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M. P. Lietzke
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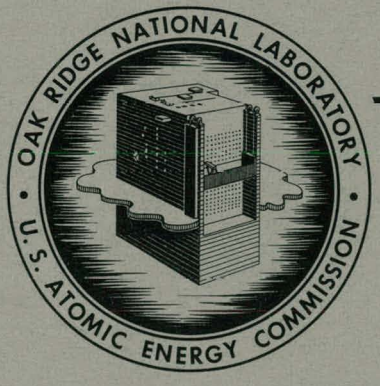

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ABSTRACT

A Fortran subroutine has been written to scale floating point data and generate a magnetic tape to plot it on the Calcomp 570 digital plotter. The routine permits a great deal of flexibility, and may be used with any type of FORTRAN or FAP calling program. A simple calling program has also been written to permit the user to read in data from cards and plot it without any additional programming. Both the Fortran and binary decks are available from Marjorie Lietzke, Mathematics Division.

CASPER: A GENERALIZED PROGRAM FOR PLOTTING AND SCALING DATA

M. P. Lietzke R. E. Smith

INTRODUCTION

CASPER (Calcomp Automatic Scaling, Plotting, Editing Routine) is a general Fortran subroutine written for use with Fortran or assembly language programs to produce scaled plots of floating point data on the Calcomp 570 plotter. A calling program is available to read and plot data if no computation is desired.

CASPER offers the following options:

1) x and y maximum and minimum values may be specified or found by the subroutine;
2) scaling and plotting may be done for blank paper (maximum sensitivity scaling with a complete grid or indicated intervals drawn) or lined graph paper (intervals are set at the inch or half-inch lines);
3) graph size may be varied ($8" \leq$ x axis $\leq 120"$, $5" \leq$ y axis $\leq 9"$);
4) a line connecting points or 16 different point-centered symbols (available in two sizes) may be used for plotting data;
5) title and labels for axes may be indicated for each graph;
6) CASPER will plot as many separate graphs as can be written on one magnetic tape, with a limit of 50 curves (a curve being a set of points connected by a continuous line or plotted with one symbol) and 65,535 total points per graph. Space will be left between graphs for cutting and binding.

These options are described in more detail in the section on "Use of Subroutine CASPER".

MATHEMATICAL DISCUSSION

The range is computed as maximum minus minimum for each axis and an interval size is established. The maximum and minimum values are then set to the nearest integral multiple of the interval size encompassing the range. If the plot is to be on lined rather than blank paper, the number of intervals is adjusted so that the size of the interval will be either one or one-half inch, and the maximum x and y values are changed accordingly. The procedure is as follows:

$$R_x = x_{max} - x_{min} = n_1 \times 10^p (.1 \leq n_1 < 1)$$

$$\Delta x = n_2 \times 10^{p-1} \qquad \text{where } n_2 = .1 \text{ if } n_1 \leq .2$$

$$n_2 = .25 \text{ if } .2 < n_1 < .5$$

$$n_2 = .5 \text{ if } n_1 \geq .5$$

$$q_x = \frac{x_{Max}}{\Delta x} = \text{Integer} + (\text{fraction})$$

$$q'_x = \frac{x_{min}}{\Delta x} = \text{Integer} + (\text{fraction})$$

If fractions exist:

for positive numbers $q_x \equiv$ Integer + 1

$$q'_x \equiv \text{Integer}$$

for negative numbers $q_x \equiv$ Integer

$$q'x \equiv \text{Integer} - 1$$

If there is no fraction q_x or q'_x is used unchanged.

$$X_M = q_x \cdot \Delta x$$

$$X_m = q'_x \cdot \Delta x$$

Similar formulae are used to establish Y_M and Y_m from y_{Max} and y_{min}.

Then

$$X_M - X_m = R'X \qquad Y_M - Y_m = R'Y$$

$$\frac{R'X}{\Delta x} = q_{R'X} \qquad \frac{R'Y}{\Delta y} = q_{R'Y}$$

If the programmer wishes to use lined graph paper with inch or half-inch intervals, the following adjustments are made:

If $q_{R'X}$ > length of x axis in inches (Sizex):

$$X_M \equiv ((2 \times \text{Sizex}) - q_{R'X})\ \Delta x + X_M$$

$$q_{R'X} \equiv 2 \times \text{Sizex}$$

If $q_{R'X}$ < Sizex:

$$X_M \equiv (\text{Sizex} - q_{R'X})\ \Delta x + X_M$$

$$q_{R'X} \equiv \text{Sizex}$$

In both cases, R'X is then recomputed:

$$R'X = X_M - X_m$$

If $q_{R'X}$ = Sizex, no changes are made.

Similar formulae are used to recompute Y_M, $q_{R'Y}$, and R'Y for this option.

The interval sizes in both cases are set as follows:

$$x \text{ interval size} = \frac{\text{Sizex}}{q_{R'X}}$$

$$y \text{ interval size} = \frac{\text{Sizey}}{q_{R'Y}}$$

The plotting area is then outlined, the intervals indicated or a full grid drawn, and the title, Y_M, Δy, y label, Y_m, X_m, x label, Δx, and X_M printed around the plotting area. All output numbers on the graph are of the form n x $(10)^p$ where $1 \leq n < 10$: e.g., 40 would be written as 4.000 + 1.

Finally, the x and y values are normalized and plotted as follows:

$$\frac{X_m - x}{-R'X} \times \text{Sizex} = XN$$

$$\frac{Y_m - y}{-R'Y} \times \text{Sizey} = YN$$

USE OF SUBROUTINE CASPER

CASPER makes use of a number of FAP subroutines written for the IBM-7090. These FAP codes must be rewritten before CASPER can be used on another machine. A list of these routines and their length is given in Table 4.

The subroutine also calls Fortran subroutine SQUASH to set up

array of BCD output numbers in scientific notation and LEGEND to put out arrays of BCD information. These subroutines are all included in the binary deck of CASPER and need not be called directly by the programmer. No other subroutines in the user's program may be given these names.

CASPER'S arguments are in the form of arrays. CASPER is called for each point (x, y) which is to be plotted, and the order in which points are given to CASPER is also the order of plotting.

1. Options

In the following description of options available in the use of CASPER a curve is defined as a set of points to be plotted sequentially with a continuous connecting line or with a single symbol repeated for each point. A plot or graph is a complete picture including grid indicators, title, labels, and containing one to fifty curves.

1.1 RANGE SETTING

CASPER will search data for x and/or y maxima and minima or accept specified values as arguments. In the latter case points outside the specified x or y range are rejected and a message written on the output tape. The plotting pen will not be lifted for rejected points; thus, if the curve is a line plot a line will be drawn to the next acceptable point of the curve. If it is desired to "blank out" some part of a curve, each segment must be indicated as a separate curve.

The x or y range for a plot cannot be zero; if the user wishes to plot a single vertical or horizontal line, he must specify some range (maximum $\neq$ minimum) for the other axis.

Specified maxima and minima may also be used to center or reduce curves in a plot.

1.2 SCALING

Scaling and plotting may be done with maximum sensitivity, so that the entire graph area is covered by the ranges $x_{max} - x_{min}$, $y_{max} - y_{min}$. For this option, either a complete grid or one-quarter inch grid indicators will be drawn perpendicular to each axis by the plotter. Blank paper should be used.

If lined graph paper is to be used, CASPER sets the intervals at the inch or half-inch accented lines and merely indicates them along the axes. In this case the plotted points may cover less than the entire graph area. (Maximum reduction of the graph is 13/24 of the axis in each direction. See Fig. 3.)

1.3 GRAPH SIZE

The graph size may be changed by the programmer within certain limits (8" ≤ x axis ≤ 120"; 5" ≤ y axis ≤ 9"). The standard plotting area is 9 x 12 with a one-inch margin for labels and binding. If the axes are shortened in either direction, titles and labels will be truncated and should be adjusted accordingly.

1.4 PLOTTING

Points in a curve may be plotted with a continuous line connecting them (a polygonal plot) or with one of 16 different point-centered symbols, which are available in two sizes. Curves may also be distinguished by plotting a set of points once with a continuous line, then plotting a few of the points again with a symbol. Thus each curve on a single graph can be indicated uniquely.

1.5 TITLING AND LABELING

A title and x and y labels may be written for each graph; if no labels are specified, the axes will be labeled 'abscissa' and 'ordinate'.

Limit on the number of characters in the title of a graph is 48; on the x and y labels, 36 each. If the x axis is shortened, the number of permissable characters in the title is 4 x (new length of x axis). If the x axis is shortened by more than 1.25", the x label limit is [8.3(x axis - 6.5)]. If the y axis is shortened by more than .75", the permissible number of characters in the y label is [8.3(y axis - 4.0)]. CASPER will automatically truncate the title or the x or y labels if they exceed the above limits.

The subroutine will also print the x and y maximum and minimum values, delta x and delta y on the graph.

2. CALLING CASPER

The subroutine may be used in Fortran programs by placing the necessary arguments in arrays and then calling CASPER with the array names. The following statements are necessary in the calling program:

```
DIMENSION A(129),   I(4),   BUFFER (optional)
CALL  CASPER (A,I, BUFFER)
```

BUFFER is the name of a floating point array dimensioned by the user to provide CASPER with storage space for the x and y coordinates which are accumulated and counted until an end of picture call. If the number of x - y coordinates is greater than the number of buffer cells, the buffer is written on logical tape 27 as many times as is necessary to handle all the points ($2 \leq$ no. of points $\geq 65{,}535$).

It is not necessary that all of CASPER'S arguments be set on every call; many are checked only once and ignored the rest of the time. CASPER does not destroy its arguments; they will remain set until changed by the calling program. Arguments such as title and labels, therefore,

may be set on a first call, although the subroutine will not use them until the end of picture call.

3. CASPER'S ARGUMENTS

A description of the arguments grouped according to necessary calls follows. See Table 1 for complete information.

3.1 ALL ENTRIES: There are only two arguments which must be set on every call of CASPER: A(1) and A(2), the x and y values, respectively, of the point to be plotted.

3.2 FIRST ENTRIES: On the first call of CASPER for each separate plot the following additional arguments must be set: A(3), A(4), A(5), A(6), A(7), A(8): I(1), I(2), I(4). A(3) and A(4) must be set to x_{max} and x_{min} respectively if the user wishes to specify the x range; if he wished CASPER to search for the range, he must set them to 0. The same holds true for Y_{max} and y_{min}, A(5) and A(6) respectively.

A(7) and A(8) are the length of the x and y plotting axes and may be left 0 if the user wishes a standard plotting area (9 x 12). Otherwise he must set them to the length desired (8" ≤ x axis ≤ 120", 5" ≤ y axis ≤ 9").

I(1) must be set to a -2 on the very first call of CASPER for the first or only graph and -1 on the first call for each additional graph. It must not be negative at any other time.

I(2) must be set to 1 or 2 to indicate a maximum sensitivity graph (blank paper) or to 0 for adjusted intervals (lined paper).

I(4) need be set only on the initial first entry and represents the size of the buffer provided by the user. It must be an integer equal to the dimension of the buffer.

3.3 END OF CURVE CALLS:

The following arguments must be set when CASPER is called with the last point in a curve: A(9); I(1), I(3).

A(9) controls the size of the plotted symbols in the case of a point plot; I(1) must be set to 1 to indicate end of curve; I(3) must be set to the type of point (see Appendix A for those available) or line plot desired for that particular curve.

3.4 END OF PICTURE CALLS:

The following additional arguments must be set when the last point of the last curve of a graph is called: A(10--129); I(2).

A(10--57) is the title of the graph, A(58--93) the y axis label, A(94--129) the x axis label. These should be read into the array in A1 format or set equal to left adjusted boolean constants representing the desired BCD characters. If blanks are read into the y or x label portion of the array CASPER will print 'abscissa' or 'ordinate' on the respective axis.

I(2) must be set to -1 to indicate end of picture.

Every call of Casper will result in the plotting of the values of x and y which are then in A(1) and A(2). The arguments for first entry, end of curve entry and end of picture entry are in addition to the x and y values. For complete information concerning the possible values of the arguments and the limitations on them see Table 1.

4. CONTROL CARDS

Control cards for the IBM 7090 monitor must include an absolute tape assignment card: *ASSIGN(8,A6), and a tape control card: *TAPE(8, POOL, SAVE), (27, POOL), (10, INPUT), (9, OUTPUT). Scratch

tape 27 will be written if the number of points to be plotted is greater than one-half the dimension given to BUFFER, but it must be specified in any case. The logical tape numbers 8,9,10, and 27 are fixed.

5. OUTPUT MESSAGES

An error message will be written on output tape 9 if the proper first entry arguments are not set, and the program will call exit. If either the x or y values are such that the range, maximum minus minimum, is zero a message will be written, no plotting will be done, and control will be returned to the calling program.

If the program finds points outside the range specified by the user, it will write a message that the nth point of the plot has been rejected and give the values of x and y. At the end of each plot the actual maxima and minima, delta x, delta y, the number of points, and the number of curves will be written on the output tape.

See Appendix A for a sample calling program of SUBROUTINE CASPER.

DESCRIPTION AND USE OF THE CALLING PROGRAM

A "packaged" CASPER (Fortran calling program and subroutines) is available for plotting data from punched cards. All the options available with subroutine CASPER are also available with the calling package.

The first five data cards for each plot must contain initializing information as follows: the title; y label; x label; arguments A(3), A(4), A(5), A(6), A(7), A(8), A(9); the first point to be plotted and an integer indicating lined paper or blank paper with

grid or indicated intervals. All the limitations on arguments listed in Table 1 apply here also. The data cards following these five should each contain the x and y coordinates of a point and a control integer which may indicate end of curve or end of picture, and type of plot. See Table 2 for data input, Table 3 for use of the control integer. The use of the calling package with various options is illustrated in figures 2 through 8. The same data were used in these plots with only the options as to paper type, range specification and plot size varying.

ADDITIONAL LABELING

If the programmer wishes to label curves or write out additional material on the finished plot, he can make use of the subroutine LEGEND to write the information at the desired point on the graph. Care must be exercised in using LEGEND for this purpose. The calling program must set up an array of right adjusted BCD characters, one per word. The call statement must be made after the first entry call of CASPER but before the end of plot call, and appears as follows:

CALL LEGEND (XP, YP, LEAN, SCALE, NUMBER, ARRAY)

where XP and YP are the coordinates in floating point inches at which the first character is to be printed; LEAN = 1 indicates horizontal printing, 2 indicates vartical printing with top of character toward left; SCALE is the factor which sets the character size to 4 SCALE wide by 7 SCALE high ($.01 \leq SCALE \leq 1.5$); NUMBER is the number of characters to be printed ($1 \leq NUMBER \leq 48$); ARRAY is the name of a highly subscripted variable containing characters to be plotted.

To set up XP add 1.5 inches to the desired distance from the left y axis; for YP add 1.0 inch in the case of blank paper, 0.5 inch for lined paper.

Table 1

ARGUMENTS FOR CASPER SUBROUTINE: CALL CASPER (A, I, BUFFER)

Array Position	Input Number	Effect	Must be Set For	Limitations
A(1)	x value	x coordinate of point to be plotted	every call	floating point
A(2)	y value	y coordinate of point to be plotted	every call	f.p.
A(3)	0	if A(4) = 0, hunt x max, x min	first entry for plot	f.p.
	x max	if A(4) = x min, x range is specified; points outside range will be ignored	first entry for plot	f.p.
A(4)	0	if A(3) = 0, hunt x max, x min	first entry for plot	f.p.
	x min	if A(3) = x max, x range is specified; points outside range will be ignored	first entry for plot	f.p.; A(3) = x max
A(5)	0	if A(6) = 0, hunt y max, y min	first entry for plot	f.p.
	y max	if A(6) = y min, y range is specified; points outside range will be ignored	first entry for plot	f.p.
A(6)	0	if A(5) = 0, hunt y max, y min	first entry for plot	f.p.

Table 1 (continued)

ARGUMENTS FOR CASPER SUBROUTINE: CALL CASPER (A, I, BUFFER)

Array Position	Input Number	Effect	Must be Set For	Limitations
	y min	if A(5) = y max, y range is specified; points outside range will be ignored	first entry for plot	f.p. A(5) = y max
A(7)	0	length of x axis (plotting area) will be set to 12".	first entry for plot	
	x axis	length of x axis will be set to input number	first entry for plot	f.p.; 8 ≤ x axis ≤ 120
A(8)	0	length of y axis (plotting area) will be set to 9"	first entry for plot	
	y axis	length of y axis will be set to input number	first entry for plot	f.p.; 5 ≤ y axis ≤ 9
A(9)	0	point scaling factor set to .05 (larger size)	end of curve call	f.p.
	pos. no.	point scaling factor set to .03 (smaller size)	end of curve call	f.p.
A(10--57)	alpha-numeric characters and blanks	title of graph printed across top	end of picture call	number of characters not > 48; if x axis shortened, reduce number of char. by 4 for each inch
	blanks	no title	end of picture call	

Table 1 (continued)

ARGUMENTS FOR CASPER SUBROUTINE: CALL CASPER (A, I, BUFFER)

Array Position	Input Number	Effect	Must be Set For	Limitations
A(58--93)	alpha-numeric characters	y label printed on side of plot	end of picture call	number of characters not > 36; if y axis reduced by more than .75", limit is greatest integer of (8.3 x (y axis - 4.0))
	blanks	y axis labeled 'ordinate'	end of picture call	
A(94--129)	alpha-numeric characters	x axis label printed across bottom of graph	end of picture call	number of characters not > 36; if x axis reduced by more than 1.25", limit is greatest integer of (8.3 x (x axis - 6.5))
	blanks	x axis labeled 'abscissa'	end of picture call	
I(1)	-2	Indicate initial first entry; initializes counters, rewinds scratch tape; calls PLOTS	set ONLY on initial first entry. (first call of CASPER in a series of plots)	fixed point
	-1	indicates beginning of new graph; initialization, checking of arguments	set ONLY on first entry for plot	fixed point
	0	no effect	all entries except first, last, end of curve	
	1	indicates end of curve; sets counters, stores information about curve	end of curve call ONLY	fixed point

Table 1 (continued)

ARGUMENTS FOR CASPER SUBROUTINE: CALL CASPER (A, I, BUFFER)

Array Position	Input Number	Effect	Must be Set For	Limitations
I(2)	-1	indicates end of graph; causes CASPER to scale data and write CALCOMP tape	end of picture call ONLY	fixed point
	0	sets up graph for lined paper, with intervals indicated on inch or half-inch lines	first entry for plot	
	1	sets up graph for blank paper and maximum sensitivity; draws entire grid	first entry plot	fixed point
	2	sets up graph for blank paper and maximum sensitivity; indicates intervals along axis	first entry for plot	fixed point
I(3)	1	points in curve will be connected by straight lines; continuous plot	end of curve call	fixed point
I(3)	4	points in curve will be plotted by point centered symbol: See Fig. 1. 4 corresponds to bottom line 19 to top line	end of curve call	fixed point
	5		end of curve call	fixed point
	6		end of curve call	fixed point
	7		end of curve call	fixed point
	8		end of curve call	fixed point

Table 1 (continued)

ARGUMENTS FOR CASPER SUBROUTINE: CALL CASPER (A, I, BUFFER)

Array Position	Input Number	Effect	Must be Set For	Limitations
	9		end of curve call	fixed point
	10		end of curve call	fixed point
	11		end of curve call	fixed point
	12		end of curve call	fixed point
	13		end of curve call	fixed point
	14		end of curve call	fixed point
	15		end of curve call	fixed point
	16		end of curve call	fixed point
	17		end of curve call	fixed point
	18		end of curve call	fixed point
	19		end of curve call	fixed point
I(4)	buffer size	size of buffer region supplied to CASPER by calling program	initial first entry	MUST be same number as dimension of array BUFFER and < 32,768
BUFFER	array name	assigns buffer region	all entries	MUST be dimensioned in calling program;

Table 2: INPUT DATA FOR CALLING PROGRAM

Card No.	Field	Variable	Type	
1	1--48	Title	BCD	number of characters not > 48; if x axis shortened, reduce number of characters by 4 for each inch
2	1--36	y label	BCD	number of characters not > 36; if y axis reduced by more than .75", limit is greatest integer of (8.3 x (y axis - 4.0))
3	1--36	x label	BCD	number of characters not > 36; if x axis reduced by more than 1.24", limit is greatest integer of (8.3 x (x axis - 6.5))
4	1--10	A(3)	f.p.	decimal point indicated
	11--20	A(4)	f.p.	" " "
	21--30	A(5)	f.p.	" " "
	31--40	A(6)	f.p.	" " "
	41--50	A(7)	f.p.	" " "
	51--60	A(8)	f.p.	" " "
	61--70	A(9)	f.p.	" " "
5	1--10	x value	f.p.	" " "
	11--20	y value	f.p.	" " "
	21--30	NCHECK	INT	right-adjusted
6--K	1--10	x value	f.p.	data points and a controlling integer are input on sub-
	11--20	y value	f.p.	sequent cards; if a series
	21--30	NCHECK	INT.	of plots is desired simply stack decks with input data in this form. (Cards 1-K)

Table 3: CONTROL INTEGER FOR CASPER PACKAGE

Value of NCHECK	When Used	Effect
0	with first point of a graph (Card 5)	lined paper graph
1	"	blank paper graph; complete grid
2	"	blank paper graph; indicated intervals
0	with all points except first, end of curve, and end of picture	indicates more data to be read
1	end of curve	indicates end of curve and line plot
4	" "	indicates end of curve and point-centered plotting symbol as shown in figure 1
5	" "	
6	" "	
7	" "	
8	" "	
9	" "	
10	" "	
11	" "	
12	" "	
13	" "	
14	" "	
15	" "	
16	" "	
17	" "	
18	" "	
19	" "	
-1	end of picutre	indicates end of curve and end of picture; line plot of last curve
-4 to -19	end of picture	indicates end of curve and end of picture; last curve will be plotted according to NCHECK as above

Table 4

SUBROUTINE NAMES AND LENGTHS

NAME	LENGTH DECIMAL	OCTAL
CASPER	3264	6300
LEGEND	105	151
SQUASH	145	221
PLOT, PLOTS, THREE, SIND	336	520
SYMBL2	279	427
RADJ	10	12
SET	44	54
PLOTL	21	25
TRW	32	40
BCDFL, BCDFX	29	35
LINK, OUT	19	23
TOTAL	4284	10274

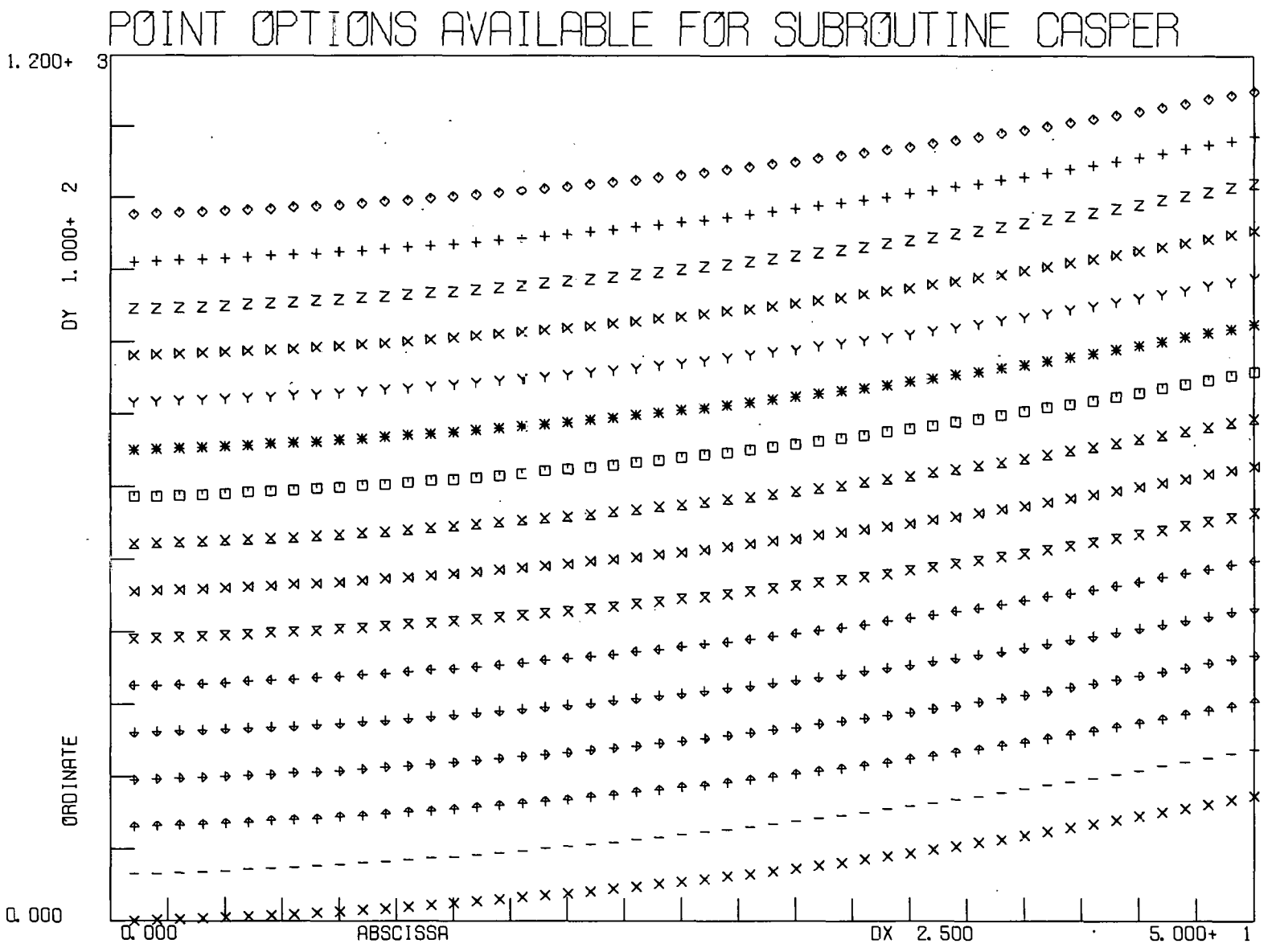
POINT OPTIONS AVAILABLE FOR SUBROUTINE CASPER
1.200+ 3
DY 1.000+ 2
ORDINATE
0.000
0.000
ABSCISSA
DX 2.500
5.000+ 1

Figure 1

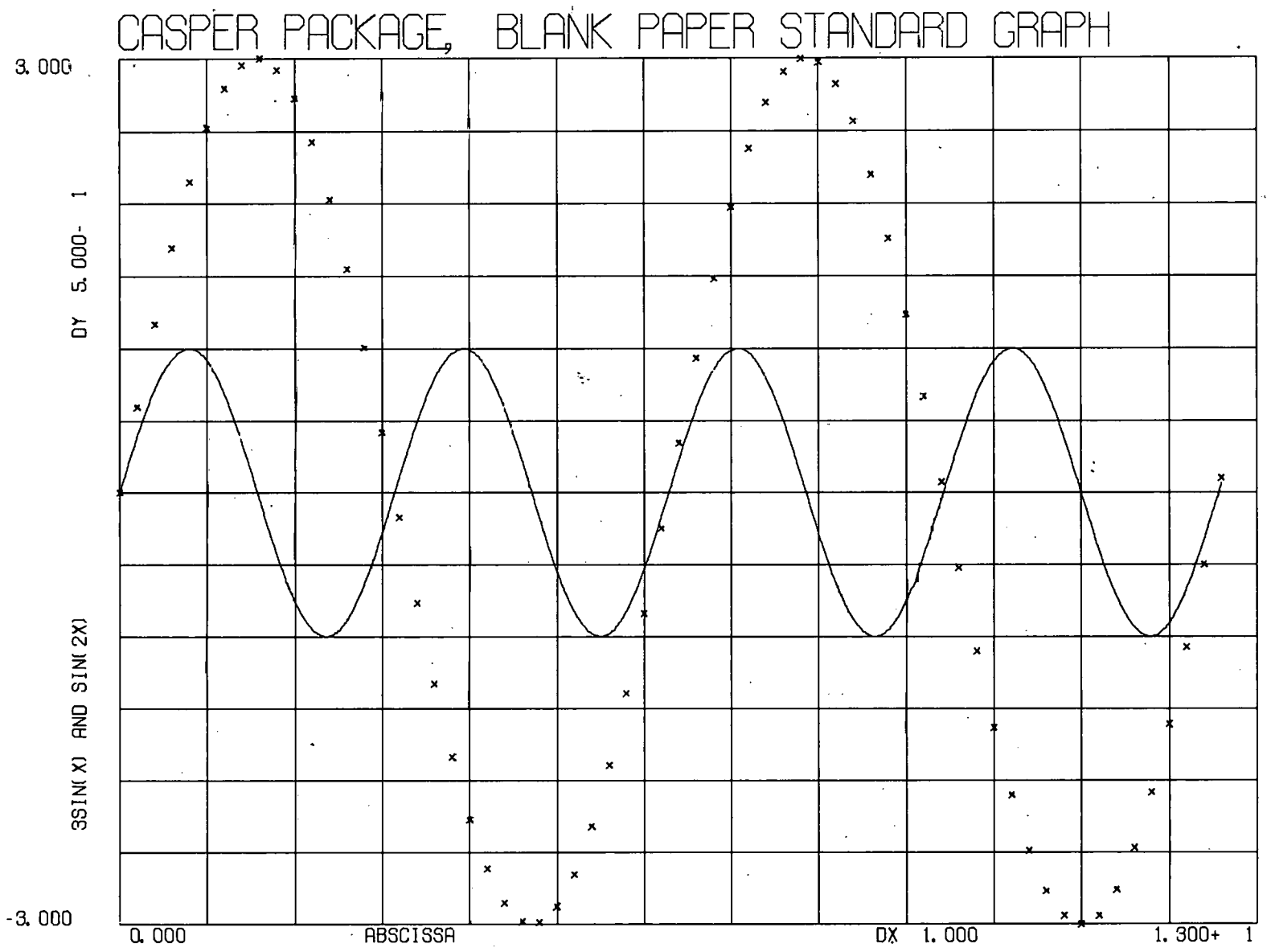
CASPER PACKAGE, BLANK PAPER STANDARD GRAPH
3.000
DY 5.000- 1
3SIN(X) AND SIN(2X)
-3.000
0.000
ABSCISSA
DX 1.000
1.300+ 1

Figure 2

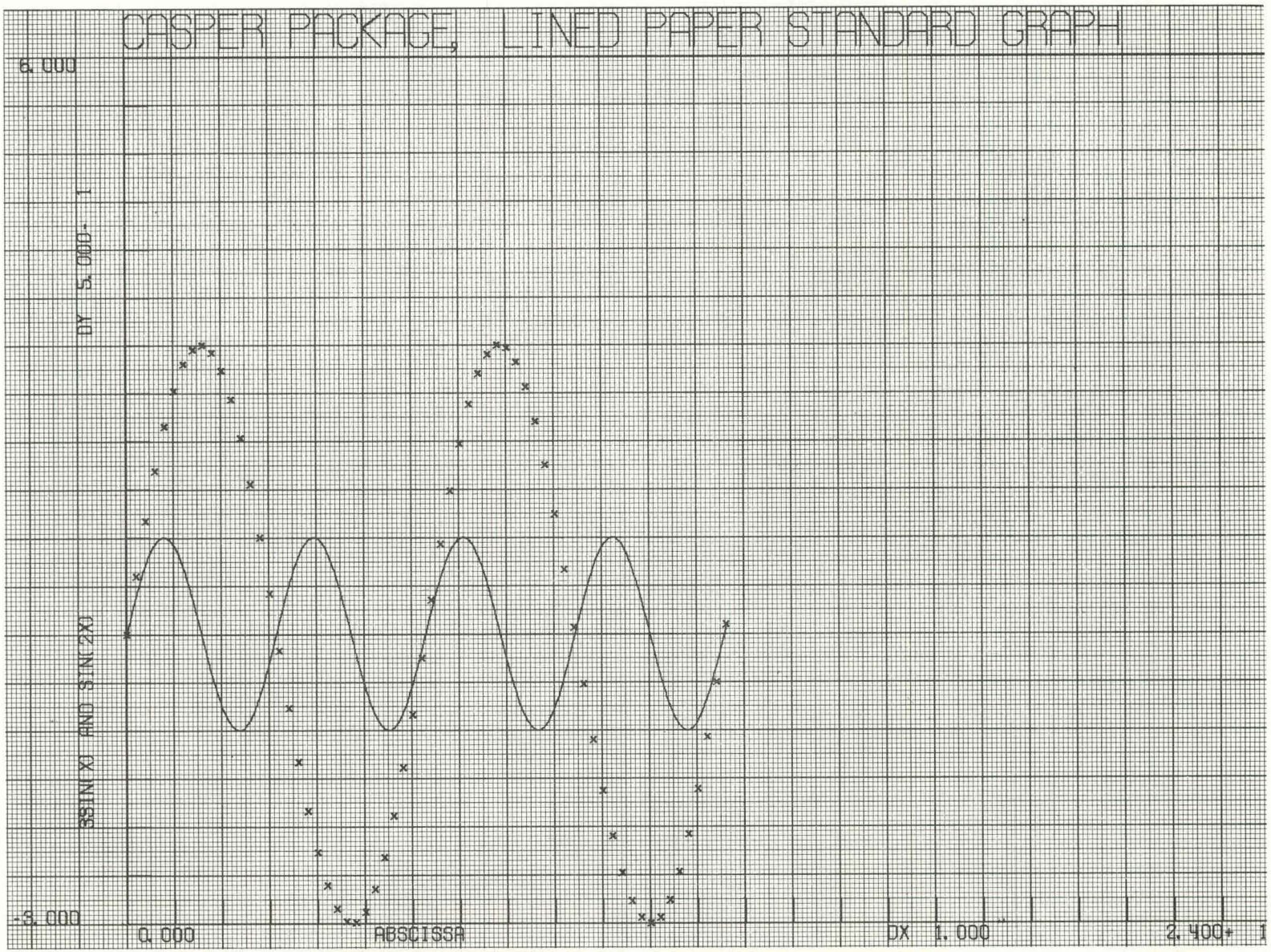
CASPER PACKAGE, LINED PAPER STANDARD GRAPH
6.000
DY 5.000
3SIN(X) AND SIN(2X)
-3.000
0.000
ABSCISSA
DX 1.000
2.400+

Figure 3

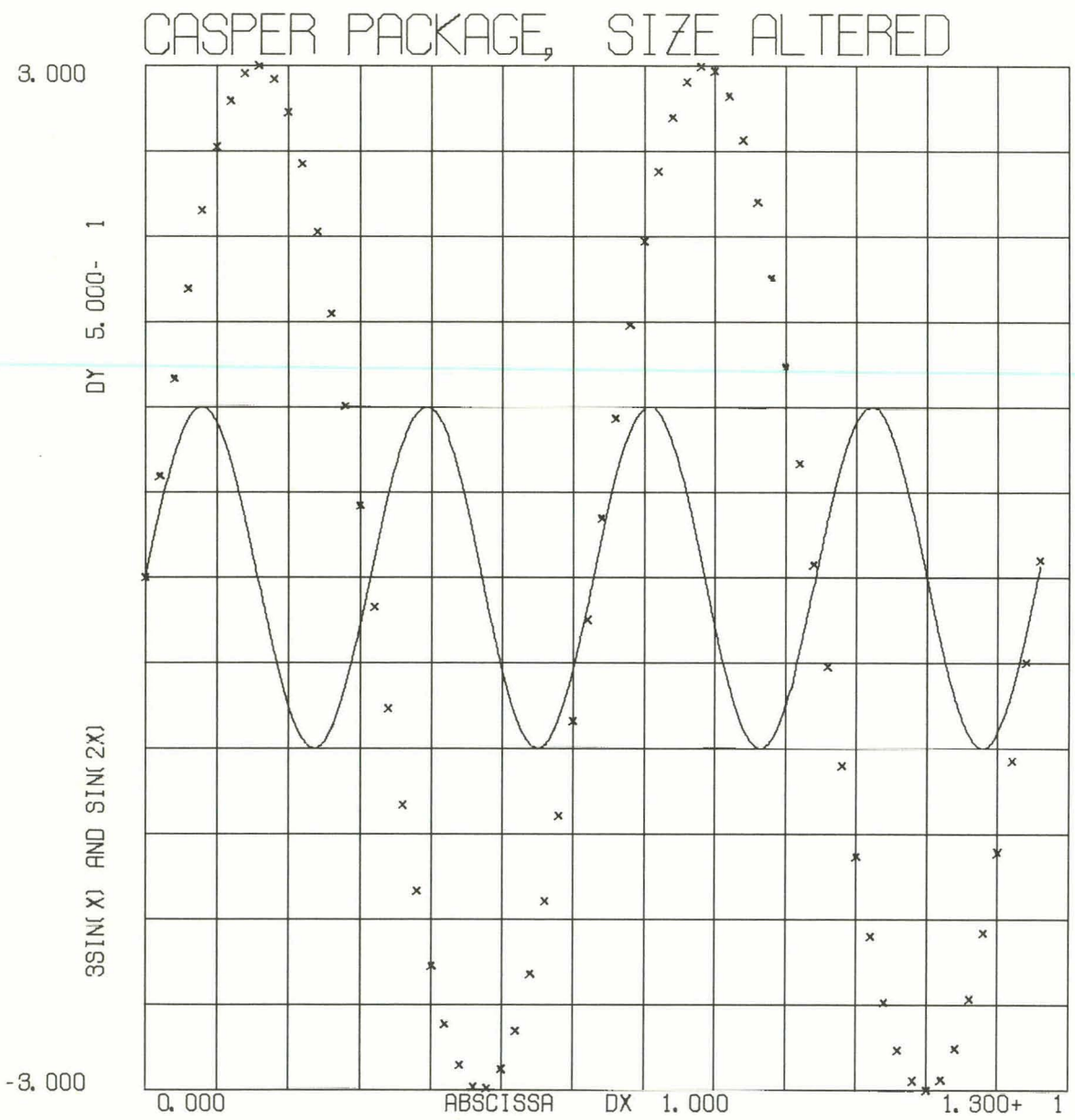
CASPER PACKAGE, SIZE ALTERED
3.000
DY 5.000- 1
3SIN(X) AND SIN(2X)
-3.000
0.000
ABSCISSA DX 1.000
1.300+ 1

Figure 4

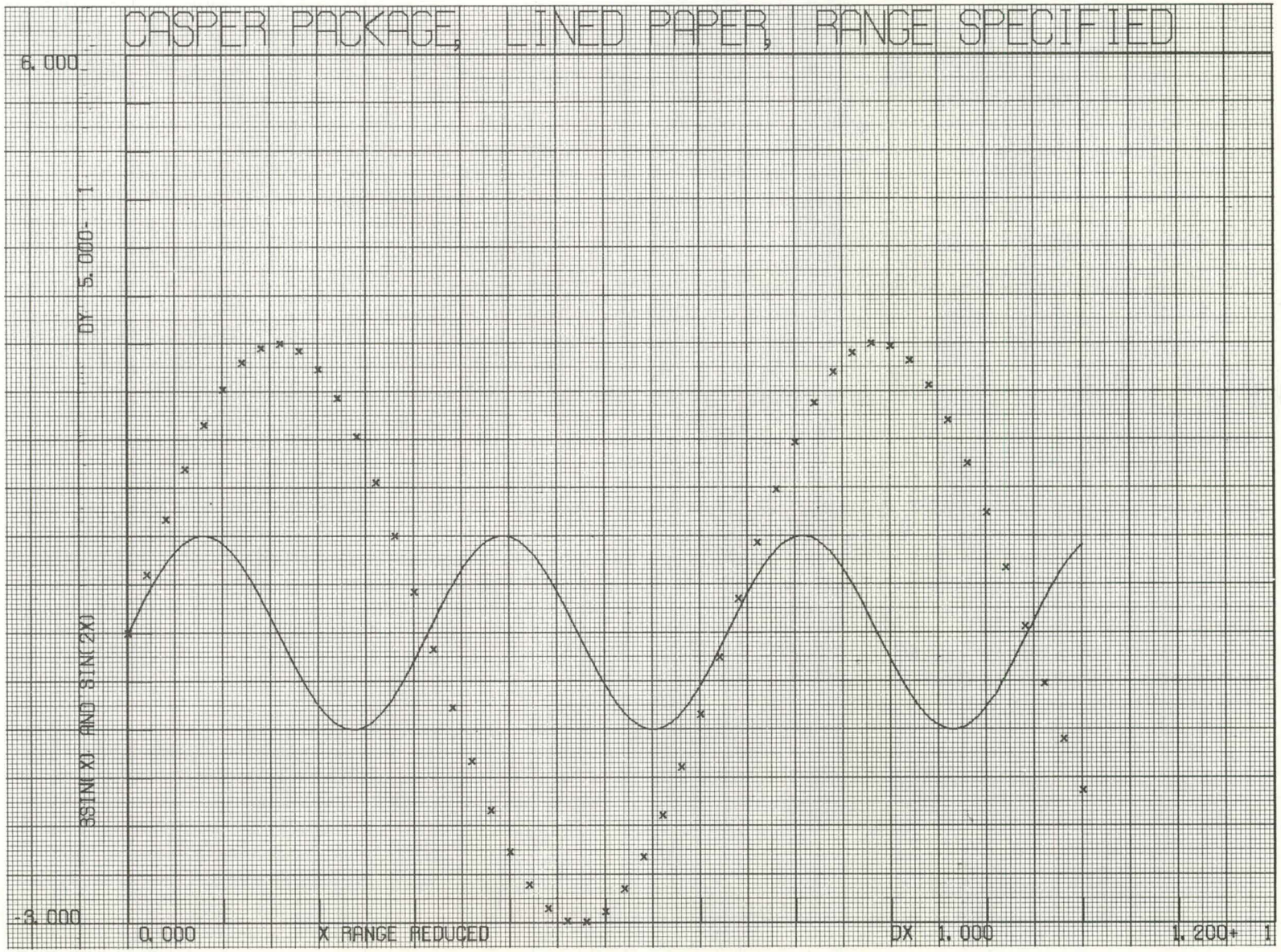
CASPER PACKAGE, LINED PAPER, RANGE SPECIFIED
6.000
DY 5.000
3SIN(X) AND SIN(2X)
-3.000
0.000
X RANGE REDUCED
DX 1.000
1.200+ 1

Figure 5

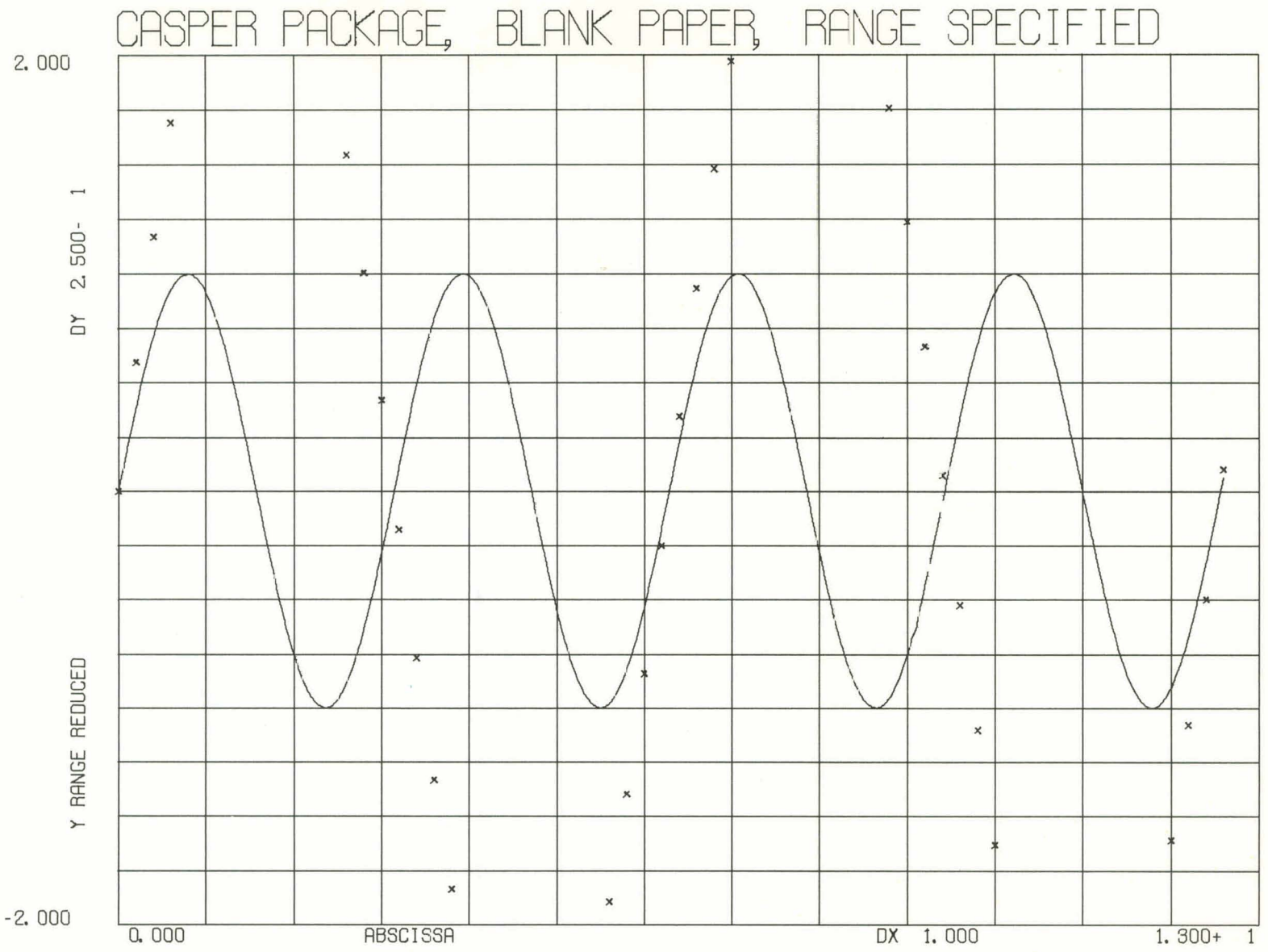
CASPER PACKAGE, BLANK PAPER, RANGE SPECIFIED
2.000
DY 2.500- 1
Y RANGE REDUCED
-2.000
0.000
ABSCISSA
DX 1.000
1.300+ 1

Figure 6

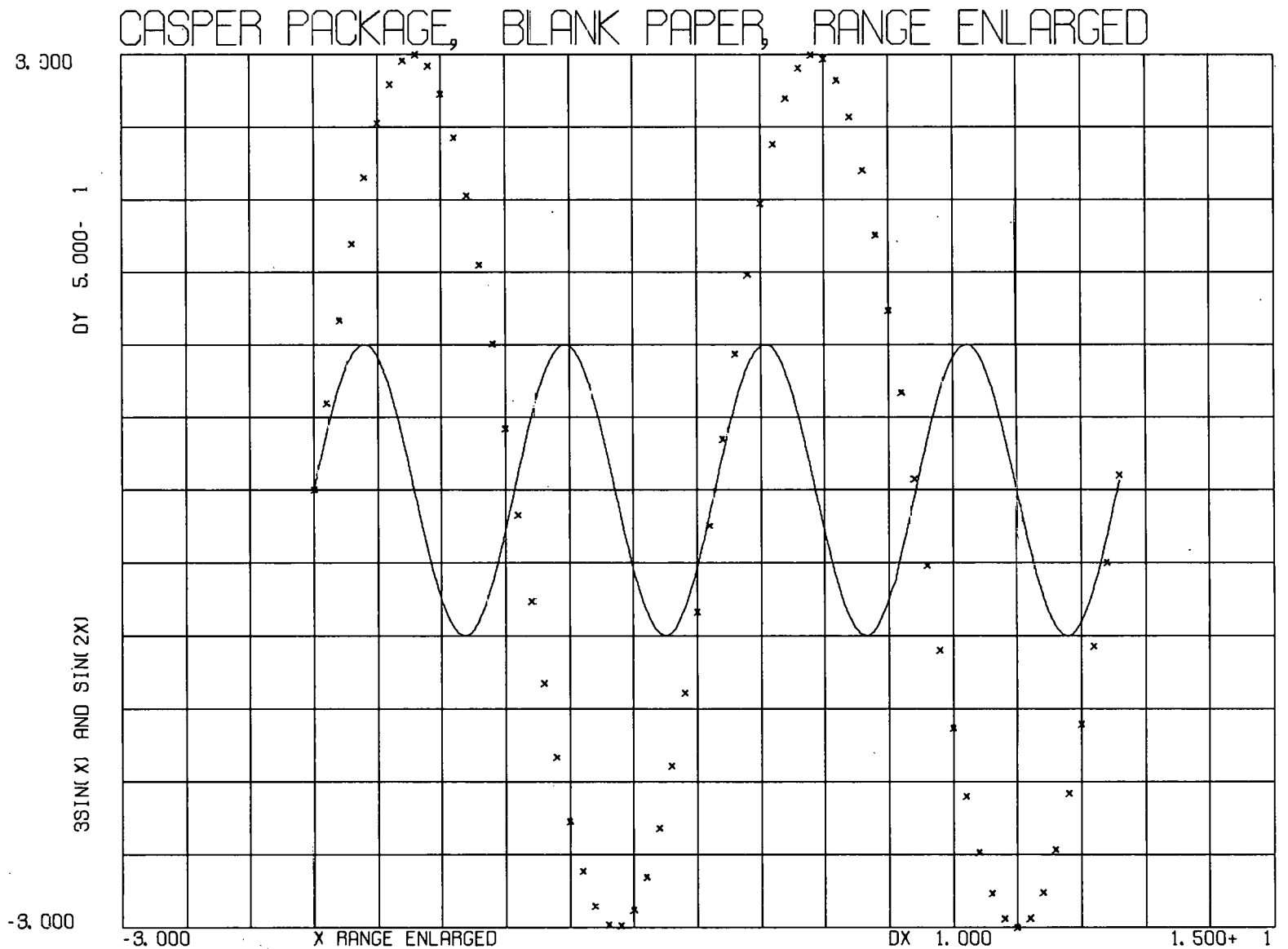
CASPER PACKAGE, BLANK PAPER, RANGE ENLARGED
3.000
DY 5.000- 1
3SIN(X) AND SIN(2X)
-3.000
-3.000
X RANGE ENLARGED
DX 1.000
1.500+ 1

Figure 7

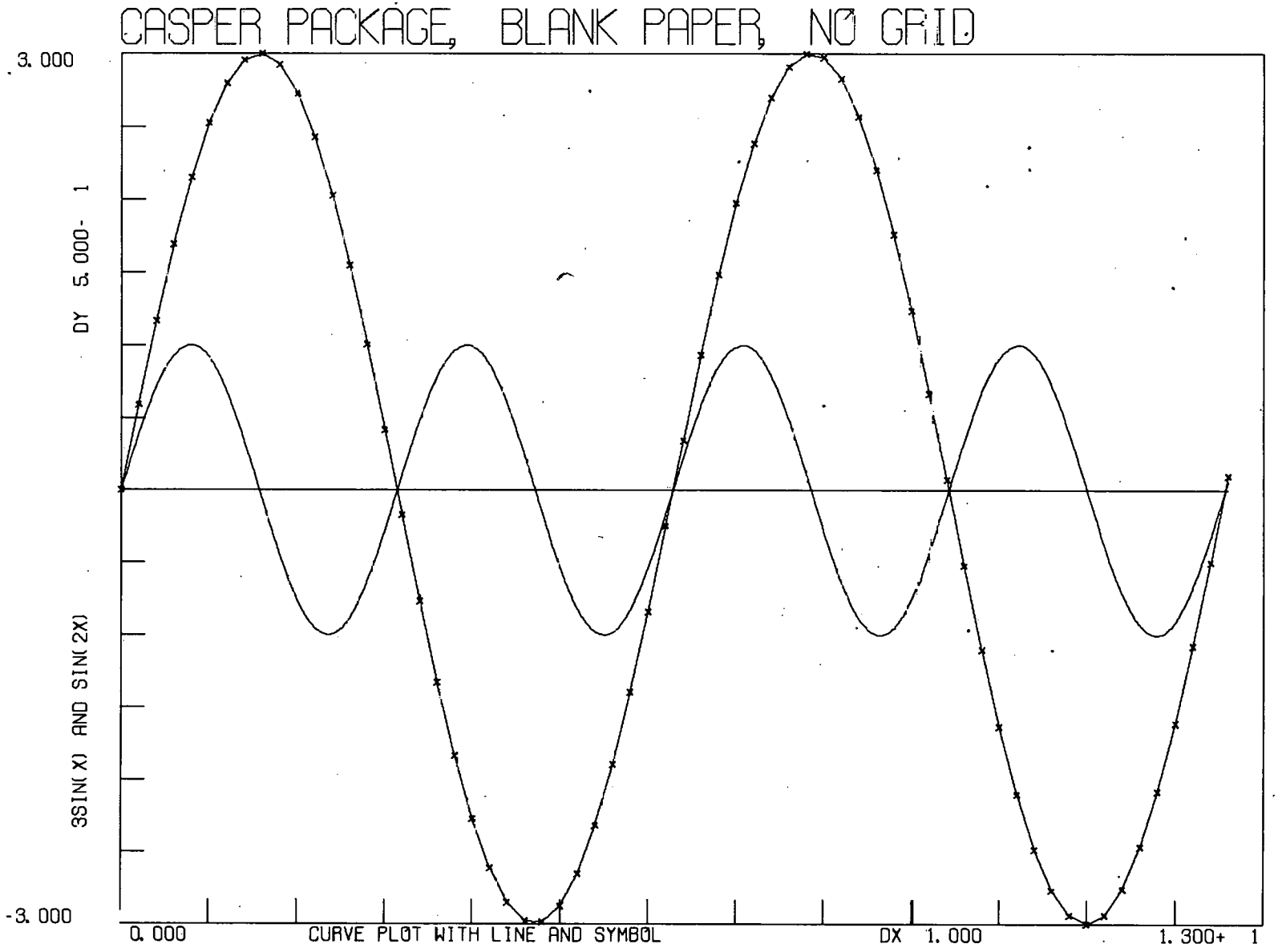
CASPER PACKAGE, BLANK PAPER, NO GRID
3.000
DY 5.000- 1
3SIN(X) AND SIN(2X)
-3.000
0.000
CURVE PLOT WITH LINE AND SYMBOL
DX 1.000
1.300+ 1

Figure 8

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