PC-PLOT

A Scientific Plotting Program

version 6.01

by

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Legal Notice

This document provides information on how to use **PC-PLOT** and describes some of its features that are not self-explanatory from the menu prompts or explained in the help screens. **PC-PLOT** is provided on an "as is" basis. There are no warranties, either expressed or implied, including but not limited to implied warranties of merchantability of fitness for a particular purpose, and all such warranties are expressly and specifically disclaimed. Should you encounter any difficulties with the program, please contact the author at (913) 532-5626 or with e-mail at `jks@ksuvm.ksu.edu`. Finally, **PC-PLOT** may be freely copied and distributed.

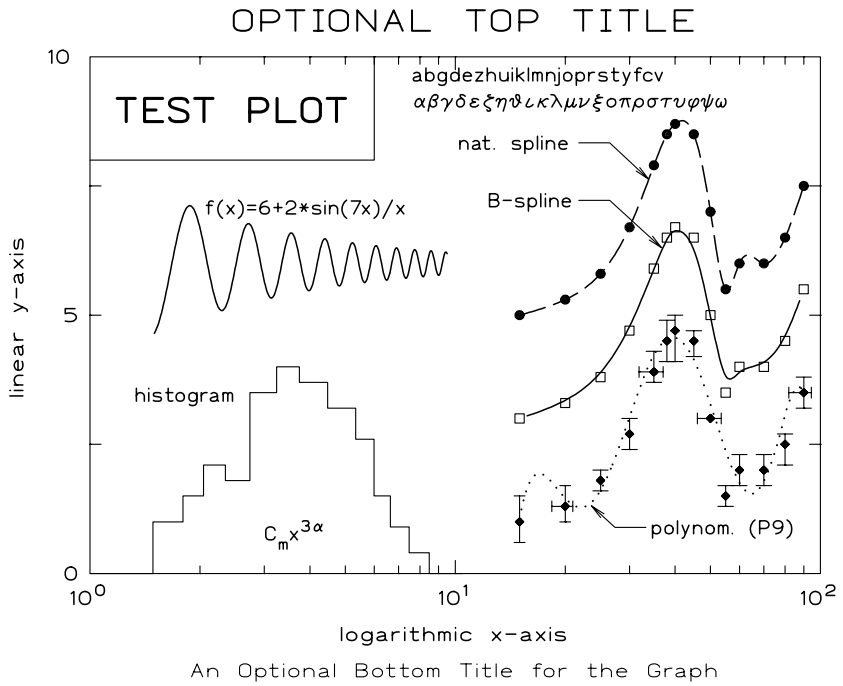
SUMMARY

PC-PLOT is a program that allows you to compose scientific linear-linear, semi-log, or log-log plots on the screen. Multiple captions and sets of data may be added, modified, or deleted at will. Additionally, functions and arrows can also be added to the graph. Once the screen plot is in the form you desire, the entire plot can be sent to an HP-compatible plotter or to a disk file for later plotting. The plot can also be saved in a file for later recall and modification. With the shareware program **PRINTGL** (Ravitz Software Inc., PO Box 25068, Lexington KY 40524-5068) the plot can also be printed on almost any printer or saved as a PostScript or bitmapped PCX file.

Data may be read from data files or entered from the keyboard. Keyboard entered data may also be saved in a disk file for subsequent incorporation into other plots. The data can then be plotted (1) as discrete points using any keyboard symbol or 10 special plotter symbols, (2) as a series of straight lines joining the data points, (3) as a natural cubic-spline fit curve passing through the data points, (4) as a B-spline fit to the data, (5) as an m-th degree polynomial obtained by a least-squares fit to the data, or (6) as a histogram. Seven different line styles are available and eight different pen widths (colors) may be used.

Captions or legends for the graph can be entered only from the keyboard; however, any caption (like any data set) can be erased or modified and rewritten on the graph until its location is exactly where you want it. Captions and labels can have subscripts, superscripts, and Greek letters.

PC-PLOT is entirely menu driven with most menu items being self explanatory, although help screens are available. The basic operation of the program is straightforward. First the size, axis types, and labels for the graph are defined and then set(s) of data and captions are added. Finally, the graph is plotted (or saved for later recall). Each step in the creation (or modification) of a graph is controlled by a program menu. While the purpose of most menu items require little explanation, there are some items which allow responses not described on the menus or help screens. This manual describes the various program options and gives details and hints about the use of **PC-PLOT**.



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Chapter 1

General Information

1.1 Installing PC-PLOT

PC-PLOT remembers its "home" directory (or folder), i.e., the directory in which the program file `PCPLOT.EXE` is placed, and where it expects to find certain auxiliary files. In particularly, it is *imperative* that the following files be placed in the same directory: `PCPLOT.EXE`, `PCPLOTSC.BAT`, `PCPLOTPR.BAT`, and `SGREEK.XY`. In addition, it is suggested that the program `PRINTGL.EXE` also be placed in the same directory (although it can be put in any directory).

The two-line files `PCPLOTSC.BAT` and `PCPLOTPR.BAT`, which **PC-PLOT** uses to preview the current plot on the screen or to produce a hardcopy on an attached printer, *must* be modified to specify the directory of the program PRINTGL.EXE. The second line in each of these files begins

```
C:\UTIL\PRINTGL %1 ...
```

The default directory `C:\UTIL\`, which begins this line, must be changed to the directory in which you place the program `PRINTGL.EXE`. For example, if you place `PRINTGL.EXE` in the directory `D:\PGMS\PCPLOT\`, then change the second line in `PCPLOTSC.BAT` and `PCPLOTPR.BAT` to

```
D:\PGMS\PCPLOT\PRINTGL %1 ...
```

The other files on the distribution disk are not needed by **PC-PLOT**. However, it is convenient to place the ASCII version of the User's Manual `PCPLOT.DOC` in the same directory you placed `PCPLOT.EXE`.

Finally, if you want to be able to invoke **PC-PLOT** from any other directory (the usual approach), it is necessary to place the directory in which `PCPLOT.EXE` resides on the *path* used by **DOS** to search for executable programs.

1.2 Starting PC-PLOT

PC-PLOT is started with the command

```
\V{PCPLOT [VGA|EGA|CGA|HERC] [COLOR|NOCOLOR] [NOMEMORY] [graphfile]}file
```

where square brackets indicate optional parameters. The program, at startup, senses the type and color capability of the video display you are using; however, some non-standard video boards may not be properly sensed by **PC-PLOT** and the optional parameters in the above command allow you to specify explicitly which graphics mode you wish to use. To run **PC-PLOT**, your computer must be equipped with a video display that is compatible with a CGA, EGA, VGA, or Hercules Graphics display,[1] and a monochrome or color monitor may be used.

The optional `graphfile` is the complete file specification of the graph you wish to begin working with (e.g., `C:\GRAPHS\FIG1.GRF`). The path need not be specified if the file is in the directory in which you started **PC-PLOT**. This program feature is a short-cut and avoids having to go to the main **Options Menu** and explicitly retrieving the file. This file must previously have been created and saved by **PC-PLOT**.

The optional parameter `NOMEMORY` should be used only if your machine has insufficient memory to save the screen graph. This option should not be needed if your computer has more than 500K of free **DOS** memory before **PC-PLOT** is started. If you specify this parameter, then each time the screen graph is displayed it is redrawn rather than simply being recalled from memory. For a complex graph on a slow machine this redraw can take considerable time. It is recommended that you do not use this startup option unless you encounter memory problems.

If you do not specify the video board or the color option when you start **PC-PLOT**, the video board and color can be altered from the **Options Menu** prior to starting a graph (or whenever you begin a new graph). These video board and color selection options disappear from the **Options Menu** once a graph has been started.

1.3 Differences Between Screen and Plotter Graphs

Because of the relatively low resolution of most screen displays, **PC-PLOT** constructs a graph to use as much of the screen, and hence show as much detail, as possible. Consequently, no matter what size is requested for a graph, the screen graph is of a fixed size covering most of the screen. However, the graph produced by the plotter always has the desired graph dimensions.

To produce as readable a graph on the screen as possible, other format differences between the screen and output plot have been introduced. For example, axis scales on the screen are shown only for the axis end-points, and the axis labels and graph title are shown in a fixed size lettering (which may be different from that specified by the user but which will be used for the output plot). To save space on the screen, any bottom title for the graph is omitted (although the top title is shown). Because of the fixed size lettering used for the titles and axis labels on the screen graph, these legends may be truncated when written on the screen; however, they do appear correctly on the output plot.

To make the graph as legible as possible on the screen, all lettering and symbols in the plotting area of the screen graph are shown with a fixed size that is independent of the size specification entered

[1] If have a really old computer and are using a Hercules graphics card, you must run the program **QBHERC** prior to starting **PC-PLOT**. (**QBHERC** is a memory resident program than allows QuickBasic's graphics commands to display properly on a Hercules system.) **PC-PLOT** senses if **QBHERC** is installed; if it does not find **QBHERC**, a warning message is displayed and the program ends.

in the input menus. Further, Greek letters are not displayed on the screen (although their input keys are, e.g. `\a` for alpha). (However, the captions and labels on the screen preview of the output plot always have the specified size.) Consequently, the length and height of captions on the screen graph do not exactly match those of the captions eventually drawn on the output plot. However, each caption on the screen shows the outline of the area in which the caption is placed on the output plot. With this caption frame and the editing facilities provided for moving captions, you can place a caption exactly where you wish on the graph.

1.4 Program Requirements and Limitations

Your PC must be equipped with a video graphics board capable of displaying VGA or SVGA graphics. For those with older machines, **PC-PLOT** can also function with an (a) IBM-compatible color graphics adapter (CGA), (b) EGA graphics board or (for really old machines) a (c) Hercules graphics board. Your machine should have at least 450 kbytes (525 for EGA) of memory.

PC-PLOT runs under **DOS** (any version above 3.0). It can run under **WINDOWS-95** in the *DOS Window* or under **WINDOWS-NT** in the *Command Console* (although a special `.BAT` file must be used to print graphs from the program — see Section 8.3).

To produce a hard copy of your graph, you must have either a HP-compatible plotter or a standard printer (HP LaserJet compatible, Epson 9-pin compatible, Epson 24-pin compatible, NEC 24-pin compatible, HP PaintJet, IBM Proprinter, IBM QuietWriter, or IBM LaserPrinter). To produce plots on your printer, you must also install the shareware program **PRINTGL** by Ravitz Software Inc. (distributed with **PC-PLOT**).

Other program default limits include:

- The total number of x-y data points without error bars must be less than 5000, although this limit can be increased if enough memory is available (see Section 2.7).
- The number of x-y data points with error bars must be less than 500, although this limit can also be increased if enough memory is available (see Section 2.7).
- There is a maximum of 40 sets of data for any one graph
- There is a maximum of 30 captions for any one graph

Chapter 2

The Options Menu

When **PC-PLOT** is first started, and after making each addition (or deletion) to the screen graph, the **Options Menu** is displayed. It is from this menu that you select the major program options by pressing the appropriate function keys `F1` to `F10` (or a Control plus function key combination, e.g., `Ctrl-F6`).

```
====================== OPTIONS MENU ======================

          F1  Plot data in a disk file
          F2  Add a caption to the graph
          F3  Plot keyboard entered data or arrow
          F4  Plot a function on the graph
     Ctrl-F1  Erase/modify a set of graph data
     Ctrl-F2  Erase/modify a caption

          F5  Define/modify a graph setup
          F6  Save graph on disk for later recall
     Ctrl-F6  Retrieve a graph from a disk file

          F7  View the current screen graph
     Ctrl-F7  Redraw the screen graph
          F8  Exit temporarily to DOS Shell

          F9  Send to plotter/printer or preview
          F10 QUIT the program and return to DOS
      Alt-F1  Toggle color off  Alt-m Memory limits
      Alt-F2  Change video display (now VGA)

==========================================================
          Press function key for desired option
```

Figure 2.1. The **Options Menu**

2.1 Creating a Graph

Before you can plot any data, you first must define the characteristics of the graph (size, type of axes, titles, etc.). To define these graph properties, select the `F5` option from the **Options Menu** to obtain the **Graph Definition Menu** from which you can specify the graph characteristics.

Once the characteristics of the graph are specified (e.g., plot size, axis labels, axis ranges, etc.), you can then plot sets of data taken from disk files (`F1`) or entered from the keyboard (`F3`). Also you can add captions to the graph area (`F2`), place piecewise linear arrows to point out features of your graph (`F3`), or plot functions of the x-variable (`F4`). After you specify that a data set, caption, arrow, or a function is to be added to the graph, the screen graph is displayed and remains displayed until you press any key to return you to the **Options Menu**.

2.2 Modifying the Graph

As you build up your graph, you may wish to erase or modify a set of data or an arrow by using the `Ctrl-F1` option. Similarly, you may erase or modify any graph caption by pressing `Ctrl-F2`. Often, after you have erased a graph element, some underlying data, captions, or arrows may also be partially erased. However, you can always redraw the graph showing all non-erased information by using the `Ctrl-F7` option. Also you can view the current screen graph at any time you are in the **Options Menu** by selection the `F7` option.

After a graph has been composed, you may wish to modify some graph characteristic (e.g., different axis ranges, titles, axis labels, etc.). Use of the `F5` option returns you to the **Graph Definition Menu** where you can make the desired changes. This **Graph Definition Menu** then allows you to retain the current graph data and captions (`F2` key) or start a new graph (`F1` key). Thus you can zoom in or out of your plot and easily change the characteristics of the graph until it is in precisely the form you desire.

2.3 Plotting the Graph

Once the screen graph is composed as you want it, you can plot the graph by using the `F9` option. You must choose if the plot is to be previewed on the screen, sent directly to an attached HP plotter, to an attached printer, or saved in a plot file (HPGL, PCX or PostScript format). If you elect to send the graph directly to an HP-compatible plotter or a printer, the printer must be connected to either a serial or parallel port of your computer. If you do not have a plotter attached to your computer, you can place the output to the plotter in a disk file for later plotting. It is suggested that such plotter files be given the extension `.PGL` to distinguish them from other types of files (although you may use any extension you wish). Alternatively, the output graph can be put into an encapsulated PostScript file or into a bitmapped PCX file for use with other programs. Finally, with the `F9` option of the **Options Menu**, you can also specify that the current graph be plotted on the screen. In this way you can preview how the graph will actually look when plotted.

2.4 Saving a Graph for Later Revision

Sometimes you may want to plot many similar graphs or wish to add data to some base graph or to some standard template. **PC-PLOT** allows you to store a graph at any time during its construction and save it for later recall. Thus you may work on a particular graph over several sessions, or you can recall a base graph to which you wish to add specific data. When in the **Options Menu**, `F6` saves the current graph to disk after asking you for a filename. Similarly, `Ctrl-F6` asks you for the filename containing a graph specification and then overwrite the current graph with the information

from the file you specify. It is suggested that you give these "graph definition files" the extension `.GRF` to distinguish them from the plotter files created with the `F9` option.

NOTE: The graph definition files (`.GRF`) saved with the `F6` option and recalled with the `Ctrl-F6` option can only be used by **PC-PLOT** — they cannot be sent from outside the program to a plotting device (as can the plot files created with the `F9` option). Likewise the plot files (`.PGL`, `.PS`, `.PCX`), created by the `F9` option, can only be used by a plotter, printer or other programs; these plot files cannot be read back into **PC-PLOT** for modification. It is suggested that the extensions `.GRF` be given to graph definition files, and `.PGL`, `.PS` or `.PCX` to output plot files so as to avoid confusion.

2.5 Changing Video Display and Color

The last three choices on the **Options Menu** (`Alt-F1`, `Alt-m` and `Alt-F2`) are available only before adding the first graphical element (data, caption, function) to a screen graph. Once you have started a screen graph, you cannot switch video display modes, switch between color and monochrome, or change memory usage until you begin a new graph. Since most EGA and VGA displays can emulate CGA displays, it is often convenient to use the CGA mode when constructing a complex graph since the CGA graphics screen is redisplayed much more rapidly than the EGA or VGA graphics screen.

2.6 Returning Temporarily to DOS

Occasionally, while you are constructing a plot, you may wish to return to **DOS** temporarily so as to change some data file, obtain a directory listing or run some other program. The `F8` option allows you to return to **DOS** temporarily by creating a *DOS shell*. When you are finished with **DOS**, typing `exit` returns you to **PC-PLOT**'s **Option Menu**.

Since **PC-PLOT** remains in your computer's memory while you are in the **DOS** shell, your system must have sufficient memory above that needed for **PC-PLOT** to load another copy of `COMMAND.COM` (the basic **DOS** program) and to accommodate any programs you wish to run while in the shell.

2.7 Changing Data Storage Limits

On the **Options Menu** at initial startup the `Alt-m` (Memory limits) option is displayed. Pressing the `Alt-m` key combination displays the current memory status of the program. You are then asked if you wish to change the size of the x-y data storage arrays. If you respond positively, you can enter new data vector sizes and replace the default sizes of 5000 data points and 500 data points with $\pm$ error limits.

Although the `Alt-m` option disappears from the **Options Menu** after a graph is started or loaded, this switch remains active. You can thus see how data memory is consumed as you add data to the graph. However, if you elect to change the sizes of the data storage vectors once a graph is in memory, the program is reinitialized, loosing any graphical data you had before invoking the `Alt-m` option. Thus before changing memory defaults during a graph drawing session, save the graph before you invoke the `Alt-m` option.

2.8 Help Screens

Most data input menus invoked from the **Options Menu** have context sensitive help screens available. An `Alt-h/HELP` prompt is displayed in the lower left corner of each menu that has help screens available. Pressing `Alt-h` while the highlighted data input window is on any item produces a help screen describing the item. The `ESC` key then returns you back to the data input menu.

Chapter 3

Defining the Graph Characteristics

Before you can create a new graph, you first must select the F5 option on the **Options Menu** to define the size of the plot, the type of plot you want, its scales, and any axis labels and titles. By selecting F5, the **Graph Definition Menu** (similar to that below) appears. It is in this menu that you enter data that defines the characteristics of the graph.

```
======================== DEFINE/MODIFY GRAPH SETTINGS ====================

 Size (max 22x16 16x22 cm):  width 20.0  height 14.0    Grid (Y/N) N
 Select pen width (1-8):                 border 6             tics 2
 Plot type (=1 linear; =2 log):          x-axis 1           y-axis 2
 X-axis range:           xmin 0.0          xmax 100           xinc 10
 Y-axis range:           ymin 1E-20        ymax 1E-17

 Include axis labels and plot titles? (y/n)                Y
 Tic Labels: (1-4) 0 sign figs every 2 x-tics; 1 sign figs every 1 y-tics
 Pen Widths (1-8):        scales 3    axes 4   top title 5   bot title 4
 Character Sizes (width[%],height[%]):
    scales 1.75%,2.3%   axes 1.75%,2.3%   top 1.8%,3%      bot 1.25%,2.5%
 X-label:  Source-to-Detector Distance (m)
 Y-label:  Nomalized Dose (g cm^-2')
 Top Title : CALCULATED AND MEASURED SKYSHINE
 Bot. Title:

========================= Use cursor and edit data ======================

                     Press F1  to start a new graph
                     Press F2  to use existing graph data
                     Press F10 to abort & return to Options Menu
Alt-h/HELP
```

Figure 3.1. The **Graph Definition Menu**

3.1 Graph Size and Axis Specification

The top portion of the **Graph Definition Menu** is used to specify the physical size of the plotted graph, whether grid lines should be used instead of tic marks along the axes, and, most important, the type of axes (=`1` for linear and =`2` for logarithmic). In Fig. 3.2 the same plot is shown with and without grid lines. Generally, grid lines are not used. However, the use of grid lines without any labels or captions outside the plot area (such as that shown in Fig. 3.2) is an excellent way to produce customized graph paper.

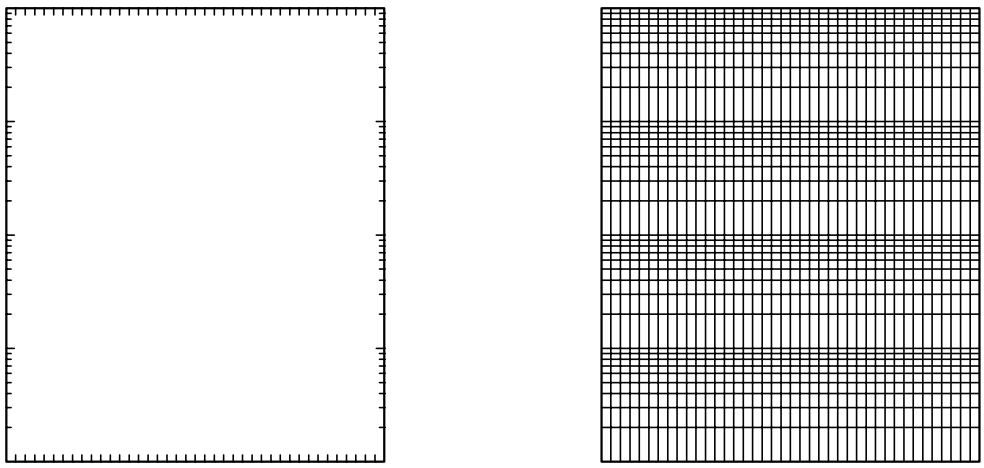

Figure 3.2. Plots without grid lines (left) and with grid lines (right).

The size of the plot area (the frame created by the axes) is limited by the 8.5 × 11 inch paper used for plotting or printing the graph. In particular, for a graph to be produced in "landscape" orientation (sideways) on the paper, the maximum frame width is 22 cm and height 16 cm. For portrait orientation (upright), the maximum width is 16 cm and height 22 cm. **PC-PLOT** does not accept a frame width or height greater than 22 cm. It also refuses to create a plot (printer, plotter, or plot file) in which the frame dimension along the 8.5 inch paper width is greater that 16 cm. Note, however, that limiting a plot to a 22 × 16 cm frame size (with the correct orientation) does not guarantee the plot will be contained on the paper. Large lettering for axis captions and the presence of optional top and bottom graph titles may put parts of the plot outside the paper edges.

On the **Graph Definition Menu** you must specify the minimum and maximum x and y values, i.e., the range of the axes. For a logarithmic axis, **PC-PLOT** automatically rounds these axis limits to whole decades (integer powers of ten) so that your specified limits are completely included. For linear axes you also must specify the x or y increment at which you wish axis tic marks (or grid lines) drawn. If you enter `0` or a value greater than the range of the axis, no tic marks (or grid lines) are drawn.

Special care must be taken when using linear axes. The minimum and maximum range values must differ at least in the third significant figure. A range such as `xmin = 4.500` and `xmax = 4.5001` causes errors since the HPGL plotter language is incapable of the fine resolution required to plot such as scale. To avoid this difficulty, rescale your data. For example, plot $10000(x_i - 4.5)$ on a scale such as `xmin = 0` and `xmax = 1`. Similarly, avoid linear scales with very large or small `xmax - xmin` values, e.g., `0` to `1E-7` or `0` to `1E7`. Again, scale the data before plotting.

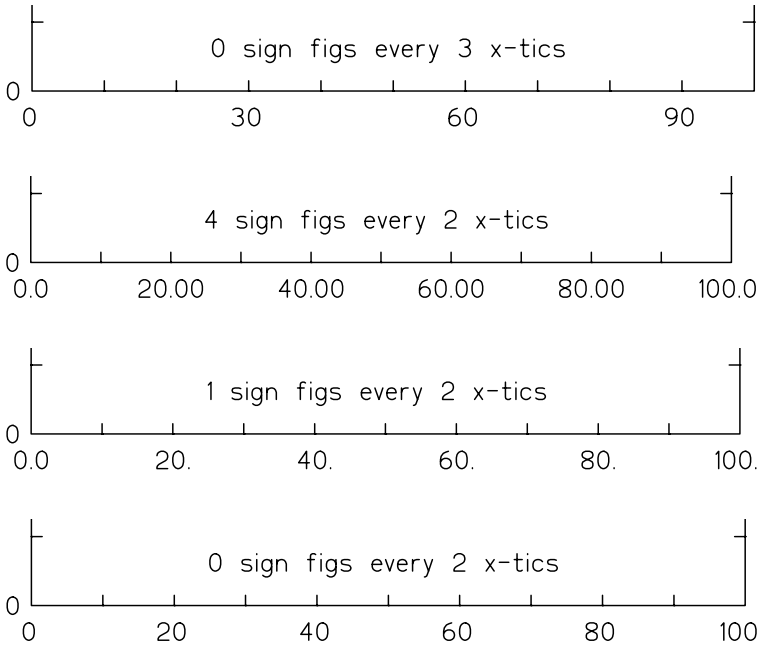

Figure 3.3. Sample linear x-axes

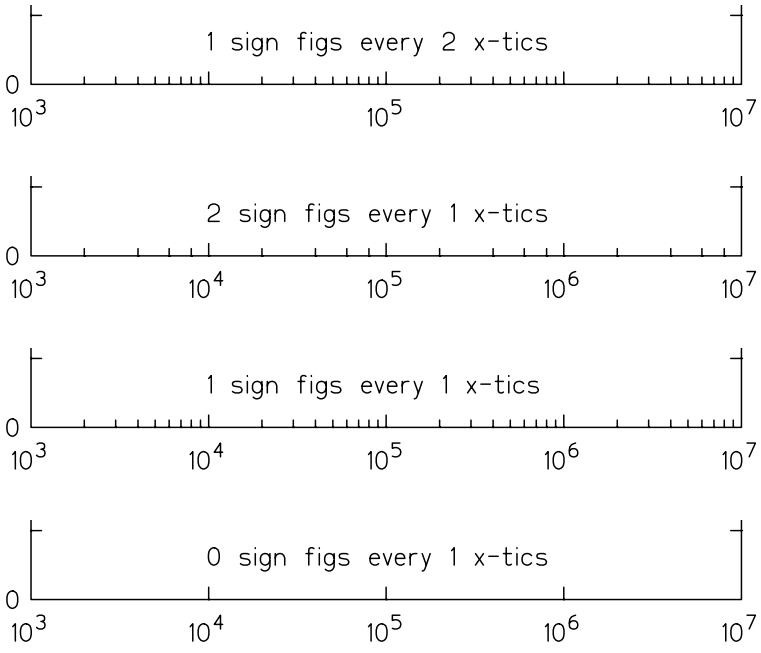

Figure 3.4. Sample logarithmic x-axes

3.2 Annotating the Graph Axes

No axis scale values, axis labels, or graph titles are produced on the graph if the parameter for axis labels and plot titles is specified as `N`. Only material within the plot frame area are drawn. This is the option used to produce the examples of Fig. 3.2.

If you specify labeling of the axes, then you must also specify the number of significant figures (`sign figs`) that are to be used for the linear axes tic annotations (1-4 significant figures). If the number of significant figures is specified as `0`, then the tic value are labeled with the integer value of the tic (no decimal point). Examples of the use of significant figures in the scale annotation for a linear axis are shown in Fig. 3.3.

For logarithmic axes, only the decade tic marks are annotated using a standard format (e.g., 10^{-12}) that is independent of the number of significant figures specified. However, for logarithmic axes the `sign figs` parameter controls the drawing of sub-decade tic marks (or grid lines). Specifically, `0` figures suppresses all sub-decade tics, `2` causes only even (2,4,6,8) sub-decade tics to be drawn, and any other value yields all sub-decade tics marks. Examples of the use of `sign figs` to control the tic-marks on a logarithmic axis are shown in Fig. 3.4.

On the **Graph Definition Menu** you may also specify the frequency with which the axis tic marks (or grid lines) are to be annotated. Tic mark annotation always begins at the left or bottom edge of the graph, and thus the right or top edge may not have a scale value if you do not choose a proper annotation frequency. Examples of the annotation frequency are also shown in Figs. 3.3 and 3.4.

3.3 Specifying Graph Titles and Axis Labels

In the **Graph Definition Menu** you may also enter axis labels and titles for the graph as well as the size of the lettering and pen widths to be used. On this menu you also specify the size of letters for annotating the axis scales. The locations of the titles and labels are shown in Fig. 3.5

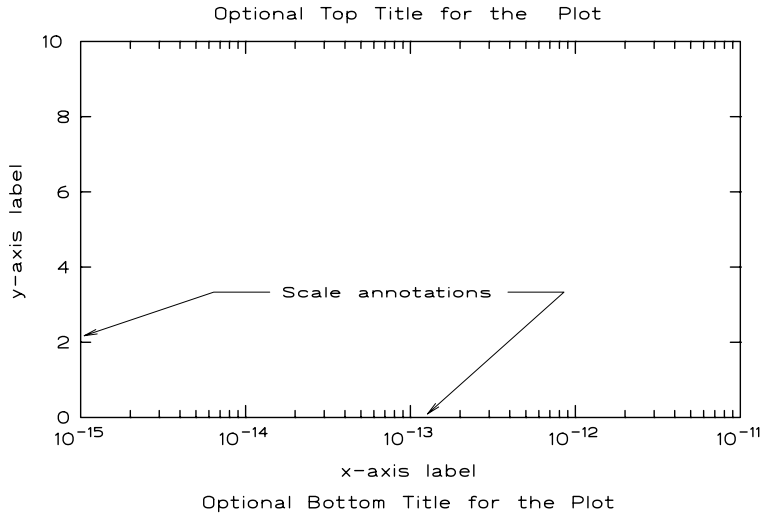

Figure 3.5. Location of axis labels, plot titles and scale annotations.

When you enter a label or title, a red vertical arrow appears beneath the input window to indicate the maximum number of characters that can be used in the label or title without extending beyond

the edges of the plotted graph. To enter a longer title or label, simply reduce the specified width of the characters for the text, and the maximum-length arrow moves to the right (up to a maximum of 65 characters). If the entered text is shorter than the displayed text window, the label or title is centered along the appropriate axis.

It should be noted that the indicated maximum label length is for a label all composed of the widest letters (e.g., `M`). However, **PC-PLOT** uses proportional fonts, and often a label longer than indicated by the maximum length warning arrow can fit properly on the graph. Even if all labels and titles fit properly within the plotted graph, some titles and labels may be truncated on the screen plot because of the fixed size lettering used in the screen graphs. However, the labels and titles will be printed properly on the plotted graph.

The size of lettering for titles, axis labels or graph captions is usually specified in terms of percentages of the axis lengths by appending a **%** sign after the size (e.g., `1.5%,2.5%`). Alternatively, by omitting the **%** sign, the character width or height is in cm. The use of relative widths and heights is usually preferred since the relative size of letters is unchanged if you later change the plot size.

Superscripts and subscripts can be included in any title, label or caption by using the half-line shift characters. A caret ^ causes all following characters to be printed one-half line upwards (superscript) and the grave accent ‘ or underscore _ causes all following characters to be printed one-half line downwards (subscripts). Thus a label for the units "(kg s^{-1})" is entered as `(kg s^-1‘)`. When entering labels or titles with imbedded ^ ‘ and _ shift codes, the titles or labels may extend beyond the maximum-length indicator arrow by the number of shift codes used since the shift codes themselves are not displayed. Generally, error messages are issued if entered labels or titles are too long.

The font used by **PC-PLOT** is a proportional sans serif English font. However, Greek letters may also be used in captions, titles and axis labels. The discussion of Greek letters and microspacing is deferred to Section 5.4 and 5.5.

3.4 Pen Widths

Different pen widths may be specified for each element of the graph. In the **Graph Definition Menu** (as well as in the Data Menus and Caption Menu), you are asked to specify a pen number. Permissible pen numbers are 1 through 8, with the higher numbers producing a thicker line if the graph is produced on a printer (or sent to a `.PS` or `.PCX` file). The default pen widths are .2, .3, ... ,.9 mm for pens 1 to 8. An example of the different default pen widths is shown in Fig. 3.6. These default widths assigned to each pen number can be altered (see Section 3.5).

For graphs produced on plotters not all pen numbers are available. For example, an HP 7470A plotter has only two pens (left and right). For these plotters, an odd pen number specifies the left pen while an even number denotes the right pen. For other plotter models with eight pens, the pen number selects the corresponding pen.

When using a printer to produce the graph, it is useful to have the pen number correspond to the line width. The correspondence between pen numbers and the line width is controlled by parameters in the batch files `PCPLOTSC.BAT` and `PCPLOTPR.BAT`. See Chapter 8 for further details.

For the screen plot on a machine with a color EGA/VGA display, eight different pen colors (representing different line widths) are supported. However, for CGA, Hercules, or monochrome EGA/VGA systems only a single color is used for drawing the screen graphs.

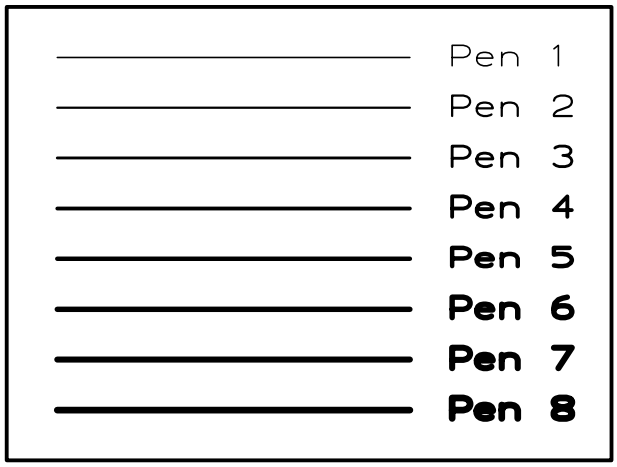

Figure 3.6. Default Pen Widths used by **PC-PLOT**.

3.5 Changing the Default Pen Widths

Sometimes when using a `.GRF` file created with an earlier version of **PC-PLOT** that used different pen widths or to create a plot with a quite different size, you may want to change the default pen widths. For plots made on a printer you need to alter the file `PCPLOTPR.BAT` which is used to make plots on your attached printer (see Section 8.2). In this file, the string `\WABCDEFG` in the `PRINTGL` command controls the pen widths for pens 1 through 8. Changing this string to `/W12345678`, for example, indicates that pens 1, ..., 8 are to have widths 1, ... ,8 pels, respectively. By contrast, widths designated as A, ... ,H have widths 0.2, ... ,0.9 mm, respectively.

To change the default pen widths used to create PostScript (`.PS`) or bitmapped `.PCX` plot files, it is necessary to create a file named `PCPLOTWD.PEN` in the same directory (folder) which contains `PCPLOT.EXE`. This file contains a single line specifying the pen widths, e.g., `\W12345678` to indicate that pens 1 to 8 are to have widths 1 to 8 pels, respectively.

Chapter 4

Plotting Data

PC-PLOT can accept x-y data for plotting from either the keyboard or from values stored in any ASCII file. While in the **Options Menu**, select `F1` if file data are to be plotted, or `F3` if you wish to add data entered from the keyboard. Both options display similar data menus which ask how the data are to be plotted. In addition, the **Plot File Data Menu** (`F1` option) asks for the name of the data file and how the data are written in the file. A example of the **File Data Menu** is shown below (the **Plot Keyboard Data Menu** is similar except no file information is requested).

```
============================ PLOT FILE DATA ============================

   Pen width for data (1-8):                                    2

   Line type or symbol for data point:                          7
    (=1 dots  =2 dash  =3 lng dash  =4 dash-dot)
    (=5 lng-shrt   =6 lng-shrt-shrt  =7 solid  )
    (=h histogrm  =s square  =c circ  =d diamnd)
    (=t ringle  =w wedge  =&x x is data symbol)

   Type of curve through data (only for lines types 1-7):     0
    (=0 no fit; =S or B (B)Spline; =Pm m-degree Polynomial)

   Data file specification (e.g. b:\sub\data.ext):     TEST.DTA

   Data file structure   (x-data col.,y-data col.)           4,2
    (=0,0 for X,X,X...Y,Y,Y; =1,1 for X,Y,X,Y,...)
    (= +-xy for data w errs  X(-xm,xp),Y(-ym,yp) )

====================== Use cursor and edit data ======================

             Press F1  to add data to the current graph
             Press F10 to abort & return to Options Menu
Alt-h/HELP
```

Figure 4.1. Example of the **Plot File Data Menu**

4.1 Specifying How Data Are To Be Plotted

When adding a data set to a graph, you must first specify in the **Plot Data Menu** (or the **Plot Keyboard Data menu** the pen width for the data and how you want the data plotted. You may plot the x-y data pairs as discrete points using any keyboard symbol or one of ten special plotting symbols. Alternatively, you may plot the data as (i) a histogram, (ii) a piece-wise straight line joining the data points, (iii) a natural cubic spline fitted curve, (iv) a B-spline fitted curve, or (v) a least-squares fitted polynomial. For any of the five continuous curves, you may specify one of seven types of lines (e.g., solid, dashed, dotted, etc.).

To draw a line through the data as well as to place symbols at the data points, simply plot the same data twice, once with a line specified (and perhaps with spline interpolation) and once using only a data symbol.

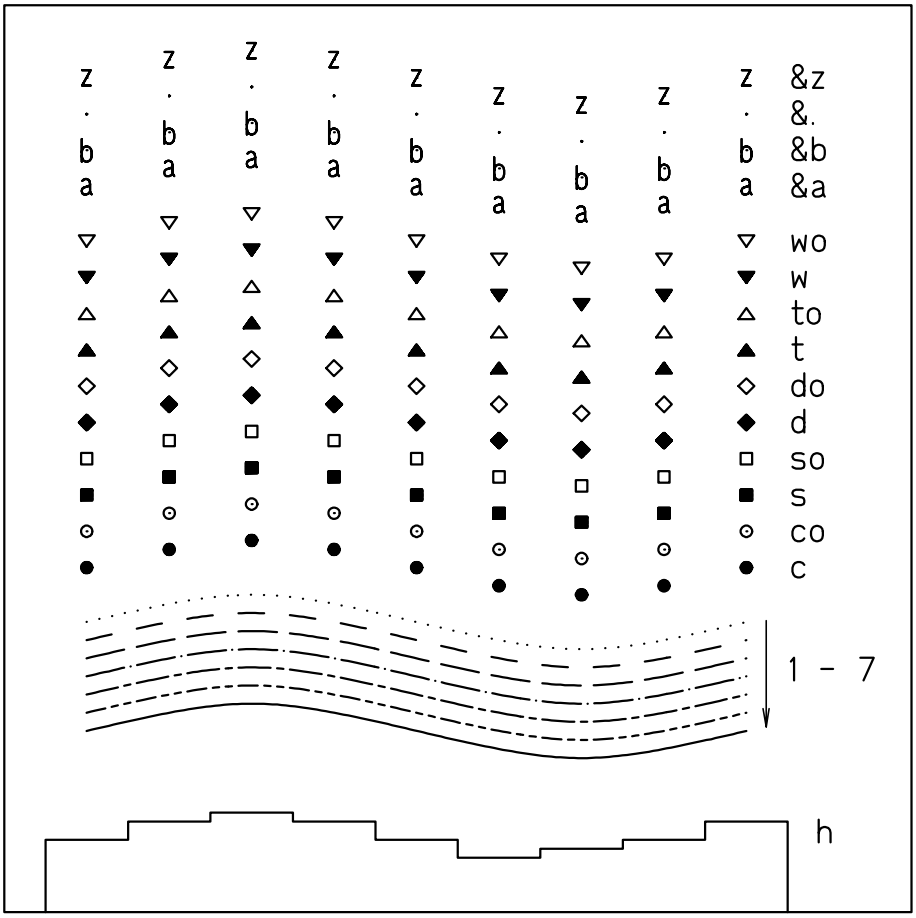

Figure 4.2. Lines styles and symbols available in **PC-PLOT**.

4.1.1 Line Type

To plot a data set by using a line to join the data points (or as a spline or fitted polynomial curve), simply specify the line type as a single number 1-7 corresponding to the desired style of line (indicated

by the menu prompt). The seven lines styles are illustrated in Fig. 4.2. Although a broken line may appear as a solid line on the screen (because of the poor screen resolution) the specified style of line will be correct on the final plot.

To indicate that a histogram is to be drawn with a solid line, use `h` as the line type. (To use a different type of line for a histogram (e.g., a dashed line), use the form `hn` where `n` is an allowed line type (1-7).)

4.1.2 Specifying Discrete Points

Data may be plotted as discrete points using two types of symbols. To use any keyboard symbol, enter `&x` where `x` is the desired character. Alternatively, there are five plotter symbols (square, diamond, triangle, wedge, and a circle) denoted by `s`, `d`, `t`, `w`, or `c` respectively. These plotting symbols are illustrated in Fig. 4.2.

These plotter symbols normally are solid (filled), but open symbols can be obtained by appending an `o` (letter, not number, for *open*) to the symbol specified (e.g., `so`).

If you choose to plot the data with symbols, another window appears on the menu asking for the symbol size. This size is entered as a percent of the axes size (complete with a concluding `%` sign, e.g., `1.5%,2.5%`). For a keyboard symbol you must specify both the width and height of the symbol, while a plotter symbol requires only a width specification. This symbol size affects only the symbols on the output plots; screen symbols are always of fixed size independent of the size specification.

4.1.3 Fitting a Curve to the Data

If you choose to plot the data with a line, you must also specify what type of curve you wish to use. The third **Plot File Data Menu** item controls the type of curve to be fitted to the data. If the type of curve is specified as `0`, a straight line is used to join the data points in the order they are received by **PC-PLOT**. Normally, you will want the data to be connected in the order of ascending (or descending) values of the x variable; however, by putting the data in non-ascending (or descending) x-order, you can draw complex geometric designs on the graph.

Three types of fitted curves can also be drawn for any data set. If you specify the type of curve as `S`, a "natural" cubic spline fit is drawn through the data points. Such a spline fit passes through each data point and has continuous first derivatives. If a spline fit is specified, the data may be in any x-order, since this option always orders the data in ascending values of x. Note, for a spline fit, no two data points may have the same x-value (**PC-PLOT** catches this error and returns you to the **Options Menu** after an appropriate error message).

A B-spline curve is drawn to the data if `B` is specified as the curve type. This curve is a cubic spline which has continuous first and second derivatives. It does not necessarily pass through any of the data points and is most useful for drawing a smooth curve through data with noise or errors.

A least-squares fitted polynomial may also be fitted to a data set by specifying the type of curve as `Pm` where m is the degree of the polynomial to be fitted. The minimum degree is 1 and the maximum 9. Also $m + 1$ must be less than or equal the number of data (if m is too large for a small data set, m is automatically reduced). Before adding this polynomial to the graph, a window opens and displays the values of the fitted polynomial coefficients. Note that the polynomial fit is performed to the data as specified by the type of axes currently in use (i.e., if a log axis is used, the fit is to the log of the data). The least-squares fit is performed without any weighting of the data points even if the data set has prescribed $\pm$ errors.

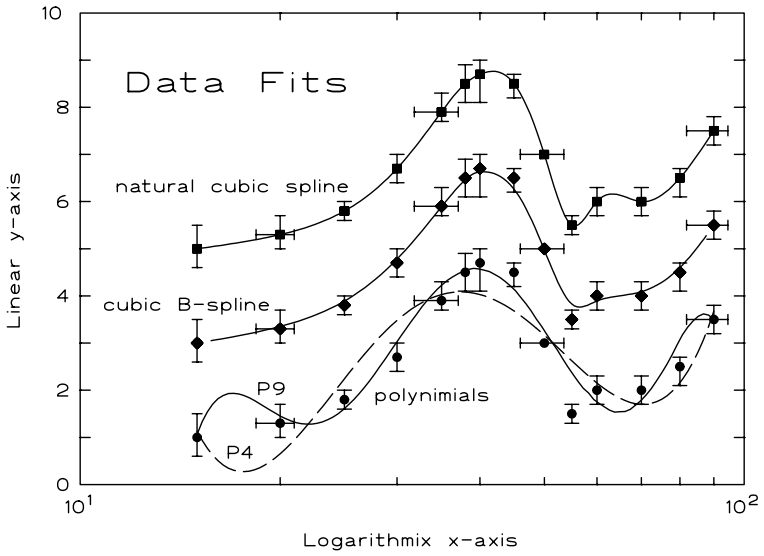

Figure 4.3. Different fits to same data on a logarithmic scale

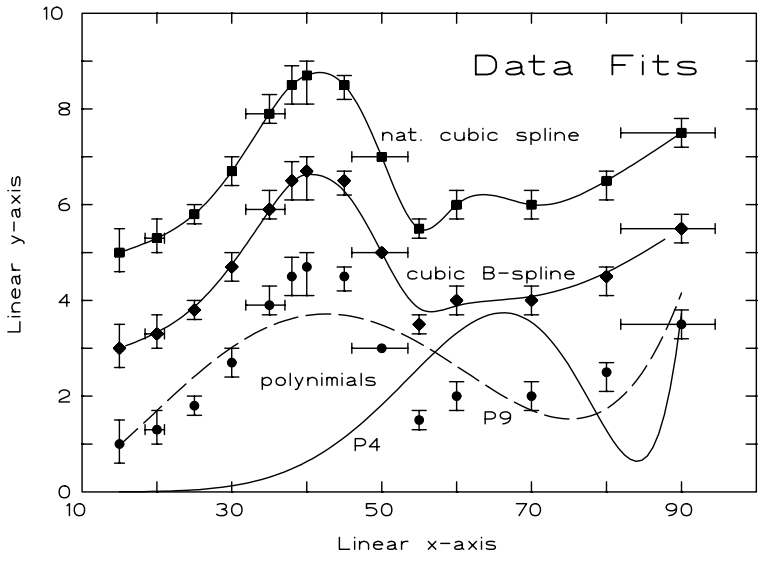

Figure 4.4. Different fits to the same data on a linear scale.

An example of the three fitting techniques is shown in Fig. 4.3. Notice the two spline fits given very similar results, with the B-spline tending to smooth out sharp changes in the data trend. The natural cubic spline fit always goes through each data point, and for closely spaced data can produce quite unrealistic fluctuations. The B-spline, by contrast does not have to go through each point and, hence, can produce a "smoother" fit. The polynomial fits give a much "gentler" fit and completely miss sharp discontinuities in the data trend.

Finally, a note of caution when using polynomial fits. If the data range is wide and a large polynomial degree is requested, the resulting polynomial may not fit the data very well as a result of numerical roundoff error. If you find spurious wiggles in the fit, try a lower degree polynomial. This problem is most pronounced when using a linear x-axis; fits to log-log data seldom exhibit this numerical problem. Also, the best fit is one which produces the smallest chi-squared parameter (also shown in the coefficient window). Thus a good tactic to obtain the "best" fit is to try fitting polynomials of increasing degree until the chi-squared parameter begins to increase.

An example of poor results for polynomial fits is shown in Fig. 4.4 in which the same data of Fig. 4.3 is fitted when plotted on a linear x-axis. Again the two spline fits produce reasonable fits. However, because of the large range of the x variable, the polynomial fits are quite poor.

4.2 Entering Data from the Keyboard

The `F3` option on the **Option Menu** allows you to enter a set of data (or also an arrow — see next section) from the keyboard. If you select this option, you first must enter the pen width, line or symbol type, and type of curve you want on the **Keyboard Data Menu**.

Once you have specified how the data are to be plotted, a template is displayed (by pressing the `F1` key) in which you enter the x-y coordinates of each datum. Enter the coordinates as two numbers separated by a comma, e.g., `1.5e-6,.0052`, where the first number is the x-coordinate and the second the y-coordinate.

After you have entered all the data (by making a null entry), you are given a chance to review the data and make any corrections. Once you have corrected the data, you are asked if you want to store the data in a disk file. Storing the data in a file is useful if you ever contemplate using the same data again and wish to avoid reentering them.

Generally, it is better to prepare your data sets in disk files before running **PC-PLOT** by using an ASCII editor or word processor. The keyboard entry option is used mostly for entering very simple data sets (e.g., to enter two points to produce a straight line in the graph's legend).

4.3 Entering an Arrow from the Keyboard

The `F3` option on the **Options Menu** also allows you to specify an arrow to highlight some feature of your graph. An arrow element is just a special kind of data set which connects the specified points and adds an arrowhead to the last point. An arrow can only be added to a graph by keyboard input.

After electing to add an arrow (`F3` option on the **Options Menu**), you must specify the pen width and line type for the arrow as well as indicate the proper "type of curve" on the **Keyboard Data or Arrow Menu**. For an arrow, specify curve type as `A`; the "arrow size" window that then appears refers to the length of the arrowhead tics and is expressed as a percent of the x-axis width (`2%` is the default). If the arrow size is specified as very small (e.g., |.0001—, since `0` is not allowed), you can also use the arrow feature to create boxes or other piecewise linear forms on the graph.

The F1 key in the **Keyboard Data or Arrow Menu**, causes the current graph to be displayed with a crosshairs in the center. Use the cursor arrow keys (or Shift-arrow keys for large steps) to move the cross hairs around the plot. Use the F9 key to select points to the joined for the arrow. The last point on the arrow (where the arrow head is to be drawn) is specified by pressing the F1 key (which also terminates input). The graph is then displayed with the specified arrow added to it.

4.4 Using Data in Disk Files

Although **PC-PLOT** allows you to enter data from the keyboard, its real strength lies in its ability to read x-y data from disk files written in a variety of formats. On the **Plot File Data Menu** you give the complete data file specification (e.g., C:\ANALYSIS\DTA\TEST.DTA). If no path information is given, the default directory is searched for the indicated file. If the file is not found, you are asked to reenter the file specification.

Data are written in "free format" in the data file, i.e., the data may be placed anywhere on a line in the data file with at least one blank (or comma) separating values on the same line. Extra blanks and commas before or after numbers are ignored. All data files must be standard ASCII files.

4.4.1 Permitted Data File Structures

Each data file must be in one of the following formats and the type of format, or the *data file structure* must be entered in the **Plot File Data Menu**.

(a) X-Data followed by Y-Data (structure code 0,0):

In this file the x-data are entered first, followed by the corresponding y-data, e.g.,

```
x1, x2, x3, x4,....., xn, y1, y2, y3, y4,......, yn
```

Any number of data can be on any one line.

(b) Multiple X-Y Data Pairs (structure 1,1):

In this type of file the x-y data are paired, any number of pairs to a line, such as

```
x1, y1, x2, y2, . . . , x7, y8
x8, y8, x9, y9, . . . , xn, yn
```

(c) Tabular Data (structure i,j):

This is the most commonly used form of input data file. In it data are tabulated in columns (with a least one blank or comma) between values. For example, such a file may be of the form

```
x1   y1  yy1  yyy1   xx1  xxx1
x2   y2  yy2  yyy2   xx2  xxx2
x3   y3  yy3  yyy3   xx3  xxx3
     .   .    .    .    .   .
xn   yn  yyn  yyyn   xxn  xxxn
```

The structure notation `i,j` (`i` different from `j`) means column `i` is assumed to be the x-coordinate and column `j` the y-coordinate. Thus, `5,2` means that column `2` (the y-values) is to be plotted against the values in column `5` (the x-values).

For data files in which the x-data are in column 1 and the y-data in column 2, the structure for the file may be specified as `1,1` or `1,2` (although the second structure is easier to remember). When keyboard entered data are stored in a disk file, they are written in the `1,2` data structure.

(d) Data With Error Bars (structure +-xy):

To read in data with errors associated with each x and each y value, use the file structure `+-xy`. Each line of such a file is of the form ([...] denotes optional quantities):

```
x [([-]xm [,] [+]xp)] [,] y [([-]ym [,] [+]yp)]
```

where `xm,xp` are the ± values associated with the value x (and `ym,yp` are the ± values for y), respectively. The errors for each value may be absolute values or expressed as percentages of the x (or y) value. Thus

```
10 (-20%,20%)  10 (-5%, 5%)
```

and

```
10 (-2,  2 )   10 (-.5, .5)
```

are equivalent. In fact, commas and signs are superfluous (as long as at least one blank or a parenthesis separates numbers). The first number in a parenthetical pair is always assumed to be the negative deviation, and the second the positive. Thus the above example may be written more succinctly as

```
10(20%,20%),10(.5,.5)
```

or even as

```
10(2,2),10(.5,.5) .
```

Notice that error limits need not be specified for both or even one x or y value. Thus a `+-xy` data file could contain the following data:

```
10(20%,2),    10(.5,10.1%)
15            25 (3, 3)
25 (5%,5%)    67
40            120.0
50.0          360 (-5% 6.3%)
 .             .
 .             .
```

One additional feature of `+-xy` data files specification is worth noting. The structure may be simply specified as `+-` if only the x,y values without the error bars are to be plotted, or as `+-x` if only x-data error bars are to be shown, or as `+-y` if only y-data error bars are to be drawn. Thus the `x` and `y` designation in a `+-xy` file structure indicate which error bars are to be drawn.

4.4.2 Non-Data Lines in Data Files

To minimize the preparation effort for creating input data files for **PC-PLOT**, Tabular Data Files [see Section 4.4.1(c) above] and Data Files With Error Data [see Section 4.4.1(d) above] may have

non-data lines such as blank lines, labels above each column, or data-set titles. Any blank line or line whose first non-blank character is not numeric (i.e., `-1234567890+.`) is ignored. Similarly, any information on a line after the data is ignored. Thus, an ASCII file prepared in the form of a table with captions, headings, separation lines, etc. can often be used directly by **PC-PLOT**.

4.4.3 Ordering the Data in Data Files

It is not necessary to order the data in ascending or descending values of the x-variable if only point/symbol plots or least-squares fitted polynomial or spline curves are desired. (For spline fits, **PC-PLOT** automatically orders the data pairs in ascending values of x and tests that no two data points have the same x value. However, the data are stored internally in the original order in case you wish to later change the way in which the data are plotted.)

However, if a straight line is selected to join the data points, the points are joined in the order that the data are read into the program. Because of this behavior, it is possible to draw quite complex figures in the plot area by entering the data in the order you wish the line to connect the data pairs.

4.5 Magnitude of Data

If data are entered (keyboard or file) in scientific notation, the absolute value of each value must be between `3E-38` and `3E+38`. If your data has larger exponents, it is necessary to scale your data before using **PC-PLOT**.

Chapter 5

Adding Graph Captions

From the **Options Menu**, pressing the F3 key displays the menu entitled **Add/Modify Plot Caption**. On this menu (shown below) you enter the pen width, lettering size, coordinates of a justification (anchor) point, as well as the caption itself.

```
======================== ADD/MODIFY PLOT CAPTION ==========================

 Pen width for caption (1-8):                                        3

 Character size for caption:  width[%]  (cm or %):                   1.5%
                              height[%] (cm or %):                   2.8%

 Caption coords. (justification point in graph's units):   X:     45.6
                                                           Y:     78.5

 Caption justification (Left|Right, Top|Middle:Bottom)               LT

 Caption  An Example Caption

======================== Use cursor and edit data ==========================

            Press F1  to add this label to the current graph
            Press F10 to abort & return to the Options Menu



Alt-h/HELP
```

Figure 5.1. Menu for adding or modifying a caption

5.1 Positioning Graph Captions

The position of a caption inside the graph frame is determined by specifying the coordinates of an "anchor" or "justification" point. This anchor point can then be specified as the Left- (or Right-) Upper, Middle, or Bottom location of the caption. Thus the caption justification may be specified as `LB, LM, LT, RB, RM,` or `RT` for how the caption is anchored to specified coordinates. In selecting this anchor point, **PC-PLOT** allows you to move a cross hairs around the graph to the position where you wish to anchor the caption. The caption anchor point must be within the graph plotting area. Only horizontal captions can be added to a graph.

Although, the lettering on the screen graph is of fixed size (i.e., unaffected by the specification of the character size), a rectangular box is drawn on the screen graph showing the precise area that will be filled by the caption on the plotted graph.

5.2 Length of the Caption

As with the title and axis label windows on the **Graph Definition Menu**, the maximum length of the caption, so that it does not extend beyond the right-hand axis, is indicated by a arrow below the caption input window. To make a longer caption, reduce the width of the caption characters. Note: the maximum caption length is determined as if all letters had maximum width (e.g., `M`). Because **PC-PLOT** uses proportional fonts, captions somewhat longer than the maximum indicated size can usually fit on the graph.

5.3 Super- and Subscripts

Superscripts and subscripts can be included in any caption by using the half-line shift characters. A caret ^ causes all following characters to be printed one-half line upwards (superscript) and the grave accent ` or underscore _ causes all following characters to be printed one-half line downwards (subscripts). When entering a caption with imbedded ^ ` _ shift codes, the caption may extend beyond the maximum-length indicator arrow by the number of shift codes used since the shift codes themselves are not displayed.

5.4 Greek Letters

Greek letters are indicated by a backslash \ followed by a letter. The case of the letter indicates the case of the Greek letter. For example, `\a` gives a lower case alpha, while `\A` produces a capital alpha. The possible letters are as follows:

```
\a alpha    \b beta      \g gamma     \d delta    \e epsilon    \z zeta
\h eta      \u theta     \i iota      \k kappa    \l lambda     \m mu
\n nu       \j xi        \o omicron   \p pi       \r rho        \s sigma
\t tau      \y upsilon   \f phi       \x chi      \c psi        \v omega
```

The upper and lower case Greek letters are shown in Fig. 5.2.

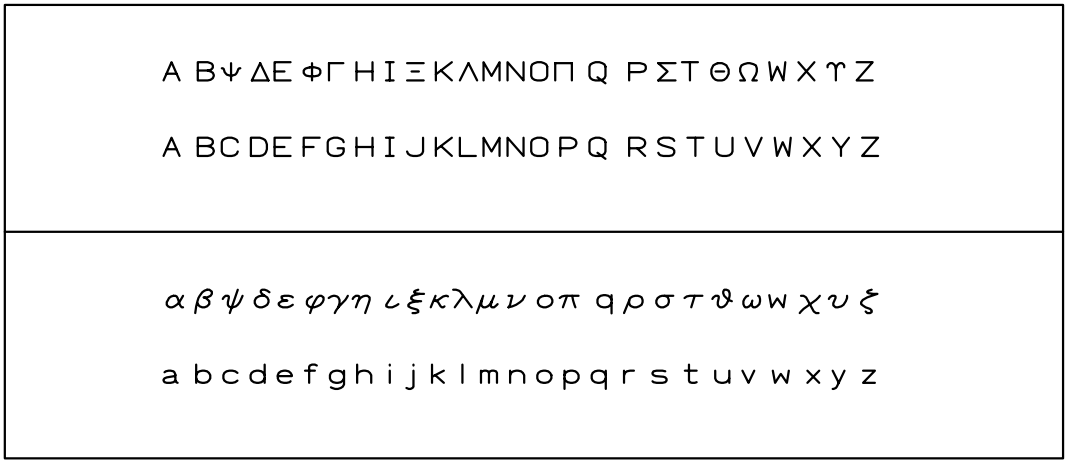

Figure 5.2. The Greek and English letters available in **PC-PLOT**.

5.5 Microspacing

The combination \␣ (backslash followed by a space) produces a space about 1/3 the normal space. By contrast \! produces a negative space or a shift to the left by about 1/3 the normal space. This latter microspace can be used to kern certain combinations. For example, a "gamma subscript epsilon" (\g_\e) looks better with the strong kern (\g_\!\!\!\e). This is illustrated below.

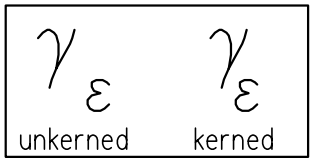

Figure 5.3. Kerns move the subscript closer to the main letter.

Chapter 6

Plotting Functions

PC-PLOT allows functions of the x-variable to be added to any graph. Pressing the **F4** key while in the **Options Menu** produces the **Plot Function Menu** shown below. On this menu you specify the pen width, type of line to be used for plotting the function, and, of course, the function you wish plotted.

```
============================== PLOT FUNCTION ==============================

   Pen width for data (1-8):                                        5
   No. of equidistant x-values (max 3842):                          50
   Type of spline line through calculated values:                   7
    (=1 dots  =2 dash  =3 lng dash  =4 dash-dot)
    (=5 lng-shrt   =6 lng-shrt-shrt  =7 solid  )

  Enter function y(x)=
     4.5 + sin(ln(x^0.567)) + sqr(abs(cos(x+4.5)))/5!

  Allowed operators:    + - * / ^ !(factorial); subgroup in parentheses()
  Supported functions:  SIN     COS     TAN     CSC     SEC     COT
                        ARCSIN  ARCCOS  ARCTAN  ARCCSC  ARCSEC  ARCCOT
                        SINH    COSH    TANH    CSCH    SECH    COTH
                        ARCSINH ARCCOSH ARCTANH ARCCSCH ARCSECH ARCTANH
                        ABS     LN      EXP     CLG     SQR
  Use upper or lower case; use E for exponential (scientific) notation

======================== Use cursor and edit data ========================

              Press F1  to add function to current graph
              Press F10 to abort & return to Options Menu

Alt-h/Help
```

Figure 6.1. The Menu for Plotting a Function

6.1 Defining the Function

The functions that **PC-PLOT** can add to a graph must be expressible in a single input line as a simple "statement function", i.e., no multi-line or conditional definitions may be used. While entering the definition of the function `y(x)`, upper and/or lower case and embedded spaces may the used for visual clarity. The only variable allowed in the function expression is `x` (or `X`). The rest of the expression must be composed of numerical constants, the operators `+ - * / !`, names of allowed intrinsic functions, or parentheses.

Expressions are evaluated as in BASIC or FORTRAN. Evaluation of the entered expression proceeds from left to right; however, quantities inside parentheses are evaluated first, i.e., parentheses define the order of calculational precedence. Parentheses around the arguments of an intrinsic function are optional, e.g., `sinx` and `sin(x)` are both allowed, although for visual clarity the standard practice of using parentheses is generally preferred unless the limited line length requires the more compact formulation.

Constants may be entered using scientific notation, e.g., 0.0000045 may be entered as `4.5E-6` (or `4.5e-6`). The factorial operator should only be applied to integer constants, e.g., `13!`, and not to the variable `x` (since `x` may assume non-integer values when plotted and the ! operator is available only for integer values).

The available intrinsic functions include:

- the six trigonometric functions `SIN, COS, TAN, CSC, SEC,` and `COT` whose arguments must be in radians
- the six inverse trigonometric functions `ARCSIN, ARCCOS, ARCTAN, ARCCSC, ARCSEC,` and `ARCCOT`. These are multi-branched functions and returned radian values are for the principal branch.
- the six hyperbolic functions `SINH, COSH, TANH, CSCH, SECH` and `COTH`
- the six inverse hyperbolic functions `ARCSINH, ARCCOSH, ARCTANH, ARCCSCH ARCSECH,` and `ARCTANH`.
- the natural logarithm `LN` and the base-10 (common) logarithm `CLG`
- the exponential function `EXP`, i.e., the inverse of `LN`
- the absolute value `ABS` and the square root `SQR`

6.2 Plotting the Function

Once a function expression has been entered, **PC-PLOT** tabulates it at the specified number of equidistant x-values between the graph limits. The maximum number of points on the **Plot Function Menu** represents the amount of free data space available, and is usually far in excess of the number of x-values needed. Typically, 50 or 100 points gives excellent results.

If you entered a complicated expression, the evaluation of the given expression can require many seconds, especially if a large number of x-values is specified. As the expression is being evaluated, the progress of the tabulation is displayed immediately above the entered expression.

Upon a successful tabulation of the entered function, the tabulated values can be added to the current graph by pressing the `F1` key. If the current graph has any log axes, the x and/or y data are

first converted to logarithmic values before plotting. Once plotted, the function data can be erased or modified like any other data set (using the `Ctrl-F1` combination from the **Options Menu**).

Since the function is graphed by fitting a spline curve through the tabulated points, functions that rapidly vary between the tabulated points may appear to have spurious oscillations if too few points are specified. Generally, 50 points gives excellent results. For highly oscillatory or rapidly varying functions, several hundred points may be needed. However, it is generally not advisable to specify several thousand points. Rather, it is preferable to plot the function separately over several subranges on the plot, each with 50 or 100 points. To plot a function over a subrange, simply redefine the `xmin` and `xmax` limits in the **Graph Definition Menu**, plot the function, and then reexpand the graph to the original limits.

6.3 Errors in the Function Definition

The function evaluator built into **PC-PLOT** is quite robust. It reports errors if functions are misspelled (e.g., `LOG` or `SQRT`), if improper arguments are encountered (e.g., `SQR(-4.5)` or `ARCSIN(2)`), or if improper definitions are entered (e.g., unmatched parentheses). If such errors are encountered during the evaluation phase, an error message is displayed and you may correct the function expression.

However, it has not been possible to completely "bullet-proof" the function evaluator from clever assaults by users. When plotting complex functions you haven't tried before (or even simple functions) it is wise to save the current graph as a `.GRF` file (`F6` on then **Option Menu**) just in case a fatal error is encountered during the function evaluation, and you are dumped out of the program. In this way you can restart the program and recall the graph with a minimum of effort.

On rare occasions, a completely correct expression produces strange results. Should you encounter such a case, try modifying the expression by adding decimal points to numbers or added extra pairs of parentheses around subexpressions.

Chapter 7

Saving and Modifying Graphs

7.1 Saving the Plot for Later Recall

From the **Options Menu**, the `F6` key allows you to save the current graph in a file that can be reread by **PC-PLOT** at a later time. These graph definition files (with the suggested extension `.GRF`) can be used only by **PC-PLOT** and cannot be sent directly to a plotter (as can `.PGL` files which are discussed in the next section).

These `.GRF` files allow you to recall a graph, modify it, or add additional information. Another use is to create a template for similar graphs which contain different data. However, you can create a `.GRF` file only if the graph definition parameters are valid and if there is at least one element in the graph (a caption or a data set). If you wish to save only the graph definition with no data or caption in the plot area, you must first create a graph by plotting a datum (probably through keyboard entry) that lies outside the plot area and hence will not be seen. Once at least one element is added to the graph you can save the graph for later recall.

7.2 Modifying Data Sets or Captions

Any plotted set of data, caption or arrow can be modified. From the **Options Menu** select `Ctrl-F1` to erase or modify a data set or arrow (which is just a special kind of data set) and `Ctrl-F2` to modify or erase a caption. In either case a table of current data sets or captions is displayed (see the examples on the next page). Select the number of the data set or caption you wish to delete or modify. You are then asked if you wish to delete or modify your selection. If you elect to modify the graph element, the appropriate Data or Caption Menu is then displayed in which you then make the desired changes.

```
====================== DELETE/MODIFY A DATA SET ========================
Set  Data File Specification  x,y-col. Sym/Lin npts   X(1)        Y(1)
 1.     B:HPIC21.PRN           1,2      so     35  0.3629E+01 0.3238E-17
 2.     keyboard               kybd     to     15  0.3380E+01 0.2581E-18
 3.     A:21DOSE.PGL           1,2      3      20  0.3125E+01 0.2198E-17
 4.     1.0E-19 * LN(x)        eqn      7      50  0.3125E+01 0.1788E-18
========================================================================
   Enter number of Set to be modified/deleted (0 to abort) ===>
```

Figure 7.1. Table for selecting a data set to modify

```
========================== DELETE/MODIFY A CAPTION =====================
  No. Caption String                      No. Caption String
  1.  21-cm shield                         2.  42.8-cm shield
  3.  No Overhead Shield
========================================================================
    Enter no. of Caption to be modified/deleted (0 to abort) ===>
```

Figure 7.2. Table for selecting a caption to modify

Chapter 8

Previewing and Plotting the Graph

Once a graph has been constructed on the screen, you can produce a copy of it on paper by selecting the `F9` option on the **Options Menu** ("Send to printer/ plotter or preview"). You then must select the orientation of the plot – "landscape" in which the x-axis is parallel to the long edge of the paper (or the screen), or "portrait" in which the x-axis is parallel to the short edge of paper (or screen). The plot orientation is toggled with the F-2 key.

You are then asked what plotting device you want to use: (1) an HP-compatible plotter, (2) a printer, (3) a disk file for the creation of a `.PGL` (HPGL format), `.PS` (encapsulated PostScript), or `.PCX` (bitmapped PCX format) file, or (4) the computer screen. You select the output mode by entering an appropriate letter: `H` for an HP compatible plotter, `P` for a printer, `G` for a disk `.PGL` file, `E` for a disk `.PS` file, `X` for a disk `.PCX` file, and `S` to preview the plot on the screen.

To use a printer or the monitor as a plotting device or to create PostScript or PCX files, it is necessary to install the program **PRINTGL** as described next.

8.1 Installing PRINTGL

To plot the graph to a printer or to the screen, requires that you have installed the program **PRINTGL** by Ravitz Software, Inc. This shareware program is distributed with **PC-PLOT** and can also be used by itself to plot `.PGL` files outside of **PC-PLOT**. **PRINTGL** supports plotting to a variety of printers and screens as indicated below (with the selection code in parentheses):

Supported Printers Supported Screens

```
IBM Proprinter (/F1)                  CGA display (/FC)
IBM QuietWriter 2&3 (/F2 & /F3)       128K EGA color display (/FE)
IBM Laserprinter (/F4)                128K EGA monochrome display (/FM)
NEC 24-pin compatibles (/F9)          Hercules graphics card display (/FH)
EPSON 9-pin compatibles (/FN)         VGA display (/FV)
Epson 24-pin compatibles (/FT)        enhanced VGA displays (/FV+ or /FV*)
HP LaserJet compatibles (/FL)
HP PaintJet (/FP)
```

Several other printers are supported, and variations (e.g., single pass, 3 pass, and 5 pass plots) of those listed above are also accommodated by **PRINTGL**. See the document file **PRINTGL**.DOC for additional printer support.

8.2 Required BAT Files

To produce plots on a printer or to preview them on the screen, it is necessary that two batch files `PCPLOTSC.BAT` and `PCPLOTPR.BAT` be installed in the same directory as `PCPLOT.EXE`. These batch files contain information about your printer and video monitor as well as certain plotting instruction (e.g., pen widths). Customizing these two batch files is discussed below.

(a) PCPLOTPR.BAT Printer Control File

This file is a batch file that invokes the **PRINTGL** program and sets switches that specify plot and printer information. A complete description of the **PRINTGL** program's switches is found in the documentation for this program (found in file `PRINTGL`.DOC). If your printer is a LaserJet attached to parallel port LPT2, then your `PCPLOTPR.BAT` would contain the two lines

```
\&ECHO OFF
C:\UTIL\PRINTGL %1  /FL/D2/M1/XSF/WABCDEFGH
```

Here the **PRINTGL** program is assumed to be in directory `C:\UTIL\`. You need to replace this with the directory you use for **PRINTGL**. The switch string, `/FL/D2/M1/XSF/WABCDEFGH`, contains program options. The LaserJet printer is indicated by `/FL` (see table at beginning of this chapter for other printer codes). The switch `/D2` indicates the printer port is LPT2 (`/D1` or `/D3` for LPT1 and LPT3, and `/DCOM1 /DCOM2 /DCOM3` for serial ports COM1 COM2 or COM3). The switch `/M1` indicated a magnification of unity (change this to expand or shrink the plot). The switch `/XSF` suppresses screen messages from **PRINTGL**. The switch /WABCDEFGH indicates that pens 1,2, ..., 8 are to have widths .2, .3, ..., .9 mm, respectively.

(b) PCPLOTSC.BAT Screen Control File

This file is invoked by **PC-PLOT** to have the **PRINTGL** program plot the graph on the computer monitor. It also sets switches that identifies the type of monitor and how the plot is to appear. If you have a VGA monitor, your `PCPLOTSC.BAT` file would contain the two lines

```
\&ECHO OFF
C:\UTIL\PRINTGL %1  /FV/M1/XSF/W11122233
```

Again the **PRINTGL** program is assumed to be in directory `C:\UTIL\`. The switch string, `/FV/M1/XSF/W11122233`, contains program options. The VGA monitor is indicated by `/FV` (see table at beginning of this chapter for other screen codes). The switch `/M1` indicated a magnification of unity (change this to expand or shrink the plot). The switch `/XSF` suppresses screen messages from **PRINTGL**. The switch `/W11122233` indicates that pens 1, ..., 8 are to have widths 1,1,1,2,2,2,3 and 3 pels, respectively.

8.3 Printing a Graph Using WINDOWS-95/NT

To run **PC-PLOT** under **Windows-95**, it is necessary to run it in a *DOS Window*. Similarly, to run **PC-PLOT** under **Windows-NT**, it must be run under a *Command Console*. Further, the Command Console does not allow **PRINTGL** to print directly to an attached printer, so that the `PCPLOTPR.BAT` file described above must be modified to create a temporary disk file, use the **Windows-NT** `PRINT` command to print the file, and then erase the temporary file. An example `.BAT` file for a LaserJet printer is

```
\&ECHO OFF
C:\UTIL\PRINTGL %1  /FL/M1/XSF/WABCDEFG/XSF/Dplot.000
PRINT plot.000
DEL plot.000
```

8.4 Plotting Directly from PC-PLOT to a Plotter

If you elect to send the graph directly to an attached plotter, you must have a plotter that uses the HP graphics language (HPGL). You are prompted next for the port to which the plotter is connected (COM1, COM2, LPT1, or LPT2) and the pen speed to be used for the plot. Finally, you are asked to make sure the plotter is turned on and ready and to press any key to begin the plot. Make sure the plotter is ready before pressing a key or the computer will hang.

At any time during the plotting, you can abort the plot by pressing `F10`. (There may be a slight delay before aborting until the plotter is finished with the element it is working on.)

8.5 Making Plots with a Printer

Once the program **PRINTGL** has been installed (see Section 8.1), you can use your printer as a plotting device. This plotter emulation program can be used outside of **PC-PLOT** to plot multiple `.PGL` files created by **PC-PLOT**, or it can be invoked from within **PC-PLOT** to plot the current graph.

When you wish to print the current graph from within **PC-PLOT**, choose the plot option (`F9`) from the **Options Menu** and type `P` at the prompt for the output plotting device. If the `PCPLOTPR.BAT` is not in the same directory as `PCPLOT.EXE`, you are asked to supply the path. The plotter emulation program **PRINTGL** is then automatically started. After plotting, you are returned to the **Options Menu** of **PC-PLOT**.

If many plots are to be generated on a printer, it is usually preferable to place each graph in a `.PGL` file, and then, after leaving **PC-PLOT**, use the **PRINTGL** program to process the `.PGL` files in its "batch mode". This batch mode operation is best accomplished by using the `PMI.EXE` program that comes with the **PRINTGL** code package.

8.6 Serial Interfaces

If your printer or plotter is attached to a serial port (COM1, COM2 or COM3), it is first necessary to setup the port before using **PC-PLOT** or **PRINTGL**. This is usually done in the `AUTOEXEC.BAT` files by including a statement such as

```
MODE COM1:9600,N,8,1,P
```

8.7 Using a .PGL File

As an alternative to sending the plot directly to a plotter, you may put the plotter commands in a disk file (suggested to have the extension `.PGL` to avoid confusion with `.GRF` files). The use of `.PGL` files has two advantages over directly plotting the graph. First, several different graphs may be created during a session and the graphs then "batch" processed outside of **PC-PLOT**. Also if

you computer does not have an attached plotter or printer, you can later take the disk with your `.PGL` files to a computer with a plotting device.

To plot a graph on a plotter previously stored in a plotter (`.PGL`) file, proceed as follows (the plotter is assumed to be connected to the COM1 port and the port has been properly setup with the MODE command as discussed in Section 8.4): At the **DOS** prompt, simple enter the command

```
TYPE filspec > COM1
```

where filspec is the complete file specification of the `.PGL` file (e.g., `C:\PLOT\RESULTS\GRAPH1.PGL`)

To plot a graph on your printer from a `.PGL` file, at the **DOS** prompt enter the command

```
PCPLOTPR filspec
```

To plot a series of `.PGL` file on your printer, use the **PMI** program.

8.8 Creating PostScript Plot Files

You may also create an encapsulated PostScript file of the graph by selecting `F9` from the **Options Menu** and typing `E` at the prompt for the output plotting device. You are asked if you want to trim the surrounding white space around the plot (useful if you are going to use the PostScript file in another program). If you elect not to trim the white space, the PostScript plot is centered on the page (useful if you plan to send the file eventually to a PostScript printer to obtain a hard copy of the graph. The PostScript file respects the "landscape" or "portrait" orientation specified.

8.9 Creating a .PCX Bitmapped Plot File

Selecting `X` as the output plotting device creates a bitmapped PCX formatted disk file which can then be used in other applications such as a word processing program. The PCX plot is always in portrait orientation (even if "landscape" is in effect), and all surrounding white space is trimmed away.