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TD3D

Drawing Three-Dimensional Things With Top Drawer

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I have found it difficult to define three-dimensional analogs of some of the operations performed by Top Drawer. I hope this note will induce some brave souls to try the new features, and to suggest additions and corrections. With enough experience, I hope to make Top Drawer work in three dimensions as easily as it does now in two.

Many commands in the vanilla version of Top Drawer, the one you are accustomed to using, work for three-dimensions as well as two. The default value for data input assumes only two dimensions. SET ORDER X Y Z or some other SET ORDER command with a Z in it is enough to specify three dimensions.

The TITLE command has not yet been modified at all. It is not yet possible to produce nifty STAR WARS pictures with text receding into the next galaxy.

Data Representation

There are two separate ways inside the program of holding data points. The first is used for any kind of data, and consists of n-tuples, with values for x, y, z, dx, dy, dz, and a symbol. Values are taken from data input, and the interpretation of the input lines is controled by the SET ORDER command, all in the usual way. Anything drawn using data in this form is treated as line segments, not surfaces, and will not mask or hide anything else in the picture. Hidden-line removal is not performed for plots of data in this form.

The second data form is the MESH, which consists of a number I of values along one axis, a number J of values along a second axis, and a number I*J of values along the third axis. MESH values can be entered using the READ MESH command. MESH data describes surfaces--hidden lines are removed from a plot, if possible. The only command which operates on MESH values at present is the JOIN command.

Hidden Lines

Structures described by MESH data are made of opaque surfaces, rather than lines, and when they are drawn, surfaces in the foreground can hide surfaces that lie behind them.

The method used to decide whether a line is visible or hidden behind some surface is essentially the same as is used by Bob Beach in the UD3DMS subroutine in the Unified Graphics System, and the U.G.S. manual contains references to the literature. It is not an exact method, but it is relatively inexpensive in its use of memory and cycles, and it is correct in many cases.

Basically, the method used is to start a horizon at the bottom of the page, and to look at each line in the picture, in the order of the lines' distance from the viewing position. Each line or part of a line that is below the current horizon is ignored, and each line or part that is above the horizon is drawn and the horizon moved up to that line.

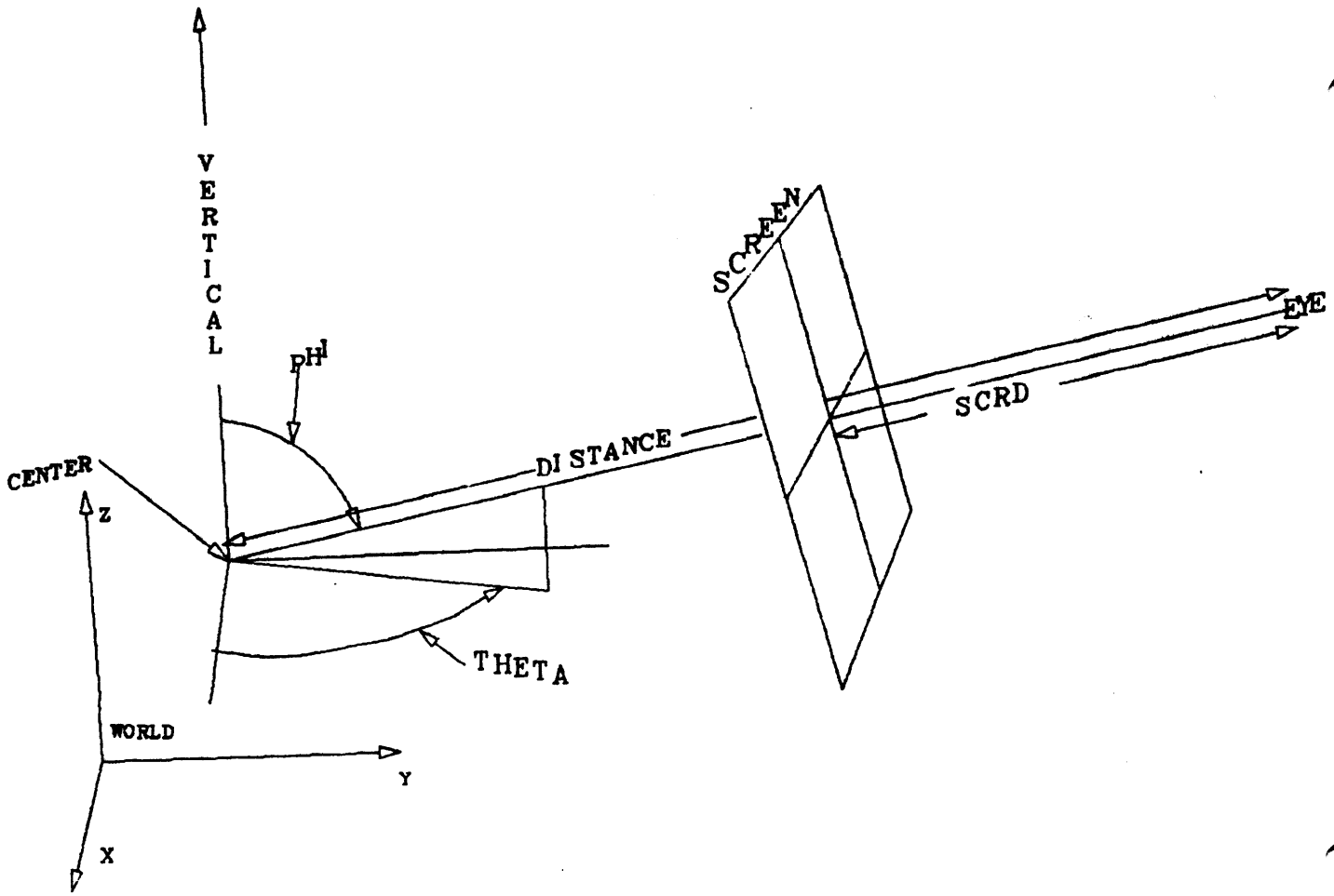
Careful consideration of this method will show that it cannot treat correctly the case of a viewpoint positioned "over" the structure being viewed, i.e. at phi near 0 or 180 degrees, nor can it work on overlapping structures, such as a data system which hides a set of coordinate axes. A more subtile effect, which is visible in some of the samples in this note, is that lines near the vertical may be treated as hidden, when in fact they should be visible. This may sometimes be corrected by moving the viewpoint far from the screen, e.g. by

SET THREE DISTANCE 400 SCRD 200

Coordinate Systems

The usual DATA system can now have three dimensions, called X, Y, and Z. Scaling can be any of the usual styles: linear, log, normal, months, user, etc., with any of the usual options for limits. The three axes in the DATA system map onto the three axes of the WORLD system, which is a box (a rectangular parallelopiped?) with default size 13 by 10 by 10 inches which floats somewhere in space. The WORLD system is viewed through the WINDOW, which is a rectangle on the screen or paper.

The size of the WORLD system and the relative positions of the WORLD system, the WINDOW, and the position of the viewer are set by the SET THREE command.



Commands

This is a fairly complete list of commands which affect 3-D plots in ways which are not obvious extensions of their 2-D function.

```
SET THREE  [OFF]
   [CENTER x y z]  [VERTICAL x y z]
   [DIRECTION x y z | [THETA theta]  [PHI phi] ]
   [DISTANCE d]  [SCRD scrd]
   [LEFT|RIGHT|MIDDLE|SEPARATION s]
   [WORLD x [BY] y [BY] z]
   [ORIGIN x y z]
```

CENTER gives the coordinates of a point in the WORLD system which will be projected to the center of the WINDOW. The default value is the center of the WORLD system.

VERTICAL gives a direction, not a point, in the WORLD system. A line in this direction starting at the CENTER point will be projected onto a vertical line in the WINDOW. The default value is the z-direction.

DIRECTION and (THETA, PHI) are two different ways of specifying the direction in the WORLD system from the CENTER point to the EYE.

PHI is the angle, in degrees, in the WORLD system, between the vertical axis and the line from the CENTER point, through the center of the window, to the viewing position. PHI is measured from 0 at the vertical through 90 in the horizontal plane, to 180 in the downwards direction. The default is 60 degrees.

THETA is the angle between the projections in the horizontal plane of the x-axis and the line to the viewing position. (If the x-axis is vertical, the z-axis is used instead.) The default is 60 degrees.

DIRECTION gives the direction in the WORLD system of the line from the CENTER point to the viewing position. The magnitude of the direction vector is irrelevant. (Irrelevant? I sought it vas a hypotenuse.)

DISTANCE is the distance from the CENTER point to the EYE. The default is 35 inches.

SCRD is the distance from the screen to the EYE. The default is 18 inches.

LEFT, MIDDLE, RIGHT, and SEPARATION all specify the distance between the true viewing point and the viewing axis. The true viewing point normally lies on the viewing axis, but for "stereo" viewing, the viewing axis corresponds to a point between the two eyes, with SEPARATION=0, and the two eye positions are slightly to the right and left. LEFT is the same as SEPARATION=-1.5 inches, and RIGHT is the same as SEPARATION=+1.5 inches. The default is SEPARATION=0.

WORLD sets the length of the WORLD axes. Lines in 3-space are not clipped ("scissored") at the edge of the world system. The default is 13 by 10 by 10 inches.

ORIGIN sets the position in the DATA system at which the three axes will intersect when the axes are drawn. (For MESH data, PLOT AXES is required to draw them.)

JOIN [X|Y|Z]

JOIN with no axis keyword, produces a wire-mesh drawing of MESH data. An axis keyword (X, Y, or Z) with the direction of an "independent" variable causes lines to be drawn only in the one direction.

The default JOIN level for non-MESH data is 1, meaning that a simple JOIN command will join pairs of data points with one straight line. A higher level may be specified in the usual way if you want smoother-looking curves.

PLOT AXES [AT x y z]

PLOT AXES draws axes. (Unlike the 2-D case, they are not drawn automatically.)

```
READ MESH [FOR] X = x1 x2 ... xn
   [FOR] Y = y1    Z = z11 z12 ... z1n
   [FOR] Y = y2    Z = z21 z22 ... z2n
     ...
   [FOR] Y = ym    Z = zm1 zm2 ... zmn
```

(Any permutation of X, Y, and Z may be used in this command. For simplicity, X and Y are shown as the two "independent" variables. This is all one command, and it may spill over into as many cards as you wish, although numbers and keywords within it may not cross a card boundary.)

This command allows you to enter n x-values, m y-values, and n*m z-values. In order to allow Top Drawer to remove hidden lines in drawing these values, the x- and y-values should be monotonic, either strictly increasing or strictly decreasing.

The storage allocated within Top Drawer for MESH data is 5150 words, so n+m+n*m must be less than 5150. This is adequate for a 50 by 100 plot, or 71 by 71.

Interesting plots in three dimensions seem to have a lot of data, and this command gets very cumbersome. I would appreciate suggestions or comments.

Batch Jobs Under OS

For any plots which do not involve the MESH data structure, the standard JCL will do it. You can use the #TOPDRAW PUBLIC execfile, or any JCL that has worked before.

For any plots involving a MESH, some extra subroutines must be loaded. You can get them by specifying TOPDRAW3 instead of TOPDRAW in the SYSLIN DD statement for the loader, e.g. by

```
//GO.SYSLIN  DD  DSN=WYL.CG.RBC.LOADMODS(TOPDRAW3),DISP=SHR
```

The #TOPDRAW PUBLIC execfile knows about this, and will make the change when it processes any input file with the word 'MESH' in it.

Interactive Jobs Under Orvyl

The program you get from Wylbur with the command CALL TOPDRAW is the equivalent of the above TOPDRAW routines, without the added code. It will process all Top Drawer commands except those which involve MESH data.

Due to errors in the Orvyl loader, I have been unable to install TOPDRAW3 consistently. Unless this is fixed I cannot make TOPDRAW3 available under Orvyl.

Fortran Calls in Batch Jobs

I have not yet decided on the calling sequences for the Fortran-callable version.

Three-D Under VM

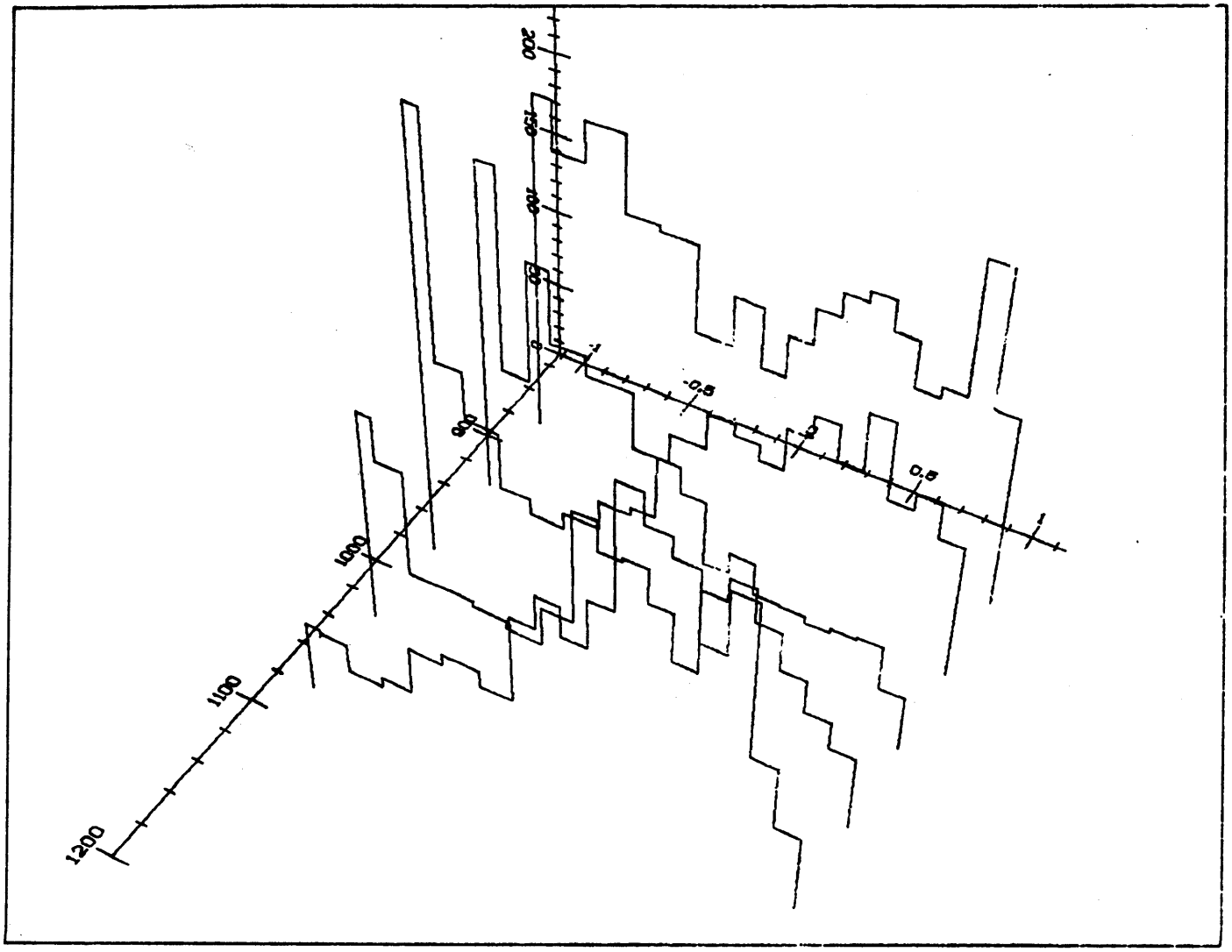
Not yet, not yet.

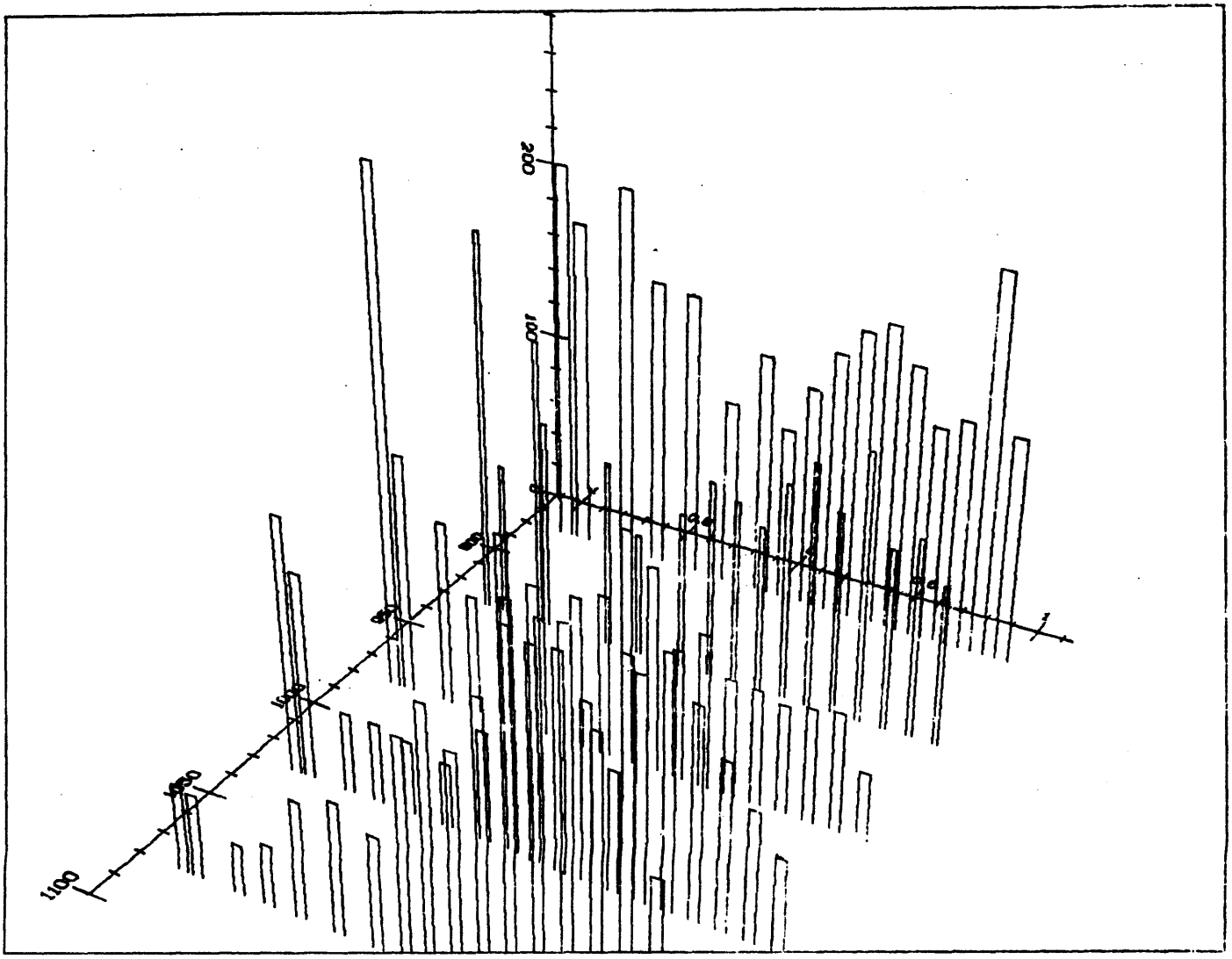
Examples

```
SET ORDER X Y Z       (ENERGY COSINE EVENTS)
SET LIMITS X FROM 830 TO 1200
SET LIM ZMAX 300
SET THREE PHI 45
SET SYMBOL 0P
880   -.93      216
880   -.85      186
880   -.65      211
880   -.51      164
880   -.36      161
880   -.19      106
880   -.05      138
880    .05       99
880    .15      126
880    .25      149
880    .35      164
880    .45      171
880    .55      152
880    .65      122
880    .75      129
880    .85      212
880    .95      127
SET SYMBOL 1P
930 -.92      213
930 -.84      86
930 -.68      162
930 -.65      117
930 -.38      105
930 -.25      69
930 -.07      88
930  .05      111
930  .15      104
930  .25      94
930  .35      121
930  .45      136
930  .55      113
930  .65      150
930  .75      101
930  .85      111
930  .95      89
SET SYMBOL 2P
980 -.93     279
980 -.87     132
980 -.70     102
980 -.58     66
980 -.45     56
980 -.30     66
980 -.15     84
980 -.04     89
980  .05     128
980  .15     112
```

```
980   .25     72
980   .35     85
980   .45     65
980   .55     64
980   .65     60
980   .75     63
980   .85     65
980   .95     37
SET SYMBOL 3P
1030 -.93     140
1030 -.87     112
1030 -.70     44
1030 -.58     44
1030 -.45     40
1030 -.30     35
1030 -.15     60
1030 -.04     134
1030  .05     115
1030  .15     117
1030  .25     95
1030  .35     63
1030  .45     118
1030  .55     133
1030  .65     112
1030  .75     88
1030  .85     67
1030  .95     50
SET SYMBOL 4P
1080 -.93     46
1080 -.87     44
1080 -.70     26
1080 -.58     32
1080 -.45     62
1080 -.30     69
1080 -.15     59
1080 -.04     115
1080  .05     136
1080  .15     117
1080  .25     148
1080  .35     225
1080  .45     207
1080  .55     195
1080  .65     151
1080  .75     190
1080  .85     93
1080  .95     53
HISTOGRAM POINTS 1 TO 17
HISTOGRAM POINTS 18 TO 34
HISTOGRAM POINTS 35 TO 52
HISTOGRAM POINTS 53 TO 70
HISTOGRAM POINTS 71 TO 88
NEW PLOT
BARGRAPH POINTS 1 TO 17
BARGRAPH POINTS 18 TO 34
```

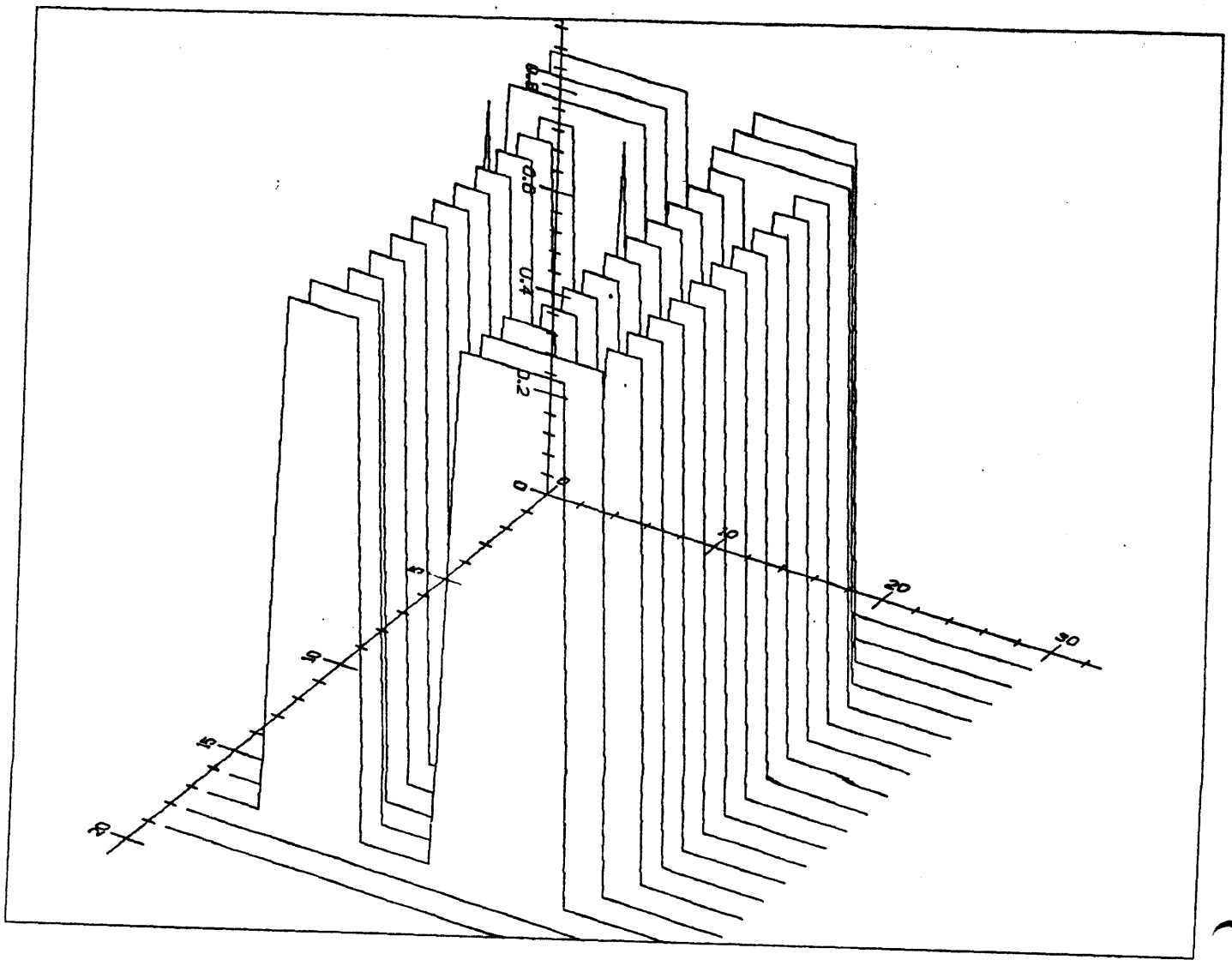
BARGRAPH POINTS 35 TO 52
BARGRAPH POINTS 53 TO 70
BARGRAPH POINTS 71 TO 88

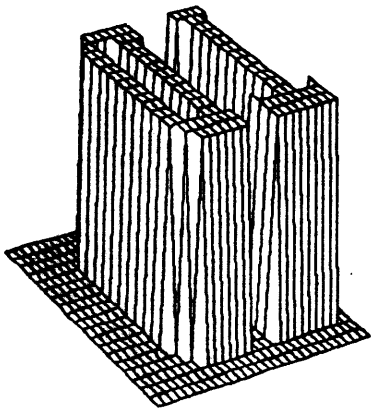



200
100
1400
1350
1300
1250
1200
1150
1100
1050
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0

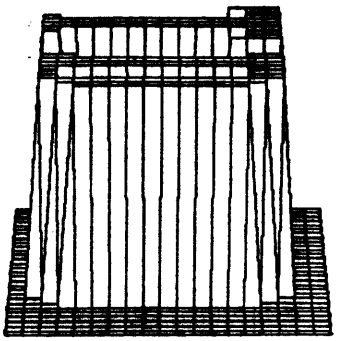
```
READ MESH
FOR Y=   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
         21 22 23 24 25
 X=0   Z=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 X=1   Z=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 X=2   Z=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 X=3   Z=0 0 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 0 0 0 0
 X=4   Z=0 0 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 0 0 0
 X=5   Z=0 0 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 0 0
 X=6   Z=0 0 1 0 0 1 1 1 0 0 1 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=7   Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=8   Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=9   Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=10  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=11  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=12  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=13  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=14  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 0 0 1 1 1 0 0
 X=15  Z=0 0 0 0 0 1 1 1 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 0 0
 X=16  Z=0 0 0 0 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0
 X=17  Z=0 0 0 0 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0 0
 X=18  Z=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 X=19  Z=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
SET THREE DISTANCE 400  SCRD 200
JOIN Y
PLOT AXES
NEW PLOT
HISTOGRAM
NEW PLOT
SET THREE DISTANCE 100
SET WINDOW X 1 OF 1.7 Y 1 OF 1.7
TITLE BOTTOM 'DEFAULT VIEW'
TITLE '(THETA=60)'
JOIN
SET WINDOW X 1.4 OF 1.7 Y 1 OF 1.7
TITLE BOTTOM 'THETA 200'
SET THREE THETA 200 DISTANCE 100
JOIN
SET WINDOW X 1.4 OF 1.7 Y 1.7 OF 1.7
TITLE BOTTOM 'THETA 0'
SET THREE THETA 0 DISTANCE 100
JOIN
SET WINDOW X 1 OF 1.7 Y 1.7 OF 1.7
TITLE BOTTOM 'THETA 300'
SET THREE THETA 300 DISTANCE 100
JOIN
NEW PLOT
SET THREE DISTANCE 100
SET WINDOW X 1 OF 1.7 Y 1 OF 1.7
TITLE BOTTOM 'DEFAULT VIEW'
TITLE '(PHI=60)'
JOIN
SET WINDOW X 1.4 OF 1.7 Y 1 OF 1.7
TITLE BOTTOM 'PHI 90'
```

```
SET THREE PHI 90 DISTANCE 100
JOIN
SET WINDOW X 1.4 OF 1.7 Y 1.7 OF 1.7
TITLE BOTTOM 'PHI 30'
SET THREE PHI 30 DISTANCE 100
JOIN
SET WINDOW X 1 OF 1.7 Y 1.7 OF 1.7
TITLE BOTTOM 'PHI 120'
SET THREE PHI 120 DISTANCE 100
JOIN
```

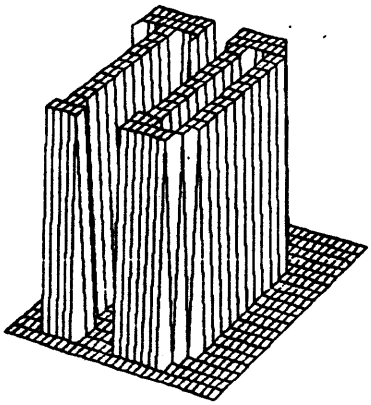




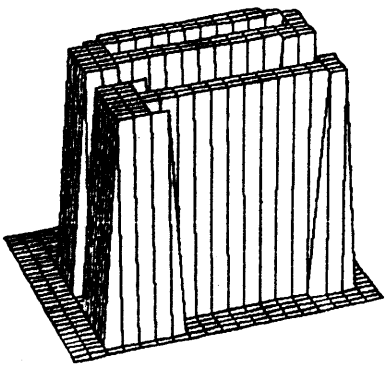
THETA 300



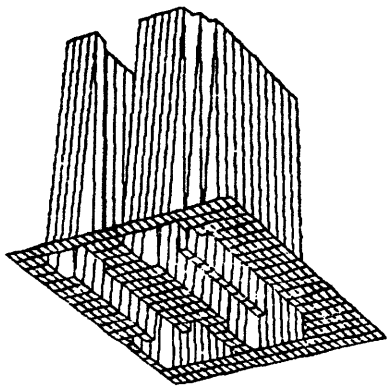
THETA 0



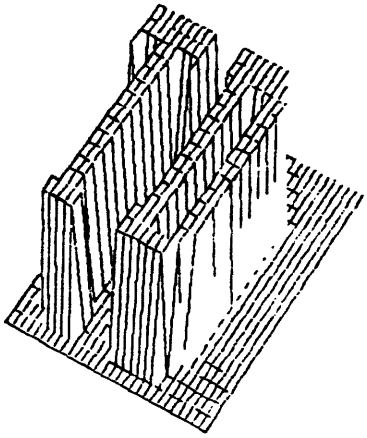
DEFAULT VIEW
(THETA=60)



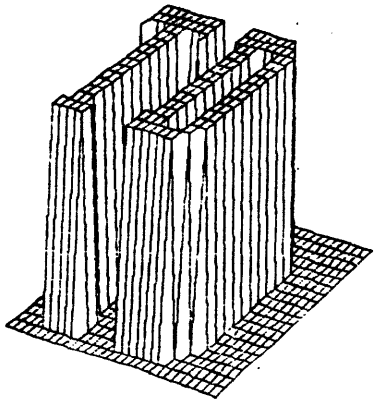
THETA 200



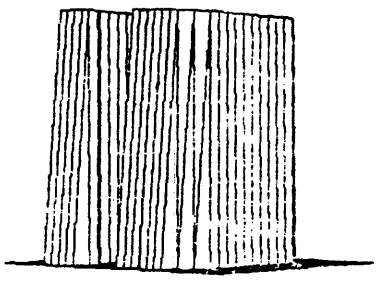
PHI 120



PHI 30



DEFAULT VIEW
(PHI=60)



PHI 90

```
READ MESH
FOR X=1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
FOR Y= -9. Z= 0.00615  0.00687  0.00766  0.00850  0.00938
              0.01025  0.01104  0.01168  0.01211  0.01225
              0.01211  0.01168  0.01104  0.01025  0.00938
              0.00850  0.00766  0.00687  0.00615  0.00551
FOR Y= -7. Z= 0.00766  0.00880  0.01014  0.01168  0.01340
              0.01524  0.01706  0.01866  0.01976  0.02016
              0.01976  0.01866  0.01706  0.01524  0.01340
              0.01168  0.01014  0.00880  0.00766  0.00668
FOR Y= -5. Z= 0.00938  0.01116  0.01340  0.01623  0.01976
              0.02404  0.02890  0.03378  0.03759  0.03906
              0.03759  0.03378  0.02890  0.02404  0.01976
              0.01623  0.01340  0.01116  0.00938  0.00796
FOR Y= -4. Z= 0.01025  0.01241  0.01524  0.01901  0.02404
              0.03067  0.03906  0.04854  0.05682  0.06024
              0.05682  0.04854  0.03906  0.03067  0.02404
              0.01901  0.01524  0.01241  0.01025  0.00858
FOR Y= -3. Z= 0.01104  0.01359  0.01706  0.02193  0.02890
              0.03906  0.05376  0.07353  0.09434  0.10417
              0.09434  0.07353  0.05376  0.03906  0.02890
              0.02193  0.01706  0.01359  0.01104  0.00912
FOR Y= -2. Z= 0.01168  0.01458  0.01866  0.02463  0.03378
              0.04854  0.07353  0.11628  0.17857  0.21739
              0.17857  0.11628  0.07353  0.04854  0.03378
              0.02463  0.01866  0.01458  0.01168  0.00956
FOR Y= -1. Z= 0.01211  0.01524  0.01976  0.02660  0.03759
              0.05682  0.09434  0.17857  0.38462  0.62500
              0.38462  0.17857  0.09434  0.05682  0.03759
              0.02660  0.01976  0.01524  0.01211  0.00984
FOR Y=  0. Z= 0.01225  0.01548  0.02016  0.02732  0.03906
              0.06024  0.10417  0.21739  0.62500  1.66667
              0.62500  0.21739  0.10417  0.06024  0.03906
              0.02732  0.02016  0.01548  0.01225  0.00994
FOR Y=  1. Z= 0.01211  0.01524  0.01976  0.02660  0.03759
              0.05682  0.09434  0.17857  0.38462  0.62500
              0.38462  0.17857  0.09434  0.05682  0.03759
              0.02660  0.01976  0.01524  0.01211  0.00984
FOR Y=  2. Z= 0.01168  0.01458  0.01866  0.02463  0.03378
              0.04854  0.07353  0.11628  0.17857  0.21739
              0.17857  0.11628  0.07353  0.04854  0.03378
              0.02463  0.01866  0.01458  0.01168  0.00956
FOR Y=  3. Z= 0.01104  0.01359  0.01706  0.02193  0.02890
              0.03906  0.05376  0.07353  0.09434  0.10417
              0.09434  0.07353  0.05376  0.03906  0.02890
              0.02193  0.01706  0.01359  0.01104  0.00912
FOR Y=  4. Z= 0.01025  0.01241  0.01524  0.01901  0.02404
              0.03067  0.03906  0.04854  0.05682  0.06024
              0.05682  0.04854  0.03906  0.03067  0.02404
              0.01901  0.01524  0.01241  0.01025  0.00858
FOR Y=  5. Z= 0.00938  0.01116  0.01340  0.01623  0.01976
              0.02404  0.02890  0.03378  0.03759  0.03906
              0.03759  0.03378  0.02890  0.02404  0.01976
              0.01623  0.01340  0.01116  0.00938  0.00796
```

```
FOR Y=   6. Z= 0.00850   0.00994   0.01168   0.01377   0.01623
               0.01901   0.02193   0.02463   0.02660   0.02732
               0.02660   0.02463   0.02193   0.01901   0.01623
               0.01377   0.01168   0.00994   0.00850   0.00732
FOR Y=   8. Z= 0.00687   0.00778   0.00880   0.00994   0.01116
               0.01241   0.01359   0.01458   0.01524   0.01548
               0.01524   0.01458   0.01359   0.01241   0.01116
               0.00994   0.00880   0.00778   0.00687   0.00608
FOR Y=  10. Z= 0.00551   0.00608   0.00668   0.00732   0.00796
               0.00858   0.00912   0.00956   0.00984   0.00994
               0.00984   0.00956   0.00912   0.00858   0.00796
               0.00732   0.00668   0.00608   0.00551   0.00499
SET THREE THETA -30 PHI 60
JOIN
PLOT AXES
NEW PLOT
JOIN X
NEW PLOT
SET THREE LEFT
SET WINDOW X 1 OF 2
JOIN Y
PLOT AXES
SET THREE RIGHT
SET WINDOW X 1.6 OF 2
JOIN Y
PLOT AXES
```