output from the HELP command so that it does not come back to the terminal, but rather is directed out to some user-defined mass-storage file. For example, suppose the analyst wanted the HELP output for the following commands--

```
PLOT
TITLE
LABEL
CHARACTERS
LINES
FONT
HARDCOPY
```

to be printed out to a file (pre-existing) which has a numeric designation of, say, 12. This may be done by use of the HELP and SET commands in the following fashion--

```
SET IPR 12
HELP PLOT
HELP TITLE
HELP LABEL
HELP CHARACTERS
HELP LINES
HELP FONT
HELP HARDCOPY
SET IPR 6
```

The SET IPR 12 command redefines the standard output unit from default (usually 6) to 12. All subsequent output will thus be diverted to the file with numeric designation 12--no output will appear at unit 6 (the terminal). The HELP PLOT command will produce output to unit 12, as will the succeeding HELP commands. The last command (SET IPR 6) will redefine the standard output unit to be 6 again, and so control will return to the terminal. The net result is that the file with numeric designation 12 will contain all of the line images which DATAPLOT would normally send to the terminal. After exiting out of DATAPLOT, the analyst may then peruse this file at will and/or send it off to the printer via a local system print/list utility command.

Redimensioning Internal Storage

DIMENSION

Upon signing onto DATAPLOT, a message will be generated which states the limits (for your particular computer) of internal data storage in DATAPLOT. The usual limits are

1) maximum number of variables = 10

2) maximum number of observations per variable = 1,000

3) maximum total internal data storage = 10 x 1,000 = 10,000

The maximum total internal data storage size is typically fixed (here = 10,000) and unchangeable; however, the analyst does have some flexibility in terms of changing the number of variables (from 10 to something larger than 10) and in terms of changing the maximum number of observations per variable (from 1,000 to something smaller than 1,000). In any event, if the analyst changes either the number of variables, or the maximum number of observations per variable, the overriding constraint will exist that their product will = the total internal data storage size (= 10,000).

The DIMENSION command allows the analyst to change the number of variables, or the maximum number of observations per variable, (or both). To change the upper limit on the number of variables from 10 to, say, 200, enter

DIMENSION 200 VARIABLES

or (equivalently)

DIMENSION 200 COLUMNS

A message will result stating that the

1) maximum number of variables = 200

2) maximum number of observations per variable = 50

3) maximum total internal data storage = 200 x 50 = 10,000

Note that in addition to the number of variables being changed from 10 to 200, the maximum number of observations per variable has also been automatically changed from 1,000 to 10,000/200 = 50.

Similarly, to change the maximum number of observations per variable from 1000 to, say, 250, enter

DIMENSION 250 OBSERVATIONS

or (equivalently)

DIMENSION 250 ROWS

A message will result stating that the

1) maximum number of variables = 40

2) maximum number of observations per variable = 250

3) maximum total internal data storage = 40 x 250 = 10,000

Note that in addition to the maximum number of observations per variable being changed from 1,000 to 250, the number of variables has also been automatically changed from 10 to 10,000/250 = 40.

Current (1/83) configurations of DATAPLOT do not permit the DIMENSION statement to change the number of variables to more than 200, nor to change the maximum number of observations per variable to more than 1,000. However, with hardware advances in memory sizes occurring so rapidly, it is clear that future versions of DATAPLOT will have both of these limits raised considerably.

Specifying the Terminal
TERMINAL

The TERMINAL command allows the analyst to specify the particular terminal being used. The default terminal is a Tektronix 4014 or equivalent. The TERMINAL command should specify both the manufacturer and the model number, as in

TERMINAL TEKTRONIX 4027

TERMINAL TEKTRONIX 4010

TERMINAL RAMTEK 6011

When the TERMINAL command is processed by DATAPLOT, it will automatically adjust internal settings relating to

1) *whether or not the terminal is continuous or discrete;*

2) *whether or not the terminal is color or non-color;*

3) *the number of screen picture points (horizontal and vertical) for the terminal.*

Thus the use of the TERMINAL command obviates the need for the CONTINUOUS/DISCRETE command, the COLOR command, and the PICTURE POINTS command.

Specifying the Host
HOST

The HOST command is seldom used. This command specifies the current host. Usually such a host-specification is automatic upon signing onto DATAPLOT, hence its rare usage. The form for the HOST command includes both the computer manufacturer and model number, as in

HOST VAX 11/780

HOST UNIVAC 1100/82

HOST IBM 4341

HOST IBM PC

Specifying the Communications Link
COMMUNICATIONS LINK and BAUD RATE

The commands in this section are rarely used. The motivation for their inclusion stems more from completeness and the ability to address potential future problems than actual past problems.

When multiple terminals are running DATAPLOT from a common host, the terminals may be running over communication links that have differing baud rates. This can at times lead to timing and buffering problems in the terminal hardware as it interacts with the underlying continuous graphics software. Typical indications that such problems are occuring are that graphs will be generated which are clipped (incomplete)--parts of the plot which should be drawn (usually frame lines) remain undrawn.

A common local cause of this is that plot directives are being processed by the terminal while a screen erasure is still in progress. It takes a typical display terminal about 1 full second to erase the screen. In that second, the terminal should be buffering commands and/or the graphics software should be sending null character strings. In order for the proper number of nulls to be sent, it is necessary that the underlying graphics software be correctly informed of the communication baud rate. If the actual baud rate is faster than the default baud rate, then an insufficient number of nulls will be generated in order for the screen erasure to be completed. In such case, the terminal hardware buffering must take over. If the terminal hardware has such buffering, then the plot will be properly formed; however, if the terminal hardware does not have buffering, then the plot will be clipped.

The default internal DATAPLOT baud rate setting is 1200. Usually this baud rate does not have to be reset (well over 95% of all DATAPLOT runs at the NBS implementation are done under the default baud rate--even though the terminals are running anywhere from 300 baud to 19200 baud). However, if such clipping problems do arise, then the baud rate setting may be the problem. To change this rate, use the BAUD RATE command, as in

```
BAUD RATE 9600
```

The type of communication link may also affect the (continuous) graphics information being transmitted. For example, the phone line rarely "eats" or "adds" control characters to a transmission, but some specialized communication networks do "eat/add" certain character sequences. It is common for graphics software directives to involve "escape" sequences; it is also common for some intelligent communication networks to have command directives which themselves involve "escape" sequences. Thus when the graphics software sends such sequences, the network itself intercepts (and acts on) them, and the terminal never receives them. The net effect is missing parts on the graph, glitches on the graph, or improperly-formed components on the graph.

If the analyst is having problems in the formation of continuous graphs, and if the problem is traceable to the communications link, then it will be necessary to inform DATAPLOT of the type of communications link so that local systems personnel may adjust the internal code depending on the type of link. The default link is the standard phone lines (as would be used, e.g., with an acoustic coupler). To change the link specification, use the COMMUNICATIONS LINK command, as in

```
COMMUNICATIONS LINK NETWORK
COMMUNICATIONS LINK ARPANET
COMMUNICATIONS LINK ETHERNET
```

Specifying the baud rate is done occasionally; specifying the communications link is done even less frequently.

Specifying Trigonometric Units

TRIGONOMETRIC UNITS

DATAPLOT has an extensive set of trigonometric and inverse trigonometric library functions. Trigonometric calculations may be carried out in radians, degrees, or grads (as is common in Europe). The default unit is radians. If it is desired to have trigonometric calculations in degrees, then enter

```
TRIGONOMETRIC UNITS DEGREES
```

or simply

```
DEGREES
```

All subsequent trig calculations will thus be carried out in degrees. To change the angle units to grads, enter

```
TRIGONOMETRIC UNITS GRADS
```

or

```
GRADS
```

To change the angle units back to radians, enter

```
TRIGONOMETRIC UNITS RADIANS
```

or

```
RADIANS
```

Another instance in which the angle units comes into play is in the scribing of text strings on a plot or diagram at an angle other than horizontal. For example, to write the text string abc starting in the middle of the screen in triplex font, one would enter

```
FONT TRIPLEX
MOVE 50 50
TEXT ABC
```

How would one write the same text string at a 45 degree angle? To do so, one uses both the TRIGONOMETRIC UNITS and the ANGLE command. The TRIGONOMETRIC UNITS command specifies the desired units (radians, degrees, or grads); the ANGLE command specifies the desired angle of the text string (in whatever angle units that were chosen). For example, to write out the text string abc in triplex font at an angle of 45 degrees, the easiest way is

```
TRIGONOMETRIC UNITS DEGREES
ANGLE 45
FONT TRIPLEX
MOVE 50 50
TEXT ABC
```

but an alternative valid way is

```
TRIGONOMETRIC UNITS RADIANS
LET A = PI/4
ANGLE A
FONT TRIPLEX
MOVE 50 50
TEXT ABC
```

or

```
ANGLE UNITS GRADS
ANGLE 50
FONT TRIPLEX
MOVE 50 50
TEXT ABC
```

Note that all of DATAPLOT's fonts may be written at any angle (except the Tektronix font--which is a terminal-hardware-generated font that may only be written in the usual horizontal (angle = 0) fashion).

A synonym command for the TRIGONOMETRIC UNITS command is the ANGLE UNITS command, thus

```
TRIGONOMETRIC UNITS DEGREES
```

and

```
ANGLE UNITS DEGREES
```

have the same effect.

Echoing Commands

ECHO

When running pre-stored DATAPLOT programs, it is at times convenient to have the commands echoed back as they are being executed. To do this, one enters

```
ECHO
```

or

```
ECHO ON
```

somewhere up near the beginning of the code.

The echoed commands will appear in an easily-noticeable box as they are being executed, The output from the execution of each command will appear immediately below the box. Thus the effect of

```
LINES SOLID DOT DASH
CHARACTERS A B C
```

is the usual

```
LINE      1 HAS JUST BEEN SET TO SOLI
LINE      2 HAS JUST BEEN SET TO DOT
LINE      3 HAS JUST BEEN SET TO DASH


CHARACTER      1 HAS JUST BEEN SET TO A
CHARACTER      2 HAS JUST BEEN SET TO B
CHARACTER      3 HAS JUST BEEN SET TO C
```

whereas the effect of

```
ECHO ON
LINES SOLID DOT DASH
CHARACTERS A B C
```

is

```
      ****************************
      **  LINES SOLID DOT DASH  **
      ****************************


LINE      1 HAS JUST BEEN SET TO SOLI
LINE      2 HAS JUST BEEN SET TO DOT
LINE      3 HAS JUST BEEN SET TO DASH

      ************************
      **  CHARACTERS A B C  **
      ************************


CHARACTER      1 HAS JUST BEEN SET TO A
CHARACTER      2 HAS JUST BEEN SET TO B
CHARACTER      3 HAS JUST BEEN SET TO C
```

When operating in a high baud rate environment in which information comes back to the terminal at a very fast rate, the use of the ECHO command will allow the analyst not only to see the output from DATAPLOT commands, but also the specific command line which generated the output. The net effect is that the analyst will more easily follow the execution of the pre-stored DATAPLOT code. This is convenient in monitoring the analysis and making sure that the analysis is proceeding as expected.

Suppressing Printed Output
FEEDBACK and PRINTING

All of DATAPLOT's commands result in some form of printed output. A broad partitioning of all DATAPLOT commands could consist of

1) Graphics commands;
2) Analysis commands;
3) All other commands (= secondary commands).

The commands in the GRAPHICS category (PLOT, HISTOGRAM, SPECTRUM, 3D-PLOT, NORMAL PROBABILITY PLOT, etc.) all result in immediate graphics output which is typically important in terms of carrying out the analysis. Such output is usually not suppressed.

The commands in the Analysis category (FIT, SPLINE FIT, ANOVA, SMOOTH, SUMMARY, LET, etc.) all have immediately-printed output which is of interest in terms of carrying out the goals of an analysis. With the possible exception of output from the LET command, the suppression of such output is rarely done.

The remainder of DATAPLOT's commands (such as CHARACTERS, LINES, READ, DIMENSION, DELETE, LEGEND, TITLE, LABEL, etc.) are not really end objectives in an analysis, but rather are necessary intermediate steps in carrying out an analysis precisely to one's specifications. These secondary commands also generate printed feedback information which assures the analyst that the command that the host received was identical to the command that was entered through the keyboard. This feedback information is comforting and reassuring to the analyst in that the specified commands are resulting in the desired action. Such feedback rarely "gets in the way" and is the default when one signs onto DATAPLOT. Occasions do arise, however, when it would be desirable to be able to suppress such feedback. To do so, enter

```
FEEDBACK OFF
```

When the FEEDBACK OFF command has been received, all feedback information from all secondary commands, (and all usual output from the LET command), will be suppressed. The most common occurrence of this is in the generation of diagrammatic graphics (diagrams, schematics, word charts, etc.) where one wishes to suppress feedback messages so that they will not clutter up the screen as the diagram is being formed. For example, the execution of the following pre-stored DATAPLOT program

```
FONT TRIPLEX ITALIC
HEIGHT 5
WIDTH 3
JUSTIFICATION CENTER
.
ERASE
MOVE 50 80
TEST GRAPHICS
HEIGHT 2
WIDTH 1
MOVE 50 70
TEXT ANALYSIS GRAPHICS
MOVE 50 60
TEXT PRESENTATION GRAPHICS
COPY
```

will (upon execution) result in the desired word chart being formed, but will also have the word chart "ruined" because the automatic feedback information from the

```
HEIGHT 2
WIDTH 1
```

commands will also appear superimposed on the word chart.

To circumvent this problem, the above code should be amended to

```
FONT TRIPLEX ITALIC
HEIGHT 5
WIDTH 3
JUSTIFICATION CENTER
.
FEEDBACK OFF
ERASE
MOVE 50 80
TEST GRAPHICS
HEIGHT 2
WIDTH 1
MOVE 50 70
TEXT ANALYSIS GRAPHICS
MOVE 50 60
TEXT PRESENTATION GRAPHICS
COPY
```

The desired word chart--uncluttered by feedback information--will be formed.

To counteract the FEEDBACK OFF command, enter

```
FEEDBACK ON
```

or

```
FEEDBACK
```

We have seen how the FEEDBACK OFF command will suppress output from all secondary commands and from the LET command. Is there any way to suppress output from any of the Analysis category commands other than LET (e.g., FIT, SPLINE FIT, ANOVA, SMOOTH, SUMMARY, etc.)? Although such suppression is rarely done, it may be carried out by entering

```
PRINTING OFF
```

To counteract this command, the analyst enters

```
PRINTING ON
```

or

```
PRINTING
```

Diverting Graphics Output to Offline Devices PENPLOTTER, ZETA, CALCOMP, and VERSATEC

When generating graphics on a terminal, it is at times convenient to have such graphics not only appear on the screen, but also to route them to alternate graphics device. If the analyst enters the

```
PENPLOTTER
```

or

```
PENPLOTTER ON
```

command, then all subsequent plots will also appear on the local penplotter (e.g., Tektronix 4662). This penplotter must be connected in serial between the host and the terminal. When using a penplotter, the analyst must have the proper baud rate (typically quite slow due to the mechanical nature of the penplotter), and also must have the proper communication switch settings on the penplotter (which depends on the nature of the communications link and the host).

To turn the penplotter off, the analyst enters

```
PENPLOTTER OFF
```

For other offline devices (such as the Zeta, Calcomp, and Versatec plotters), the analyst should enter the commands

```
ZETA
CALCOMP
VERSATEC
```

or

```
ZETA ON
CALCOMP ON
VERSATEC ON
```

respectively. The net effect of any of these commands is the same in DATAPLOT, namely, to capture whatever graphics information is going to the screen, allow it to proceed to the screen, but also write that same information out to a plot file. The net result is that when the DATAPLOT session is finished, the analyst will have in this plot file a full record of all the character strings that (when sent to the Tektronix terminal) would cause the plots to reform. In fact, such plots could be reformed by simply going into the plot file with the local editor and printing out some number of lines with an editor print. If the terminal being used is a Tektronix, then the plot will reform; if the terminal being used is a Tektronix-incompatible or an alphanumeric (non-graphics) terminal, then lines of unintelligible gibberish will appear.

The name of the plot file which DATAPLOT writes such information out to is DPPL1F. DATAPLOT automatically creates this file when these alternate plot devices are specified. The FORTRAN unit number that DATAPLOT assigns to this file is 43. The file is temporary (it will remain after the analyst signs off of DATAPLOT, but will disappear when the analyst logs off the computer). When the analyst signs off of DATAPLOT, a message will be generated which reminds the analyst what file name (DPPL1F) and file number (43) were given to the plot file, and will also give the analyst instructions on how to post-process the file so that the Tektronix characters may be converted to Zeta, Calcomp, Versatec, etc. plots.

To consider a specific example, note the following program--

```
ZETA
PLOT X**2 FOR X = 1 1 10
EXIT
```

When the

```
ZETA
```

command is encountered, the following feedback message will appear--

```
DEVICE    2 INFORMATION
            POWER          --ON
            MANUFACTURER   --ZETA
            CONTINUITY     --ON
            COLOR          --OFF
            PICTURE POINTS--    1000    1000
```

Note that "device 2" is any alternate graphics output device, while "device 1" is the terminal itself.

When the

```
PLOT X**2 FOR X = 1 1 10
```

is encountered, the screen will erase, and the quadratic plot will appear. While this is happening, the same character strings which caused the plot to form on the screen are being copied into file DPPL1F (= file 43).

When the analyst enters

```
EXIT
```

DATAPLOT will remind the analyst that an alternate plotting device has been specified, and will provide the following feedback messages--

```
NOTE--THE ALTERNATE PLOT FILE
      IS CLOSED.
      THE NAME OF THE FILE IS    DPPL1F.    .
      TO EXAMINE THE FILE, USE ANY EDITOR,
      (@EDM, @ED, @CTS, ETC.), AS IN
      @EDM,Q DPPL1F.
      P *
      TO SEND THE FILE TO THE ZETA    , ENTER
      @NBS*PLIB$.AUNIPLOT,I DPPL1F.,,ZETA,FMT/TEK
      WHERE THE I OPTION ALLOWS UP TO 3 LINES OF
      OPERATOR DIRECTIVES (PEN, POINT, COLOR, PAPER)

THIS IS AN EXIT FROM DATAPLOT.
```

Note that the contents of the exit message are clearly site-dependent. The above message was captured from output generated on the NBS Univac 1100/82. @EDM, @ED, @CTS are local Univac editors; and

```
@NBS*PLIB$.AUNIPLOT,I DPPL1F.,,ZETA,FMT/TEK
```

is a local Univac post-processor (completely independent and separate from DATAPLOT) which allows any file (in particular, file DPPL1F) containing Tektronix graphics strings to be converted and send to the NBS Zeta plotter.

Under current (1/83) configurations, DATAPLOT will not write directly to the Zeta, Calcomp, or Versatec); rather, DATAPLOT writes a Tektronix graphics string file (the same file regardless of whether the ultimate device is the Zeta, Calcomp, Versatec, or some other device), and then the analyst must apply a locally-provided, system-dependent post-processor to this file to send its contents to its ultimate destination.

DATAPLOT does not provide the Tektronix-to-... post-processor; it must be locally provided. In this regard, 2 items are noted--

1) *future versions of DATAPLOT will have direct writing to alternate graphics devices;*

2) *it has been reported (though not yet substantiated) that commercially-available post-processors are being developed for a variety of computers and a variety of output devices.*

Note that if the analyst enters

```
ZETA OFF
CALCOMP OFF
VERSATEC OFF
```

then DATAPLOT will also close the alternate plot file, and will provide the same feedback messages. As in the example above, if the analyst chooses to leave the file open, then upon exit from DATAPLOT, it will automatically be closed.

As many plots as desired may be written out to the alternate plot file. Caution should be exercised in multiple opening and closing of the alternate plot file during the same DATAPLOT session--this should not be done because subsequent openings of the file will overwrite the existing plots on the file. For example, consider the following 10-line DATAPLOT program--

```
ZETA ON
PLOT X FOR X = 1 1 10
PLOT X**2 FOR X = 1 1 10
ZETA OFF
.
ZETA ON
PLOT X**3 FOR X = 1 1 10
PLOT X**4 FOR X = 1 1 10
ZETA OFF
```

The net effect is that the linear and quadratic plot residing on file DPPL1F will be overwritten by the cubic and quartic plots. If all 4 plots were desired to be on the file, then the program should be amended to

```
ZETA ON
PLOT X FOR X = 1 1 10
PLOT X**2 FOR X = 1 1 10
PLOT X**3 FOR X = 1 1 10
PLOT X**4 FOR X = 1 1 10
ZETA OFF
```

Redefining I/O Units and Saving DATAPLOT Output
SET

For most computers,

1) the default numeric designation for the input unit is 5;

2) the default numeric designation for the input unit is 6.

The underlying code in which DATAPLOT is written is FORTRAN (ANSI 77). The underlying FORTRAN variable names which specify the above 2 default I/O unit numbers are

1) IRD for the input unit;
2) IPR for the output unit.

Whenever DATAPLOT is reading commands from the terminal, it is reading from unit 5; whenever DATAPLOT is sending information back to the terminal (both non-graphics and graphics information), it is writing to unit 6.

We have seen in other sections how the use of the ZETA, CALCOMP, and VERSATEC commands allows us to capture graphics information and copy it out to a file (file DPPL1F = file 43). This leads us to the question of how one might capture all information (graphical and non-graphical) and place it in a file (perhaps for future perusal, or perhaps to increase execution speed). Although this is rarely done, it is nevertheless possible--via the SET command. The SET command allows us to change a variety of underlying FORTRAN settings; we focus here on altering the settings of the IRD and IPR variables. The form for the SET command is

SET FORTRAN variable name Desired setting

Thus to change the standard input unit from 5 to 11, one could enter

SET IRD 11

and to change the standard output unit from 6 to 21, one could enter

SET IPR 21

Note that if the analyst changes the standard output unit from the terminal to some file, then all output will go to that file (and no output will go to the terminal). Such a file may, of course, be subsequently perused and edited. In practice, the "average" analyst will rarely (if ever) find the need to change IRD and IPR settings.

Controlling The Terminal--Erasing, Hardcopying, etc.
PRE-ERASE, HARDCOPY, ERASE, and COPY

The following 4 commands are useful to control elementary erasing and copying operations at the terminal--

PRE-ERASE
HARDCOPY

ERASE
COPY

The PRE-ERASE command, as in

PRE-ERASE ON

or simply

PRE-ERASE

instructs DATAPLOT that every subsequent plot command (that is, every command from the Graphics category--PLOT, BOX PLOT, 3D-PLOT, CONTROL CHART, LAG ... PLOT, HISTOGRAM, SPECTRUM, etc.) should automatically erase its screen prior to the plotting operation. Since graphics is a core DATAPLOT operation, this automatic pre-erasure is reserved for all of the commands in the DATAPLOT Graphics category. Only commands in this category have this automatic pre-erasure option. Note that the default setting for plot pre-erasure is ON, and so the analyst only rarely needs to explicitly enter the PRE-ERASE command. To turn the pre-erasure off, the analyst enters

PRE-ERASE OFF

This capability is only occasionally used. Its main use arises in the superposition of plots atop one another, as in

```
XLIMITS 10 20
YLIMITS 100 150
PRE-ERASE OFF
ERASE
PLOT Y1 X
PLOT Y2 X
PLOT Y3 X
etc.
```

This program will

1) Set the x-axis limits to 10 and 20 for all subsequent plots (so that all superimposed plots have the identical scale);

2) Set the y-axis limits to 100 and 150 for all subsequent plots (for the same reason);

3) Turn off the automatic plot pre-erasure (so that the second, third, etc. plots do not erase the screen when they are being superimposed);

4) Manually erase the screen prior to the first plot;

5) Generate one plot;

6) Superimpose a second plot;

7) Superimpose a third plot;

8) etc.

The superposition of plots in this fashion allows us to generate plots with an indefinitely large number of plot points--thus circumventing any DATAPLOT restrictions that might exist as to maximum number of points per plot.

The automatic, "hands-off" copying of all generated plots to the local hardcopy units is a convenient feature. To activate this feature, the analyst enters

HARDCOPY ON

or simply

HARDCOPY

Every plot command subsequently entered will result in not only the plot being generated on the terminal screen, but also the plot being automatically copied to the local hardcopy unit as soon as the plot finishes constructing itself on the screen.

To specify multiple hardcopies per plot, the analyst appends the desired number to the end of the command, as in

HARDCOPY ON 3

or

HARDCOPY 3

which will make 3 local hardcopies of every plot which appears on the screen.

To terminate the automatic copying of plots, the analyst enters

HARDCOPY OFF

The default setting of the plot hardcopy switch is off.

The PRE-ERASE and HARDCOPY commands are passive commands--they set internal switches which are later scanned when plot commands are entered. The last 2 commands (ERASE and COPY) are active commands in the sense that when these commands are encountered, something happens immediately--the terminal erases its screen, or the terminal makes a local hardcopy of the current contents of the screen.

To erase the screen under program control, use the ERASE command. To copy the contents of the screen under program control, use the COPY command. Anytime DATAPLOT encounters the ERASE and COPY commands, the screen will be immediately erased and copied, respectively. In addition, if the analyst is running interactively from a terminal, the terminal itself usually has erase and copy keys which may be manually depressed. The ERASE and COPY commands are, however, more convenient to use because they may be entered in pre-stored DATAPLOT programs. A typical example of when the ERASE and COPY commands are useful is

```
ERASE
FIT Y = some model
COPY
```

This program will

1) erase the screen;

2) generate the usual FIT output;

3) copy the FIT output to the hardcopy unit.

Another example is in diagrammatic graphics, as in

```
FONT TRIPLEX ITALIC
JUSTIFICATION CENTER
.
ERASE
MOVE 50 50
TEXT ABC
COPY
```

This program will

1) Set the font style to triplex italic;

2) Set the justification to center justified;

3) erase the screen;

4) move to the middle of the screen;

5) write out the text string ABC ;

6) copy the screen to the hardcopy unit.

Activating Local Settings
IMPLEMENT

The IMPLEMENT command allows the analyst to automatically activate local settings, conventions, and preferences. The form of the command is

IMPLEMENT number

as in

IMPLEMENT 1

AND

IMPLEMENT 2

Different installations have different features--depending on local preferences. For example, at NBS, we have only 2 local settings which may be accessed via the IMPLEMENT command. If the analyst here enters

IMPLEMENT 1

then this would be equivalent to the following 5 lines of code--

```
X2TIC MARKS OFF
X2TIC MARK LABELS OFF
Y2TIC MARKS OFF
Y2TIC MARK LABELS OFF
Y2LABEL
```

and so the IMPLEMENT 1 command would have the net effect of causing all subsequent plots to be produced with neither tic marks nor tic mark labels on the upper and right frame lines, and with no vertical label on the right side of the frame. If the NBS analyst entered

IMPLEMENT 2

then this would be equivalent to entering

FRAME CORNER COORDINATES 15 20 75 85

that is, this would cause all subsequent plots to have a square shape rather than the default rectangular shape. Such a square shape is, for example, useful in Youden plots (an interlaboratory graphical data analysis technique). The IMPLEMENT 1 and IMPLEMENT 2 commands at other installations will typically cause these same 2 features to be activated. In addition, the local DATAPLOT service group may have added other convenient features which could be accessed via IMPLEMENT 3, IMPLEMENT 4, etc. Check the local DATAPLOT service group for such augmentations.

Entering Comment Lines
COMMENT and .

It is good programming practice to enter non-executable comments in stored DATAPLOT programs. There are 2 ways to enter a comment line--

1) via the COMMENT command;
2) via the . command.

The 2 commands (COMMENT and .) are equivalent. Any DATAPLOT statement that starts with COMMENT or . will become a null (or "no-op") statement--such statements are non-executable. The following programs are identical--

```
COMMENT CALIBRATION ANALYSIS
COMMENT JANUARY 1983
READ XYZ. X Y
TITLE CALIBRATION
PLOT Y X
LET A = 10
LET B = 5
LET C = .5
FIT Y = A+B*EXP(-C*X)
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

and

```
. CALIBRATION ANALYSIS
. JANUARY 1983
READ XYZ. X Y
TITLE CALIBRATION
PLOT Y X
LET A = 10
LET B = 5
LET C = .5
FIT Y = A+B*EXP(-C*X)
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

Note that the . command is often useful for visually segregating chunks of DATAPLOT code. Note the difference between the above code and

```
. CALIBRATION ANALYSIS
. JANUARY 1983
.
READ XYZ. X Y
.
TITLE CALIBRATION
PLOT Y X
.
LET A = 10
LET B = 5
LET C = .5
FIT Y = A+B*EXP(-C*X)
.
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

The latter is easier to read because it has been separated into functionally-modularized "chunks" of code. The programs would execute identically. Note that the COMMENT command (and the . command in particular) must be followed by at least 1 space so as to separate it from any remaining text on the line; thus

```
. CALIBRATION ANALYSIS
```

is correct, but

```
.CALIBRATION ANALYSIS
```

is incorrect.

If COMMENT or . is not followed by any text, then the trailing space is, of course, not needed--COMMENT and . may be succeeded immediately by a carriage return.

*The . command is also a convenient way of "commenting out" code (in stored DATAPLOT programs) that we have already executed in previous runs, that we no longer wish to execute, but still wish to retain in the code as a memory aid. For example, suppose we executed the above code which fitted the model Y = A+B*EXP(-C*X), but now wish to execute the same code with the model Y = A+B*X**C. We could delete (via the local editor) the original FIT statement from the stored code, but alternatively we may wish to simply "comment out" the original FIT statement as a reminder of models that were already tried; as in*

```
. CALIBRATION ANALYSIS
. JANUARY 1983
.
READ XYZ. X Y
.
TITLE CALIBRATION
PLOT Y X
.
LET A = 10
LET B = 5
LET C = .5
. FIT Y = A+B*EXP(-C*X)
FIT Y = A+B*X**C
.
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

Recommended Programming Practices

When constructing (via the editor) DATAPLOT programs (that are to be stored in a file/subfile) for later execution, it is recommended that liberal use of comments (especially at the beginning of the code) be used. The COMMENT command and the . command assist in this regard. Liberal use of the . command to visually separate chunks of DATAPLOT code also make for easier reading and understanding of the code after-the-fact. Contrast, for example, the following 2 DATAPLOT programs--both of which are identical in execution--

```
READ XYZ. X Y
TITLE CALIBRATION ANALYSIS
YLABEL PRESSURE
XLABEL TIME
PLOT Y X
LET A = 1
LET B = 10
LET C = .5
FIT Y = A+B*SQRT(C+X)
CHARACTERS LINES BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
YLABEL RESIDUALS
PLOT RES X
```

and

```
. CALIBRATION ANALYSIS
. SPECIMEN 247
. JANAURY 1983
.
READ XYZ. X Y
.
TITLE CALIBRATION ANALYSIS
YLABEL PRESSURE
XLABEL TIME
PLOT Y X
.
LET A = 1
LET B = 10
LET C = .5
FIT Y = A+B*SQRT(C+X)
.
CHARACTERS LINES BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
.
YLABEL RESIDUALS
PLOT RES X
```

A common set of commands which often appears at the beginning of many DATAPLOT runs (whether running interactively, or running stored DATAPLOT programs) is

```
ECHO ON
HARDCOPY ON
SEQUENCE ON
```

The ECHO ON command tells DATAPLOT to echo back all entered commands (in a noticeable box) as the commands are being executed. If one is running a stored DATAPLOT program in a rapid-fire fashion, then the echoing helps to keep track of exactly what command is being executed--because one sees not only the produced output (which may "fly by" and fill the screen quickly), but also one sees the specific input command that produced the output. This is useful for monitoring the execution of "canned" programs.

The HARDCOPY ON command causes every plot which appears on the terminal screen to be automatically copied to the local hardcopy unit. This "hands off" feature is very helpful in producing a record of how the analysis proceeded.

The SEQUENCE ON command causes an automatically-incremented sequence number to appear (inconspicuously) in the upper right corner of plots as they are being generated. When used in conjunction with the HARDCOPY ON command, it gives the analyst an ordered set of graphics output which provides a valuable record of how a data analysis proceeded.

For doing analysis graphics (= graphics for extracting structure from data), the analyst should use the default Tektronix font for the titles, labels, legends, etc. This font is not as "pretty" as the fancier-script fonts but is quite adequate, very readable, and is quickly generated. For such graphical data analysis, the default Tektronix is more than adequate and will not slow down the analysis. One should wait until the end of the analysis--when structure has been extracted and when conclusions have been formulated--before one uses the fancier fonts. As the analysis graphics stage is being finished, and the presentation graphics (= graphics for communicating conclusions via journals, seminars etc.) stage is being started, then the analyst should consider using the "fancier" fonts. The switch to such fonts is a one-command operation in DATAPLOT, namely the FONT command, as in

```
TITLE LINE STANDARDS ANALYSIS
YLABEL WIDTH
XLABEL POSITION
FIT Y = A+B*X
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
.
FONT TRIPLEX ITALIC
PLOT Y PRED VERSUS X
```

The titles and labels from the first plot will be default Tektronix font--they will be generated very fast; the titles and labels from the second plot will be in triplex italic font--they will take more time to generate, but will be of much higher quality.

Of all the plot control commands available in DATAPLOT, the 2 commands which the analyst will find him/herself using most heavily are the CHARACTERS and LINES commands. The CHARACTERS command specifies the desired plot characters to appear at the plot points of a trace; the LINES command specifies the desired line type which connects the various plot points of the trace. The default character type is blank, and the default line type is solid. These defaults allow for the rapid continuous-trace plotting of data sets and functions. Display terminals typically take longer to generate traces which have non-blank plot characters than those with blank plot characters--such terminals draw solid traces very rapidly, but draw individual characters much more slowly. If the trace has 100 points or so, then the time difference will be neglible; if the trace has 1000 points, then the time difference will be noticeable. As the electronics of display terminals improve, this time-of-plot consideration should disappear.

A particular case of the CHARACTERS and LINES command which arises time and time again whenever a fitting operation has been carried out is

```
CHARACTERS X BLANK
LINES BLANK SOLID
```

The usual context in which this appears is

```
FIT Y = some model
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
```

The above code will

1) *carry out a fit according to some model, and automatically store the resulting predicted values (in a variable named PRED) and residuals (in a variable named RES).*

2) *specify that the characters on succeeding plots have X's for the first trace, and blanks for the second trace (if there is a second trace);*

3) *specify that the lines on succeeding plots have no connecting lines for the first trace, and solid connecting lines for the second trace (if there is a second trace);*

4) *plot the raw data (Y) versus X and superimpose the predicted values (PRED) from the fit versus X. Note that the Y versus X trace will have X's as plot characters and no connecting lines, and the PRED versus X trace will have blank plot characters and a solid connecting line. The usual form for the superimposed plot of raw data and predicted values is to have the raw data appear as discrete X's and the predicted values to appear as a solid trace. The above CHARACTERS and LINES commands in conjunction with the PLOT Y PRED VERSUS X command allow the analyst to do this easily.*

5) *plot the residuals (RES) from the fit versus X. Note that since only 1 trace is being outputted here, then the plot will follow the first specification of the above CHARACTERS and LINES commands, namely to have X's as plot characters, and to have no connecting lines.*

Interrupting, Saving, and Resuming A Run

SAVE and RESTORE

Suppose one is in the middle of an interactive session with DATAPLOT, and one is forced to interrupt a run (to go to a seminar, say). In such case it would be extremely convenient to be able to save all of DATAPLOT's internal settings so as to be able to continue the run at some later time. To do so, one uses the SAVE and RESTORE commands. The form for the SAVE command is

SAVE XYZ.

where XYZ is a pre-existing user file to which all of the internal DATAPLOT settings will be dumped. Upon signing onto DATAPLOT at a later time, the analyst would enter

RESTORE XYZ.

and then proceed with the analysis at precisely the point of interruption. As with all DATAPLOT commands which involve file/subfile usage, the file name should be followed by a period in the command statement; thus

SAVE XYZ.

is correct, but

SAVE XYZ

is incorrect.

Note that the RESTORE command requires the save file to pre-exist. For many computers, such a requirement may be circumvented by local operating system directives. For example, on UNIVAC computers, if file XYZ does not exist and yet is needed in the middle of a DATAPLOT run, then the analyst may enter

@@ASG,UP XYZ.

and that will create a file XYZ while still leaving the analyst in DATAPLOT. For other computers, the analyst should check locally to see if a similar system capability exists.

Starting Over

RESET

It is at times convenient to simply reset all of DATAPLOT's internal settings to their sign-on initial values. One way to do this is, of course, to simply exit out of DATAPLOT (via EXIT) and then sign back onto DATAPLOT (via the local sign-on procedure). An alternate way to do the same is to use the RESET command, as in

RESET

This will reinitialize all internal data settings (including, of course, all variable, parameter, and function settings). A synonym for RESET is CLEAR.

Communicating with the Host Operator

OPERATOR

The OPERATOR command allows the analyst to send a message (while in the middle of a DATAPLOT run) to the host operator. The form of the command is

OPERATOR message

Check locally with the DATAPLOT Service Group to determine if this feature has been implemented, and to determine if there are any restrictions on this feature (for example, the NBS Univac 1100/82 restricts the number of characters per line for a given message to be 40 at most). If it is necessary to send a multi-line message, then each line should start with the OPERATOR command, as in

```
OPERATOR Please set Zeta plotter with
OPERATOR wet ink #1 pen (red) and 30 inch paper.
OPERATOR Please send output to room 707.
```

Communicating with DATAPLOT Service Group
MESSAGE, NEWS, MAIL, and BUGS

The user may communicate with the DATAPLOT Service Group via the MESSAGE command. The form for the MESSAGE command is

```
MESSAGE message
```

If a message takes more than one line, then each successive line should start with the same MESSAGE command, as in

```
MESSAGE What is the easiest way to do
MESSAGE dynamic, color, 3d rotation?
MESSAGE Bill Martingale, extension 3365
```

Note that the message should contain the name of the user, along with other contact information such as phone and room number. This message will be inserted into a message file which the DATAPLOT Service Group will peruse on a regular basis, and respond accordingly.

There are 4 ways in which the DATAPLOT Service Group can communicate with a user--

1) *via the sign-on message;*
2) *via the NEWS command;*
3) *via the MAIL command;*
4) *via the BUGS command.*

There is 1 way in which the user can communicate to the Dataplot Service Group--

5) *via the MESSAGE command.*

The sign-on message appears whenever any user signs onto DATAPLOT. It contains important current information, and is usually short and to the point.

Details regarding current DATAPLOT developments may be evoked by the analyst entering the NEWS command, as in

```
NEWS
```

This will print out more detailed information regarding topics of current interest.

The DATAPLOT Service Group communicates directly to an individual user by use of the MAIL command. For example, suppose the Service Group wished to inform user John Smith that the chunk of code that he desired has been written. This is done by using the sign-on message to inform John Smith that he has mail, and then allowing John Smith to enter the MAIL command, as in

```
MAIL SMITH
```

which will in turn print out the detailed mail message that the DATAPLOT Service Group had constructed.

The BUGS command is a fourth way of communicating with the user-community. The form of the BUGS command is

```
BUGS
```

This will print out a list of known bugs (if any) of the local implementation, and suggested code corrections to circumvent such bugs.

DATAPLOT File Information for Implementation

The following information is of interest only to the local DATAPLOT Service Group and may be skipped over by the general reader.

The file which contains the desired sign-on message is named DPMESF and has unit number 21 attached to it. The first line image of the file consists of a floating point number which is the number of lines actually contained by the message. Such lines follow immediately after the first line. For example, DPMESF might consist of the following 3 lines--

```
2.
New developments--Looping, Conditionality, and
Variable Printing.  Use NEWS command for details.
```

If no message is to be printed out, then the file DPMESF should have the first line consisting of merely a 0. on it.

The file which contains the desired news is named DPNEWF and has the unit number 22 attached to it. The structure of this file is the same as the message file-- namely, a first line consisting of a floating point number defining the number of lines of the news, and succeeding lines which actually consist of the news, for example,

```
4.
The general form of the LOOP command is
LOOP FOR parameter name = start increment stop
To terminate the loop, use the
END OF LOOP command.
```

The file which contains the desired bug information is named DPBUGF amd has the unit number 25 attached to it. The structure is as before--a leading line image with the number of lines of bug information, and successive line images containing the actual bug information, as in

```
2.
TIC COORDINATES command not working.
DOUBLE PRECISION command not working.
```

The file which contains the desired mail information is named DPMAIF and has unit number 23 attached to it. Since mail can exist for several users simultaneously in the file, a different structure has been used-- to enter the mail for Carter, say, the DATAPLOT Service Group enters (via the local editor) a line image in the file which consists only of the 6 characters CARTER. The following line images consist of the mail message. The message is terminated whenever a line image is encountered which consists of at least 5 hyphens in a row. Such a line image is deliberately entered into the file in order to terminate a mail message and to separate such a mail message from the mail message to another user. For example,

```
MAIL CARTER
3/3/83
The desired code is
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
NORMAL PROBABILITY PLOT RES
-----------------------------
```

If the mail file has multiple pieces of mail for the same user, then only the first mail message is accessed. Thus the analyst should add new mail to the beginning of the file and may thus have a permanent record of all mail since old mail messages will be shunted off toward the back (end) of the file.

The MESSAGE file is named DPQUEF and has unit designation 26. Every entry which the analyst enters via the MESSAGE command gets copied character by character out to this file. Most recent entries are placed at the beginning of the file.

A summary of the DATAPLOT file/subfile structure is as follows--

Purpose	Unit Number	Name	File or Subfile	Command
Message	21	DPMESF	file only	MESSAGE
News	22	DPNEWF	file only	NEWS
Mail	23	DPMAIF	file only	MAIL
Help	24	DPHELF	file only	HELP
Bug	25	DPBUGF	file only	BUG
Query	26	DPQUEF	file only	QUERY
Log	27	DPLOGF	off	---
Read	31	user-defined	file or subfile	READ and SERIAL READ
Write	32	user-defined	file or subfile	WRITE
Macro	33, 35-40	user-defined	file or subfile	CREATE and CALL
Save	34	user-defined	file or subfile	SAVE and RESTORE
Scratch	41	DPSCRF	file only	---
Data	42	DPDATF	file only	---
Plot	43	DPPL1F	file only	---
Plot 2	44	DPPL2F	file only	---

Default Output Device Settings

Only the primary output device (the terminal) is on. All 4 secondary output devices are off. The primary output device is a Tektronix 4014 (or equivalent). The primary output device is continuous, non-color, and has 1024 horizontal picture points and 781 vertical picture points. The penplotter is turned off. The automatic local hardcopy is off. The Zeta, Calcomp, and Versatec are off.

Color Graphics TERMINAL, COLOR, and PICTURE POINTS

The default color status for DATAPLOT is off--that is, DATAPLOT believes it is communicating with a non-color terminal for its graphics. If one wishes to generate color graphics, then the default device is the Tektronix 4027. To inform DATAPLOT of this, the analyst must use the TERMINAL command, as in

TERMINAL TEKTRONIX 4027

The message will come back that the primary output device has been changed to the Tektronix 4027, the color status has been changed to on, and the picture points have been changed to 640 (horizontally) by 480 (vertically).

A second color terminal which DATAPLOT supports is the RAMTEK 6211. To inform DATAPLOT that one is running on such a terminal, one enters the following--

TERMINAL RAMTEK 6211

Multiple Commands Per Line
TERMINATER CHARACTOR

The vast majority of DATAPLOT programs have only one command statement per line image. Such a style is conducive to readability. On occasions, however, the analyst may wish to have multiple command statements per line. This is permitted by use of the terminator character (= a semicolon). Anytime that DATAPLOT encounters a semicolon (or a carriage return) in a line image, it assumes that one command statement has terminated and the next command statement is beginning.

Although the default terminator character is the semicolon, other terminator characters are possible. The TERMINATOR CHARACTER command specifies such a character, as in

```
TERMINATOR CHARACTOR !
```

which would replace the ; with a ! as a terminator character.

The semicolon was chosen as the default terminator character because its use otherwise in the usual assortment of DATAPLOT command statements is rare. The only place where its inadvertent use might arise is in the TITLE and ...LABEL statements--one should be careful about the use of the semicolon in such cases. If one wants a semicolon as part of a title or label, then one should first change the terminator character to something else, otherwise the title or label will be clipped and a syntax error will result.

Given that the semicolon is the terminator character, then the following 2 programs are identical--

```
READ ABC. X Y
PLOT Y X
FIT Y = A+B*X+C*X**2
CHARACTERS X BLANK
LINES BLANK SOLID
PLOT Y PRED VERSUS X
PLOT RES X
NORMAL PROBABILITY PLOT RES
```

and

```
READ ABC. X Y; PLOT Y X; FIT Y = A+B*X+C*X**2;
CHARACTERS X BLANK; LINES BLANK SOLID; PLOT Y PRED VERSUS X;
PLOT RES X; NORMAL PROBABILITY PLOT RES
```

The terminator character may be either included or excluded when it is the last character of a line image. In lines 1 and 2 above, it was included; in line 3 above, it was omitted.

Specifying Post-Plot Cursor Position and Size
CURSOR SIZE

This section refers to the size of the cursor (and the size of the characters) when the terminal is not generating graphics, but rather is simply receiving commands from the keyboard or is simply printing out results from various non-graphics DATAPLOT commands (such as FIT, ANOVA, SMOOTH, LET, etc.) In such case, it is at times convenient to be able to control the size of the characters being printed. It is also convenient to have the cursor/character size at one setting for the non-graphics, and perhaps at other settings for the graphics. Thus after a plot is formed (regardless of the size of the characters used in the plot), it is preferable for the cursor/characters to return to the non-graphics size.

In DATAPLOT this is controlled via the CURSOR SIZE command. The default cursor/character size is 3 (= 3% of total screen height). To set the cursor size to 1.5, say, the analyst enters

```
CURSOR SIZE 1.5
```

The above comments apply only for those terminals which have multiple cursor sizes. For those terminals with only 1 size (e.g., Tektronix 4010, and Tektronix 4025), that 1 size will, of course, appear regardless of the cursor size setting.

1. General

2. Command Categories

3. Parameters, Variables, and Functions

4. Input/Output

5. Program Control

6. Miscellaneous

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This manual provides DATAPLOT code solution to a variety of commonly occurring graphical problems. A line-by-line explanation of code is given, along with illustrations and general discussion.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

computer software; data analysis; DATAPLOT; fitting; graphics; interactive fitting; interactive graphics; interactive language; language; mathematics; non-linear fitting; software; statistical methods.

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