APPLICATION DATA SHEET

2200

GRAPH UTILITY SYSTEM (GUS)

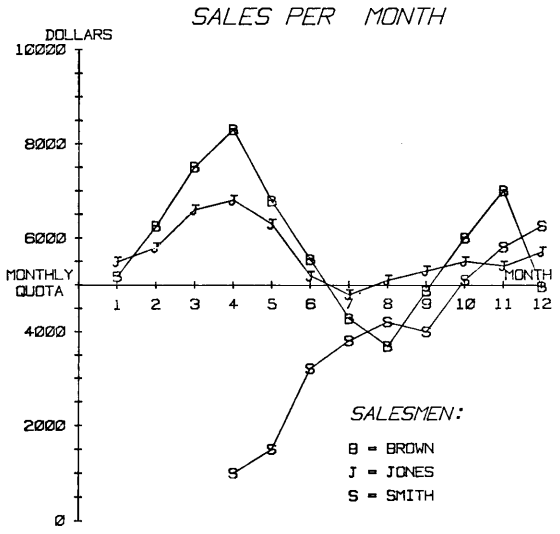
The Graph Utility System (GUS) is designed to meet the plotting demands of the classroom, the laboratory, and industry by providing a convenient methodology for creating, saving and updating the information necessary in initiating a plot. The system consists of a stand-alone program which enables the user to draw and label 2 and 3-dimensional graphs of several types, variable size, and from varying data sources on any plotter currently supported by Wang. Each module uses a table "fill-in" technique to enter data into the system. Table items are filled in step by step, where each step prompts the operator to the options and choices available.

In the system, the user is asked to supply general information on the plotter type, plot size parameters, data point or other data sources, and labels. As items of information are collected, the information is saved on disk where it can be called upon at plotting time.

The Graph Utility System consists of five modules; each module performs a separate information gathering function. An Initializing module receives information on the plotter model being used, the physical unit of measurement and the CRT width of the computer system. A Parameter module requests information for both 2- and 3-dimensional plotting. The module receives information on the size of the plot area, graph type, scale type, type of data source, the maximum and minimum values of the X and Y axis, and axis parameters. For 3-dimensional plotting, additional information, such as type of coordinate system, surface direction of view, hidden points, and line options for scaling and plotting, is required.

In 2-dimensional plotting, a Data Points module is used to accept the X and Y coordinates of the data points to be plotted. In a Labels module, the user can create any number of files, each containing words, phrases, equations, or other information to identify a graph or some of its features. Each character string may be sized, rotated, slanted, and automatically centered, left or right justified in relation to a coordinate point. A Plot module coordinates all input from the other modules and initiates the plotting activity.

- **Generates Plotting Information**
- **2-Dimensional Plotting in Linear and Non-Linear Scales.**
- **Axis Marking at Specified Intervals**
- **Graph Labeling and Character Sizing**
- **3-Dimensional Plotting in Specified Coordinate Systems**
- **Plotting via Data Files or Computed Function**



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Much of the time normally spent assembling plotting information is minimized and simplified by GUS. The system has many built-in features that simplify and, wherever possible, validate input. For instance, errors detected while entering values can be corrected by simply reselecting the item number in question. A powerful tool for directing module control and assisting the user in selecting menu options is the use of function letters. A function letter is simply a letter code entry from the keyboard that directs the system to perform or initiate a task. A letter code entry (C) from the keyboard can change one item, a sequence of items, or all items on a menu. When all items on a particular menu are complete and correct, the user can enter one of three letter codes to initiate action to save the data file on disk. One code (S) saves the file and returns the system to the beginning of the same module to start entering information in another file. Another code (R) initiates saving a data file and transfers control to the main system menu. A third code (A) also saves a data file, but transfers control to the next module. In all cases where data files are saved, a hardcopy of the information may be output on a printer immediately after the information is saved on disk.

Letter codes FX, D, and L are used in the Labels module to retrieve, delete, and plot labels. In the Data Points module, letter codes I and D are used to insert and delete data points. In the Parameters module, function letters are also available to facilitate the automatic scaling of a computed function.

Graph Utility System Features

Graph Type:

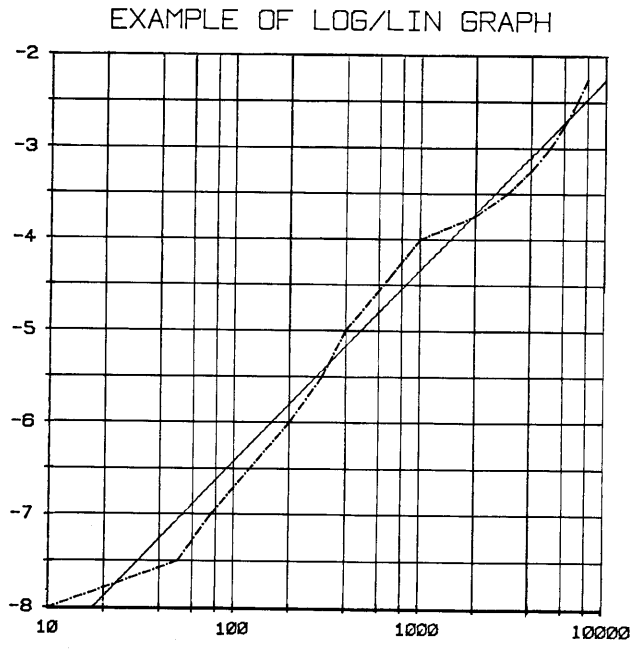
Three types — Line, Point, and Bar — are available for 2-dimensional plotting.

Line Graph: A solid line, dash, dotted, or dash/dotted line can be selected with an option of three sizes of interdot space or dash length. Additionally, it is possible to identify the data points between line segments on a line graph with point symbols selected from a standard character set provided with GUS or from hardware characters (Plotter Models 2272 and 2282, only). The point symbol feature allows the user to display several sets of related data as overlays on the same axes.

Point Graph: Any character in the standard set or hardware set (if available) may be chosen to be plotted at the data points. Small, medium, or large size characters may be plotted.

Bar Graph: The data is displayed as a series of vertical bars of user-specified width. (A bar graph is available only if the scale for the X-axis is linear.)

3-D Plot: This option provides for 3-dimensional plotting of a computed function. The 3-dimensional surface is represented visually on the plotter surface as a grid resembling a "stretchable net".



Scale Type: (2-dimensional plotting)

The data may be plotted using any of the following five scale types:

Linear:	Linear in both X and Y.
Log/Log:	Log scale in both X and Y.
Lin/Log:	Linear X and log Y scale.
Log/Lin:	Log X and linear Y scale.
Polar:	Data received in polar coordinate format (r, θ) is plotted onto a scale linear in both X and Y.

Coordinate System: (3-dimensional plotting)

All coordinates for 3-dimensional plotting are derived from a computed function. The computed function of the 3-dimensional surface may produce coordinates in one of the following coordinate systems:

Rectangular: The surface is specified as a function of two independent variables, x and y, which, in general, define the three dependent variables X, Y, and Z. In the simplest case, X $\leftarrow$ x, Y $\leftarrow$ y, and Z $\leftarrow$ f (x,y).

Cylindrical: The surface is specified as a function of two independent variables, x and y, which define three dependent variables r, θ, and z.

Spherical: The surface is specified as a function of two independent variables, x and y, which define three dependent variables r, θ, and ϕ.

Data Source:

Three alternatives are provided:

Standard Data File: (2-dimensional plotting)

Data points may be keyed in, printed out, edited, and maintained in files created by the Data Entry section of GUS. Data may be keyboard entered or read from a file previously created by the system. Data points are entered as numeric pairs of values corresponding to X and Y (or r and θ if polar coordinates). If the points are uniformly spaced along the X-axis, the user may elect to have the X values provided automatically during Data Entry. Data points may be changed, deleted, or inserted within or added to the end of an existing file.

Nonstandard Data Files: (2-dimensional plotting)

The user may wish to plot unique data files created in some arbitrary format. In this case, a program must be provided which consists of a subroutine to read the data file, unpack the data points and provide the coordinates to the main line processor one point at a time as called. As an example of such a program, the GUS disk contains the routine needed to read a file of statistical data created by the Wang statistical programs, thereby enabling immediate access to this data for plotting.

Computed Function:

For 3-dimensional plotting the user must provide a program file containing a subroutine to compute values of the function to be plotted. The function of two independent variables may provide the values for the 3 coordinates of a point in rectangular, cylindrical, or spherical coordinates. These coordinates in 3-dimensional space are then projected onto the plotting surface.

In 2-dimensional plotting the program file subroutine calculates rectangular or polar coordinates from the function specified parametrically.

In GUS, it is possible to automatically scan the function over the domain of independent variable(s) to produce anticipated minimum and maximum values of the dependent variables used to automatically scale the graph.

Size and Positioning:

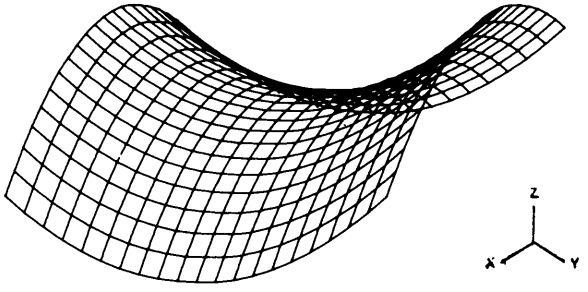
The user specifies in physical units of measurement (i.e., inches, centimeters, etc.) the overall length and width of the graph, the location of the plotting rectangle on the plotter surface, and the desired size of a margin around the axis and data area for use in labeling the plot. Plotting is restricted to the plotting rectangle.

The system determines if the specified graph is small (less than 16 cm or 8 in.), medium (16 to 32 cm or 8 to 16 in.), or large (more than 32 cm or 16 in.). For 2-dimensional plotting, the system automatically adjusts the size of hash marks and axis numbering in reasonable proportion to the overall size of the graph.

Graph Scale Units: (2-dimensional plotting)

This information includes the maximum and minimum data values on each axis, the point at which the axis will cross, and the distance between hash marks. The data is entered in the units to be represented on the graph. Graph scale units are typically not a physical distance but may be any unit in which the data was measured, such as dollars, years, or miles per hour.

SADDLE POINT



Axis Hash Marks: (2-dimensional plotting)

The length of the interval between hash marks on either axis is specified in graph scale units. Optionally, these hash marks can be extended the full width of the graph horizontally and/or vertically to allow the drawing of a graph-paper-like grid. This feature facilitates the reading of data points, especially on a logarithmic scale.

Axis Numbering: (2-dimensional plotting)

Optionally, hash marks can be numbered at each hash mark interval or at multiples of that interval. Axis numbering is done by hardware-provided characters on the Model 2282 and 2272 plotters. the other plotters use software routines for numbering.

Linear Regression: (2-dimensional plotting)

The plotting of a standard linear regression line is optional on any scale type or 2-dimensional graph type.

Directions of View: (3-dimensional plotting)

The surface may be viewed from any direction. The resulting projection can be rotated to any position relative to the vertical direction of the plotting surface.

Line Options for Plotting: (3-dimensional plotting)

The "stretchable net" representation is obtained by calculating various values of the function at points along one line of an independent variable and plotting line segments between those points. This is repeated along several lines which span the surface of interest to the user. The calculation procedure may be executed in the direction of either independent variable or in both directions. Increased "smoothness" is provided by specifying that additional points and lines be used.

Line Options for Scaling: (3-dimensional plotting)

Line options are provided for scaling purposes. During scaling, the surface of the function is scanned and points are calculated as they would be during the actual plotting. The purpose of scaling is to obtain the extremes of the values to determine the appropriate scale factor for the specified size.

Boundaries of Function: (3-dimensional plotting)

The 3-dimensional function is evaluated over the domain of independent variable values. For this calculation, the user specifies maximum and minimum values of these variables.

Hidden Points: (3-dimensional plotting)

This option is applicable only to functions represented in rectangular coordinates for which x = X and y = Y. If utilized, the program determines if one portion of the surface is hidden behind another portion and if so, does not plot the hidden part. An accuracy factor must be specified. A greater accuracy factor will refine the boundary between the hidden and displayed portions.

Labeling:

The user can create any number of files each containing words, phrases, equations, sequence numbers, or other information which may be helpful in identifying a graph or some of its features. This file contains the text, character size, and positioning of this information. Each string of characters may be rotated, slanted, and automatically centered or left or right justified.

If hardware lettering is available on the plotter model being used, the user has the option of plotting in hardware, or software characters. On any plotter, the user can specify the standard character set provided or use a unique character array.

CPU and Peripheral Requirements

Minimum required configuration includes a 2200T, 2200VP, or MVP, a minimum of 16K bytes of memory, a dual diskette drive, printer (optional), and any Wang plotter. (With the addition of a special interface, a Tektronix graphic display terminal or graphic CRT also is supported.) The printer is used to generate a hard copy of files input to the system.

A mini diskette version of GUS is also available for the PCS II.

Ordering Specifications

A diskette-based software package enabling the user to create 2- and 3-dimensional plots on Wang Plotter Models 2232B, 2272, 2282, 2281W or a Tektronix graphic display terminal. The system must use a simple table "fill-in" technique to enter data on plotter type, plot size parameters, labels and data sources. As items of information are collected, the information must be saved on disk where it can be called upon at plotting time. Data editing features and the option to generate hard copies of data files on a printer, also must be offered. For 2-dimensional plotting, the system must provide options for selecting linear, logarithmic or polar scale types, and line, point, or bar graph types. In addition, options must be provided for the generation of axis hash marks, axis numbering, and full-width grids. A linear regression option must be offered in 2-dimensional plotting. The system must permit the creation of labels. Label options must size, rotate and slant characters and provide text justification in relation to a coordinate point. Three data sources must be available for 2-dimensional plotting — a standard data file with editing features, a computed function, and a nonstandard data file. Data point generation using computed function techniques must be available for 3-dimensional plotting. The system uses a minimum of 16K bytes of memory.

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