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QUICKLITE 1:
A DAYLIGHTING PROGRAM
FOR THE TI-59 CALCULATOR

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QuickLite I

ABSTRACT

This paper presents a set of daylighting programs that can be run on a TI-59 hand calculator. The paper gives the program listings, the step-by-step procedures for using the programs, worksheets, and a worked sample problem.

The programs calculate interior horizontal illumination levels or daylight factors from a window. The user can specify the location of the calculation point, or, if a printer is available, the locations of a grid of points. Calculations can be performed for both CIE clear and overcast sky conditions.

The direct sky component calculation uses Rivero's approximation for window transmission. The interreflected component calculation uses a split-flux approximation.

INTRODUCTION

Daylighting is now considered one of the most promising energy conservation strategies for nonresidential buildings. Although substantial savings in both electrical energy and peak power demand are possible, potential savings may not be achieved given the present state of daylighting design procedures. A major obstacle to the effective utilization of daylighting is the lack of accurate and simple procedures for daylighting design and analysis.

Three types of design tools have been used to predict interior daylight illumination: scale models, graphic techniques, and calculations. A detailed discussion of the strengths and limitations of each is beyond the scope of this paper; we focus here on computational approaches.

Calculations can provide a fast and accurate assessment of illumination levels for typical room and glazing design. Present procedures for calculating daylight illumination can be divided into two categories: simplified procedures, which often make simplifications and assumptions that may reduce flexibility and accuracy, and large-scale computer programs, which, although they may be more flexible and accurate, require the preparation of detailed input data and access to computers or time-sharing computer facilities. There is a need for a calculation procedure that combines the speed, low cost, and ease of the simplified methods with the flexibility and accuracy of the large computer models. This paper describes a calculation procedure, using a programmable hand calculator, that is a major step toward that goal.

QUICKLITE 1 PROGRAM DESCRIPTION

Quicklite 1 will predict daylight illumination at any point within a room. The methodology and algorithms used in the development of this program are documented in a previous paper.[1] Further details and additional program capabilities will be described in a later publication.[2]

The program utilizes the CIE sky luminance distribution functions for the overcast and clear skies.[3,4] The light reaching the interior point being considered is separated into two components. Light arriving directly from the sky (Sky Component or SC) is calculated using a source area formula. Light reflected from external and internal surfaces (Reflected Component or RC) is calculated using the split flux approach. The total for these two components is given as either the daylight factor (the ratio of illumination at the reference point to illumination on a horizontal surface from the unobstructed sky) or illumination (in footcandles) for the point(s) being considered. This paper describes the use of the program to calculate daylight illumination for a simple window without obstructions or sun-control devices. The program can also be used to solve more complex daylighting problems; however, the length of this paper limits their inclusion. Solutions to these problems are described in reference 2.

Quicklite 1 has been designed to be accurate, simple, and relatively fast-running. The output compares well with other daylighting calculation procedures as well as with a series of physical scale-model measurements. However, it must be remembered that no calculation procedure, no matter how accurate, can duplicate all the complexities that daylighting poses. In most cases we seek comparative performance levels rather than absolute quantitative results. We must also remember that the non-quantifiable aspects of lighting design are equally important and that nothing can substitute for good design judgment.

I: SKY COMPONENT PROGRAM: This program uses the TI-59's master library. If multiple point calculations are desired for a single program execution, the PC-100 printer must be used.

Step 1: Repartition the calculator memory by entering 5 and then pressing 2nd OP 17.

Step 2: Determine if sky condition is clear or overcast, then read appropriate program into calculator. The clear sky program will require reading sides 1, 2, and 3, while the overcast sky program requires reading only sides 1 and 2.

Step 3: a) Enter window transmission at normal incidence (90° to the plane of the window).

NOTE: Steps (3b-3e) should be executed only for the clear sky program.

b) Enter the normalization factor (N_{sc}) which is the ratio of illumination on a horizontal plane to the luminance at the zenith. This factor is a function of solar altitude and is given as follows:

Solar Altitude	N_{sc}
10°	3.654
20°	3.565
30°	3.235
40°	2.741
50°	2.178
60°	1.632
70°	1.159
80°	0.782
90°	0.503

c) Enter window azimuth angle (in degrees), which is the angle that a line normal to a vertical window makes with south (which is taken to be 0°). Clockwise rotation from south is measured as positive while counter-clockwise rotation is measured as negative. (See Figure 1)

d) Enter solar azimuth angle (in degrees), which is the azimuthal angle of the sun from south. Here again clockwise rotation from south is measured as positive while counter-clockwise rotation is measured as negative. (See Figure 1)

NOTE: This program does not compute the effect of direct sun in the room. There will be direct sun at some point in the room for an obstructed window if the absolute value of the difference between the window azimuth and solar azimuth is less than 90°.

e) Enter solar altitude (in degrees from horizontal). (See Figure 1.)

Step 4: Enter the location and size of the window and the workplane height at which illumination is to be calculated. A rectangular coordinate system is used to locate the window as well as the calculation point(s) (see Figure 2). The origin of this coordinate system should be placed at the lower left-hand corner of the window-wall's interior face. When facing the window from the interior of the room, the X-axis will run along the floor perpendicular to the window-wall. The Y-axis will run to the right, along the intersection of the floor and the window-wall. The Z-axis will point straight up. The location and size of the window is described by four values: Y_{left} and Y_{right} represent the respective distances of the left- and right-hand sides of the window from the Z-axis, Z_{bottom} and Z_{top} represent the respective distances of the bottom and top of the window from the floor. Finally, the height of the calculation point(s) above the floor (Z_p) must be determined. For most office tasks Z_p is assumed to be 2.5 feet. Figure 2 illustrates these relationships.

Step 5: Determine if the output is to be calculated in units of daylight factor or illumination. To calculate the daylight factor, the number 1 must be stored in register 35. To calculate illumination, the appropriate horizontal illumination from the sky (E_{sky}) must be stored in register 35. This value can be found in Figure 36A, B, C, or D in the IES Recommended Practice of Daylighting,[5] in reference 2, or can be taken from any other source of measured or calculated illumination data.

NOTE: To calculate values for a single point, proceed to steps 6a and 7a. If a printer is available, multiple points on a rectangular grid may be calculated and printed by proceeding to steps 6b and 7b.

Single Point Procedure:

Step 6a: Enter the location of the point at which the daylight factor or illumination calculation is to be made. Y_p is the distance from the measurement point to the wall to the left of the window. X_p is the distance from the measurement point to the window-wall. (See Figure 2)

Step 7a: Calculate the sky component by pressing 2nd B'.

Multiple Point Procedure:

Step 6b: Enter the corner locations of the rectangular grid of calculation points. Y_{min} and Y_{max} are, respectively, the distances from the wall at the left of the window to the closest and the farthest columns of calculation points. X_{min} and X_{max} are, respectively, the distances from the window-wall to the closest and the farthest rows of calculation points. (See Figure 2) Finally, the number of calculation points for the Y-column (N_y), and X-row (N_x), must be determined. N_y and N_x include the corner points and thus must be greater than or equal to two. Setting N_y or N_x to one will result in a "divide by zero" error.

Step 7b: Calculate the sky component values by pressing 2nd D'. Run time for this option is approximately 1.2 minutes per point for overcast sky and 3 minutes per point for the clear sky.

General Notes: Sky Component Program

1) It is unnecessary to re-enter all the input data for repeated calculations. Only those input values entered in step 6a or 6b must be re-entered to rerun the program. All other input values need to be changed only if their new values differ from those used in the previous run.

2) All inputs that relate to distance (such as width of the window) may be entered in any unit, English or metric, so long as the user is consistent.

3) If a printer is being used, it is highly advisable to make a list of the register contents before running the program. To obtain a permanent list of the data registers, enter 30 and then press INV LST before executing step 7a or 7b. (For register assignments see Figure 6.)

4) Figure 4 summarizes the steps required to enter and run the Sky Component program.

REFLECTED COMPONENT PROGRAM: This program used the TI-59's master library. The PC-100 printer is optional.

Step 1: Repartition the calculator memory by entering 3 and then pressing 2nd OP 17.

Step 2: The reflected component requires reading sides 1 and 2.

Step 3: Enter window width and height.

Step 4: Enter room width, depth, and height plus the height of the window sill above the floor.

Step 5: Enter normal incidence window transmission.

Step 6: Enter reflectance of ceiling, floor, glass and walls as well as exterior ground.

NOTE: There are four options for output from this program. The appropriate option must be chosen from steps 7a, b, c, or d.

Step 7a: To calculate the daylight factor from the reflected component under an overcast sky, enter the window factor (f_s). The window factor is the ratio of the light flux entering the window from the sky to the light flux on an exterior horizontal plane. For an unobstructed sky $f_s = .39$.

Step 7b: To calculate the illumination level from the reflected component under an overcast sky, enter the window factor (f_s) as in step 7a and the horizontal illumination from the sky (E_{sky}), which can be found from Figure 36A in reference 5.

Step 7c: To calculate the daylight factor from the reflected component under a clear sky, enter the window factor (f_s), the horizontal illumination from the sky (E_{sky}) from Figure 36B, C, or D in reference 5, and the horizontal illumination from the sun

(E_{sun}) from Figure 37A in reference 5. The window factor for a clear sky is a function of solar altitude as well as of window azimuth from the sun and is given below.

Solar Altitude	Window Azimuth from Sun 0°	45°	90°	135°	180°
10°	.68	.65	.50	.35	.32
20°	.72	.67	.50	.33	.28
30°	.73	.70	.50	.30	.27
40°	.74	.69	.50	.31	.26
50°	.73	.68	.50	.32	.27
60°	.70	.66	.50	.34	.30
70°	.66	.62	.50	.38	.34
80°	.59	.56	.50	.44	.41
90°	.50	.50	.50	.50	.50

Step 7d: To calculate the illumination level from the reflected component under a clear sky, proceed as in step 7c, but a different label is pressed for the resulting answer.

General Notes: Reflected Component

1) A single average value for the reflected component is computed for the entire room.

2) It is unnecessary to re-enter all the input data for repeated calculations. Change only those values entered in steps 3 through 6 that differ from the previous run. Then execute the program beginning at step 7.

3) If a printer is being used, it is highly advisable to make a list of the register contents before running the program. To obtain a permanent record of the data registers, enter 15 and then press INV LST before executing step 7. (For register assignments see Figure 7.)

4) Figure 5 summarizes the steps required to enter and run the Reflected Component program.

SAMPLE PROBLEM

Calculate the illumination for the room shown in Figure 3, which is

30 feet wide, 20 feet deep, and 8.67 feet high and which has one large window, 5 feet high by 28 feet wide. The window is 2 feet above the floor and centered on a wall facing due west. Glazing consists of two layers of 1/4 inch clear glass having a combined normal daylight transmission of 78%. The ceiling has a reflectance of 80%, the floor 20%, the wall 50%, and the glass 14%.

Illumination is to be calculated under both clear and overcast conditions. The sun is assumed to be due south at an altitude of 40°. The horizontal illumination from the sky (E_{sky}) is 1400 footcandles under overcast sky conditions (from Figure 36A in reference 5) and 1200 footcandles under clear sky conditions (from Figure 36C in reference 5). The horizontal illumination from the sun (E_{sun}) is 4800 footcandles (from Figure 37A in reference 5). Finally, a three-by-three calculation grid (9 calculation points) was selected, each edge of the grid being five feet from the nearest wall. (See Figure 3)

The sky component program for both clear and overcast skies was run first. Figure 6 shows the sample input and output from this example in which both the data register contents and results are identified. The reflected component program for both sky conditions were then run. Figure 7 shows the sample input and output from this run; here again data register contents and results have been identified. Finally, the sky component and reflected component values were added to determine overall illumination values. Results from the overcast sky example are shown in Figure 8. Notice that the illumination is symmetric about the center line of the room as expected. Results for the clear sky example are given in Figure 9. Here the change in sky luminance with azimuth results in an asymmetrical illumination distribution across the room. In each case the reflected component is calculated as an average value throughout the room. This approximation will generally result in an overestimate of daylight illumination in the back of the room. Comparison between reflected component results from the average value approach described here, and a more detailed calculation is given in reference 2.

CONCLUSION

A relatively accurate, simple, and fast procedure for calculating interior daylight illumination has been presented. It is hoped that the application of this procedure will encourage the use of daylighting, placing it in a proper relationship to other design considerations. A lengthier version of this paper that includes a detailed program description, user instructions, and several worked examples (which include external obstructions, overhangs, direct sun in room, etc.) will be available from the authors at the address below. This calculation procedure is one of several daylighting design tools now under development as part of the LBL/DOE Daylighting Program. For information on the availability of other daylighting design tools, write to:
Windows and Daylighting Program, Lawrence Berkeley Laboratory,
Building 90, Room 3111, Berkeley, California 94720.

ACKNOWLEDGEMENTS

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2. Bryan, H.J., Clear, R.C., Rosen, J., and Selkowitz, S., Quicklite 1 Users Manual." (To be published as an LBL report.)

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4. CIE Technical Committee 4.2, "Standardization of Luminance Distribution on Clear Skies," CIE PUBLICATION No. 22, Commission Internationale de l'Eclairage, Paris, 1973.

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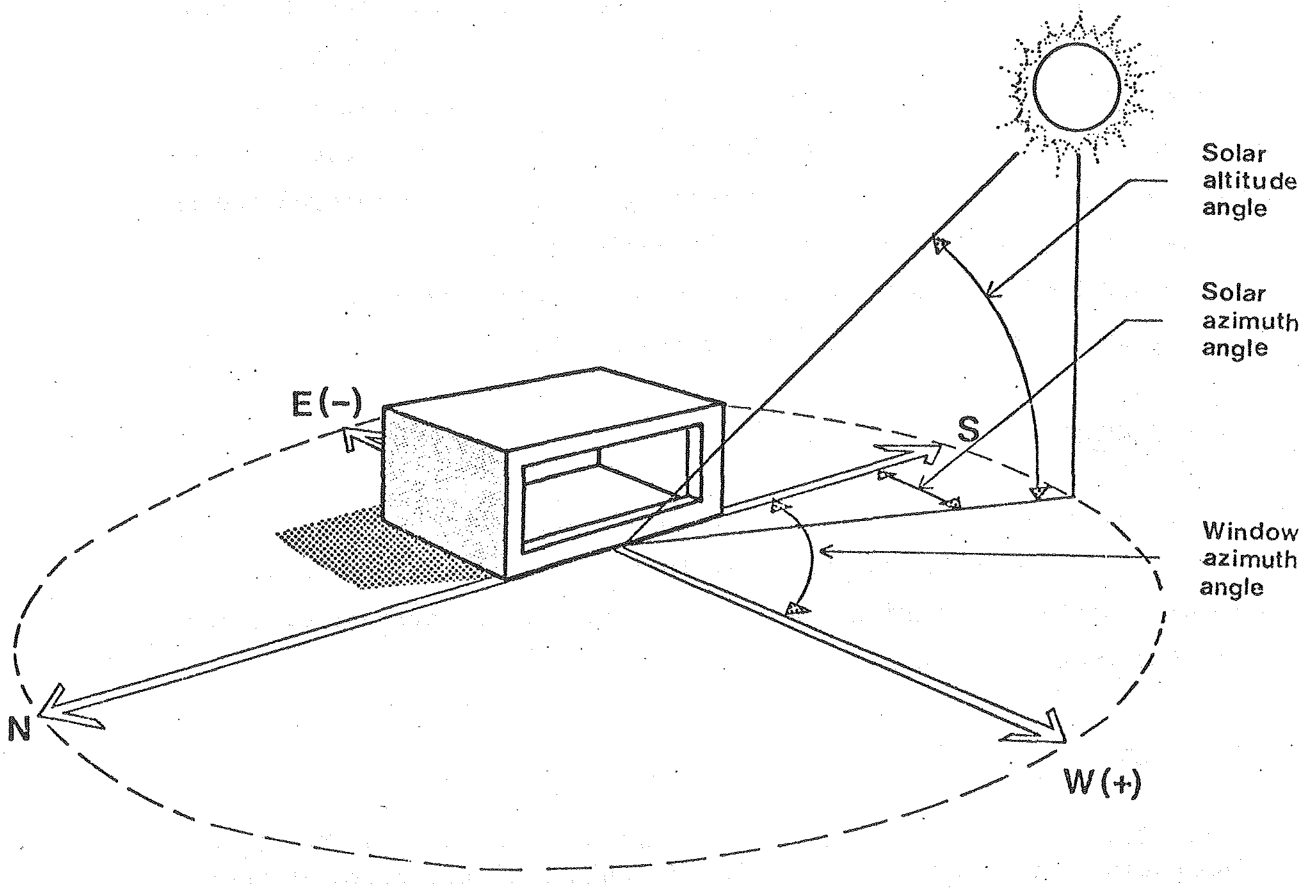

FIGURE 1. SITE COORDINATE SYSTEM FOR PROGRAM

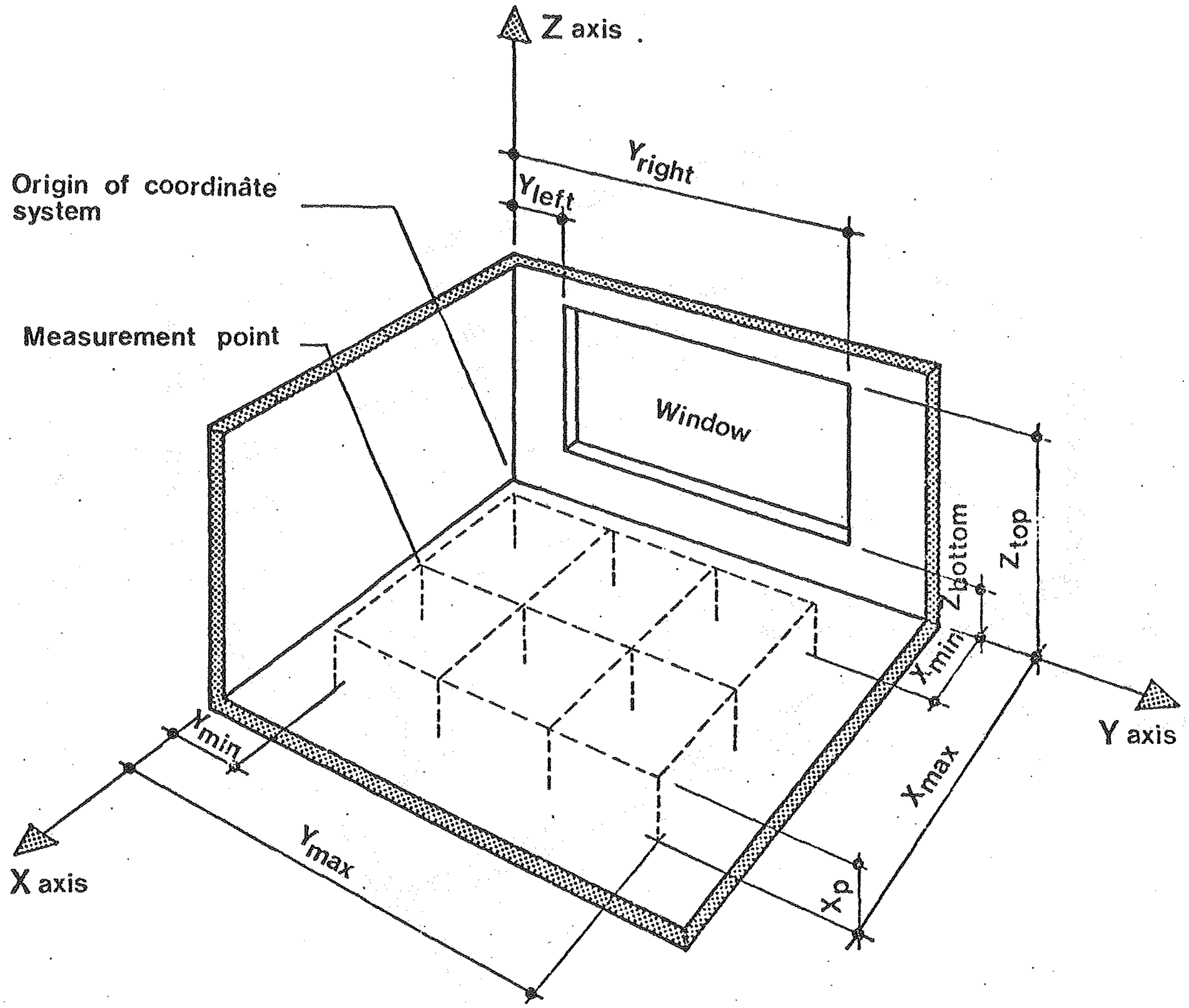

FIGURE 2. ROOM COORDINATE SYSTEM FOR PROGRAM

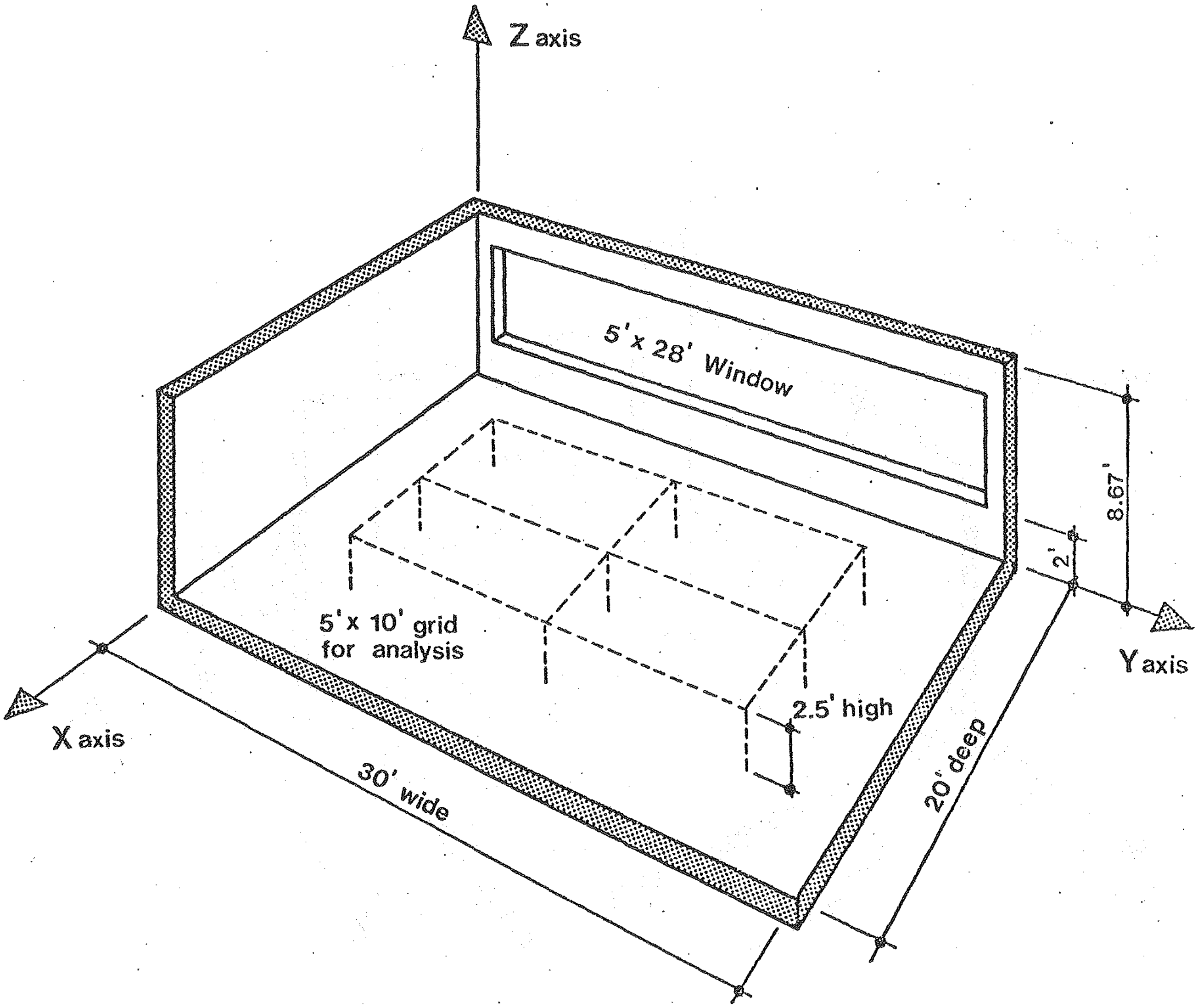

FIGURE 3. EXAMPLE ROOM

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Repartition calculator	5	2nd OP 17	559.49
2	Clear Sky: Read sides 1, 2 & 3	1,2,3	2nd INV WRITE	1,2,3
	Overcast Sky: Read sides 1 & 2	1,2	2nd INV WRITE	1,2
3a	Enter Window Transmission	T_o	A	$1.018T_o$
Note:	Steps 3b-3e should be executed for clear sky only			
3b	Enter Normalization Factor	N_{sc}	R/S	N_{sc}
3c	Enter Window Azimuth (in degrees)	AZ_{window}	R/S	AZ_{window}
3d	Enter Solar Azimuth (in degrees)	AZ_{solar}	R/S	AZ_{solar}
3e	Enter Solar Altitude (in degrees)	ALT_{solar}	R/S	ALT_{solar}
4	Enter Y_{left}	Y_{left}	STO 30	Y_{left}
	Enter Y_{right}	Y_{right}	STO 31	Y_{right}
	Enter Z_{bottom}	Z_{bottom}	STO 32	Z_{bottom}
	Enter Z_{top}	Z_{top}	STO 33	Z_{top}
	Enter Z_p	Z_p	STO 34	Z_p
5	To calculate Daylight Factor: Enter 1 To calculate Illumination: Enter E_{sky}	1 or E_{sky}	STO 35	1 or E_{sky}
Note:	For Single Point Calculation:			
6a	Enter Y_p	Y_p	STO 36	Y_p
	Enter X_p	X_p	STO 37	X_p
7a	Run Program	–	2nd B'	S.C.
Note:	For Multiple Point Calculations:			
6b	Enter Y_{min}	Y_{min}	STO 38	Y_{min}
	Enter Y_{max}	Y_{max}	STO 39	Y_{max}
	Enter X_{min}	X_{min}	STO 40	X_{min}
	Enter X_{max}	X_{max}	STO 41	X_{max}
	Enter number of points along Y axis	N_y	STO 42	N_y
	Enter number of points along X axis	N_x	STO 43	N_x
7b	Run Program	–	2nd D'	S.C.

FIGURE 4. SKY COMPONENT PROGRAM WORKSHEET

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Repartition calculator	3	2nd OP 17	719.29
2	Read sides 1 & 2	1,2	2nd INV WRITE	1,2
3	Enter Window Width	Width_{win}	STO 15	Width_{win}
	Enter Window Height	Height_{win}	STO 16	Height_{win}
4	Enter Room Width	Width_{rm}	STO 17	Width_{rm}
	Enter Room Depth	Depth_{rm}	STO 18	Depth_{rm}
	Enter Room Height	Height_{rm}	STO 19	Height_{rm}
	Enter Window Sill Height	Height_{sill}	STO 20	Height_{sill}
5	Enter Window Transmission	T_o	STO 21	T_o
6	Enter Ceiling Reflectance	ceiling	STO 22	ceiling
	Enter Floor Reflectance	floor	STO 23	floor
	Enter Glass Reflectance	glass	STO 24	glass
	Enter Wall Reflectance	wall	STO 25	wall
	Enter Ground Reflectance	ground	STO 26	ground
7a	Daylight Factor for an overcast sky:			
	Enter Window Factor	f_s	STO 27	f_s
	Run Program	—	A	R.C.
7b	Illumination for an overcast sky:			
	Enter Window Factor	f_s	STO 27	f_s
	Enter Illumination from sky	E_{sky}	STO 28	E_{sky}
	Run Program	—	B	R.C.
7c	Daylight Factor for a clear sky:			
	Enter Window Factor	f_s	STO 27	f_s
	Enter Illumination from sky	E_{sky}	STO 28	E_{sky}
	Enter Illumination from sun	E_{sun}	STO 29	E_{sun}
	Run Program	—	C	R.C.
7d	Illumination for a clear sky:			
	Enter Window Factor	f_s	STO 27	f_s
	Enter Illumination from sky	E_{sky}	STO 28	E_{sky}
	Enter Illumination from sun	E_{sun}	STO 29	E_{sun}
	Run Program	—	D	R.C.

FIGURE 5. REFLECTED COMPONENT PROGRAM WORKSHEET

	OVERCAST SKY		CLEAR SKY	
VARIABLE	INPUT	MEMORY #	INPUT	MEMORY #
Y_{left}	1.	30	1.	30
Y_{right}	29.	31	29.	31
Z_{bottom}	2.	32	2.	32
Z_{top}	7.	33	7.	33
Z_p	2.5	34	2.5	34
E_{sky}	1400.	35	1200.	35
Y_p	0.	36	0.	36
X_p	0.	37	0.	37
Y_{min}	5.	38	5.	38
Y_{max}	25.	39	25.	39
X_{min}	5.	40	5.	40
X_{max}	15.	41	15.	41
N_y	3.	42	3.	42
N_x	3.	43	3.	43
$1.018T_o$	0.79404	44	0.79404	44
N_{sc}	0.	45	2.741	45
AZ_{window}	0.	46	90.	46
AZ_{solar}	0.	47	0.	47
ALT_{solar}	0.	48	40.	48
	0.	49	0.	49

```
        OUTPUT                            OUTPUT

             5.      X                         5.      X
             5.      Y                         5.      Y
   88.96117803      SC               77.88657598      SC

             5.      X                         5.      X
            15.      Y                        15.      Y
   102.7729127      SC               104.8656102      SC

             5.      X                         5.      X
            25.      Y                        25.      Y
   88.96117803      SC               96.82265492      SC

            10.      X                        10.      X
             5.      Y                         5.      Y
    21.5263186      SC               25.84613883      SC

            10.      X                        10.      X
            15.      Y                        15.      Y
   27.28921538      SC               37.53479146      SC

            10.      X                        10.      X
            25.      Y                        25.      Y
    21.5263186      SC                 32.852973      SC

            15.      X                        15.      X
             5.      Y                         5.      Y
    8.23775761      SC               12.04242839      SC

            15.      X                        15.      X
            15.      Y                        15.      Y
   10.48444276      SC               16.81735902      SC

            15.      X                        15.      X
            25.      Y                        25.      Y
    8.23775761      SC               15.02274864      SC
```

FIGURE 6. INPUT AND OUTPUT FOR SKY COMPONENT PROGRAM

	OVERCAST SKY		CLEAR SKY	
VARIABLE	INPUT	MEMORY #	INPUT	MEMORY #
WIDTH_{win}	28.	15	28.	15
HEIGHT_{win}	5.	16	5.	16
WIDTH_{rm}	30.	17	30.	17
DEPTH_{rm}	20.	18	20.	18
HEIGHT_{rm}	8.67	19	8.67	19
HEIGHT_{sill}	2.	20	2.	20
T_o	0.78	21	0.78	21
$\rho_{ceiling}$	0.8	22	0.8	22
ρ_{floor}	0.2	23	0.2	23
ρ_{glass}	0.14	24	0.14	24
ρ_{wall}	0.5	25	0.5	25
ρ_{ground}	0.2	26	0.2	26
FS	0.39	27	0.5	27
E_{sky}	1400.	28	1200.	28
E_{sun}	0.	29	4800.	29
	OUTPUT		OUTPUT	
R.C.	27.	RC	61.	RC

FIGURE 7. INPUT AND OUTPUT FOR REFLECTED COMPONENT PROGRAM

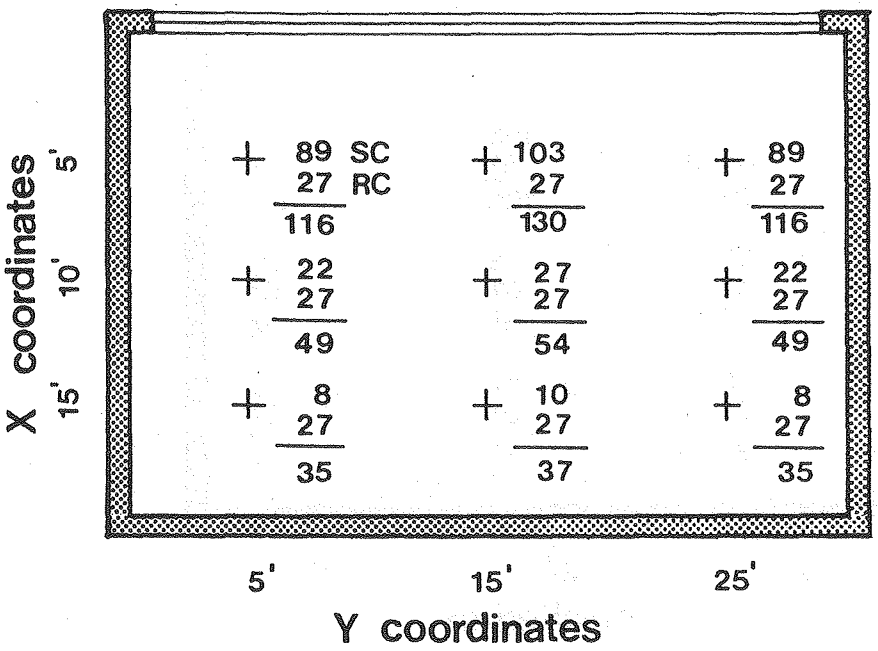

FIGURE 8. OVERCAST SKY ILLUMINATION VALUES (fc) FOR EXAMPLE ROOM

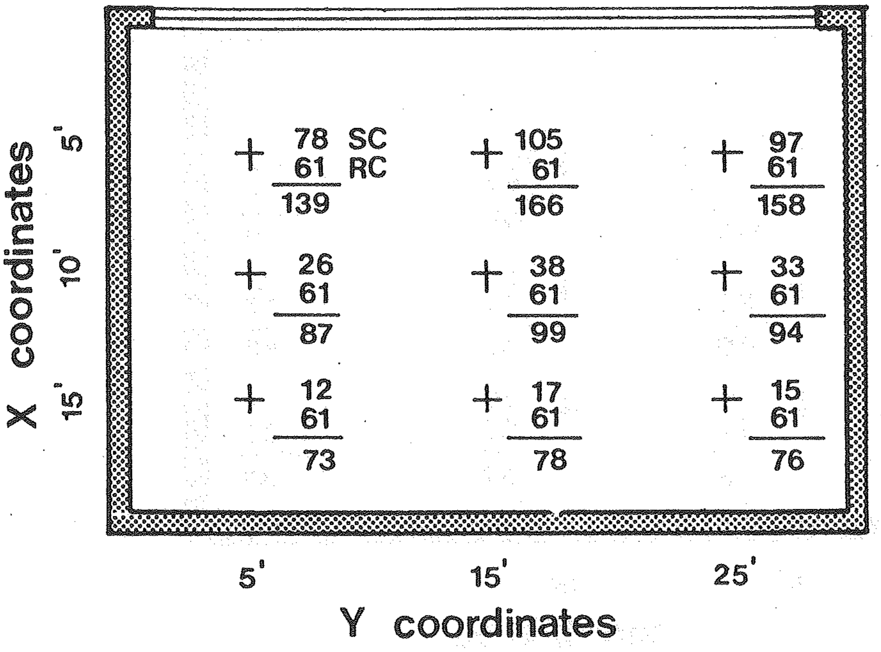

FIGURE 9. CLEAR SKY ILLUMINATION VALUES (fc) FOR EXAMPLE ROOM

SKY COMPONENT PROGRAM: OVERCAST SKY

```
000  76 LBL     055  18  18     110  42 STO     165  97 DSZ
001  16 A'      056  34 ΓX      111  08  08     166  09  09
002  42 STO     057  85  +      112  02  2      167  68 NOP
003  15  15     058  01  1      113  42 STO     168  43 RCL
004  39 COS     059  54  )      114  07  07     169  22  22
005  42 STO     060  65  ×      115  76 LBL     170  44 SUM
006  16  16     061  43 RCL     116  58 FIX     171  10  10
007  33 X²      062  17  17     117  03  3      172  97 DSZ
008  53  (      063  65  ×      118  42 STO     173  08  08
009  42 STO     064  43 RCL     119  24  24     174  42 STO
010  17  17     065  16  16     120  76 LBL     175  06  6
011  65  ×      066  55  ÷      121  42 STO     176  42 STO
012  43 RCL     067  53  (      122  02  2      177  24  24
013  12  12     068  43 RCL     123  22 INV     178  02  2
014  85  +      069  18  18     124  44 SUM     179  42 STO
015  43 RCL     070  45 YX      125  24  24     180  08  08
016  13  13     071  02  2      126  43 RCL     181  61 GTO
017  54  )      072  93  .      127  10  10     182  42 STO
018  42 STO     073  05  5      128  39 COS     183  76 LBL
019  18  18     074  54  )      129  42 STO     184  68 NOP
020  53  (      075  54  )      130  11  11     185  89  π
021  53  (      076  92 RTN     131  33 X²      186  55  ÷
022  53  (      077  76 LBL     132  42 STO     187  02  2
023  53  (      078  11  A      133  12  12     188  95  =
024  43 RCL     079  65  ×      134  42 STO     189  32 X:T
025  13  13     080  01  1      135  14  14     190  43 RCL
026  85  +      081  93  .      136  43 RCL     191  21  21
027  43 RCL     082  00  0      137  10  10     192  42 STO
028  17  17     083  01  1      138  38 SIN     193  10  10
029  65  ×      084  08  8      139  33 X²      194  67  EQ
030  43 RCL     085  95  =      140  42 STO     195  59 INT
031  14  14     086  42 STO     141  13  13     196  97 DSZ
032  54  )      087  44  44     142  94 +/-     197  07  07
033  55  ÷      088  91 R/S     143  44 SUM     198  58 FIX
034  43 RCL     089  76 LBL     144  14  14     199  76 LBL
035  18  18     090  13  C      145  04  4      200  59 INT
036  54  )      091  43 RCL     146  36 PGM     201  98 ADV
037  45 YX      092  23  23     147  09  09     202  04  4
038  01  1      093  42 STO     148  13  C      203  04  4
039  93  .      094  10  10     149  36 PGM     204  69 OP
040  05  5      095  94 +/-     150  09  09     205  04  04
041  85  +      096  85  +      151  14  D      206  43 RCL
042  01  1      097  43 RCL     152  65  ×      207  37  37
043  54  )      098  21  21     153  43 RCL     208  69 OP
044  65  ×      099  95  =      154  13  13     209  06  06
045  53  (      100  55  ÷      155  65  ×      210  04  4
046  02  2      101  04  4      156  43 RCL     211  05  5
047  65  ×      102  42 STO     157  11  11     212  69 OP
048  43 RCL     103  09  09     158  65  ×      213  04  04
049  16  16     104  95  =      159  43 RCL     214  43 RCL
050  65  ×      105  42 STO     160  24  24     215  36  36
051  43 RCL     106  22  22     161  95  =      216  69 OP
052  11  11     107  00  0      162  44 SUM     217  06  06
053  55  ÷      108  42 STO     163  19  19     218  03  3
054  43 RCL     109  19  19     164  22 INV     219  06  6
```

OVERCAST SKY (cont.)

```
220  01    1        275  55    ÷        330  35  1/X        385  76  LBL
221  05    5        276  53    (        331  91  R/S        386  22  INV
222  69  OP         277  43  RCL        332  76  LBL        387  43  RCL
223  04   04        278  06   06        333  12    B        388  30   30
224  43  RCL        279  75    -        334  70  RAD        389  75    -
225  19   19        280  01    1        335  29  CP         390  43  RCL
226  65    ×        281  54    )        336  43  RCL        391  36   36
227  43  RCL        282  95    =        337  32   32        392  95    =
228  44   44        283  42  STO        338  75    -        393  55    ÷
229  65    ×        284  41   41        339  43  RCL        394  43  RCL
230  43  RCL        285  76  LBL        340  34   34        395  37   37
231  22   22        286  43  RCL        341  95    =        396  95    =
232  55    ÷        287  71  SBR        342  42  STO        397  22  INV
233  07    7        288  12    B        343  23   23        398  30  TAN
234  55    ÷        289  61  GTO        344  94  +/-        399  42  STO
235  89    π        290  44  SUM        345  22  INV        400  01   01
236  65    ×        291  76  LBL        346  77   GE        401  43  RCL
237  43  RCL        292  24  CE         347  23  LNX        402  31   31
238  35   35        293  71  SBR        348  89    π        403  75    -
239  95    =        294  22  INV        349  55    ÷        404  43  RCL
240  69  OP         295  76  LBL        350  02    2        405  36   36
241  06   06        296  44  SUM        351  95    =        406  95    =
242  92  RTN        297  71  SBR        352  42  STO        407  55    ÷
243  76  LBL        298  13    C        353  21   21        408  43  RCL
244  14    D        299  22  INV        354  61  GTO        409  37   37
245  43  RCL        300  97  DSZ        355  33  X²         410  95    =
246  42   42        301  00   00        356  76  LBL        411  22  INV
247  42  STO        302  34  √X         357  23  LNX        412  30  TAN
248  00   00        303  43  RCL        358  43  RCL        413  42  STO
249  75    -        304  39   39        359  37   37        414  02   02
250  01    1        305  44  SUM        360  55    ÷        415  87  IFF
251  95    =        306  36   36        361  43  RCL        416  01   01
252  35  1/X        307  61  GTO        362  23   23        417  13    C
253  65    ×        308  24  CE         363  95    =        418  92  RTN
254  53    (        309  76  LBL        364  22  INV        419  76  LBL
255  43  RCL        310  34  √X         365  30  TAN        420  17  B'
256  39   39        311  22  INV        366  42  STO        421  86  STF
257  75    -        312  97  DSZ        367  21   21        422  01   01
258  43  RCL        313  06   06        368  76  LBL        423  61  GTO
259  38   38        314  35  1/X        369  33  X²         424  12    B
260  42  STO        315  43  RCL        370  43  RCL        425  76  LBL
261  36   36        316  42   42        371  37   37        426  19  D'
262  54    )        317  42  STO        372  55    ÷        427  22  INV
263  95    =        318  00   00        373  53    (        428  86  STF
264  42  STO        319  43  RCL        374  43  RCL        429  01   01
265  39   39        320  38   38        375  33   33        430  43  RCL
266  53    (        321  42  STO        376  75    -        431  43   43
267  43  RCL        322  36   36        377  43  RCL        432  42  STO
268  41   41        323  43  RCL        378  34   34        433  06   06
269  75    -        324  41   41        379  54    )        434  61  GTO
270  43  RCL        325  44  SUM        380  95    =        435  14    D
271  40   40        326  37   37        381  22  INV
272  42  STO        327  61  GTO        382  30  TAN
273  37   37        328  43  RCL        383  42  STO
274  54    )        329  76  LBL        384  23   23
```

SKY COMPONENT: CLEAR SKY

```
000  76 LBL     055  53  (      110  53  (      165  42 STO
001  16 A'      056  53  (      111  93  .      166  44  44
002  42 STO     057  43 RCL     112  02  3      167  91 R/S
003  15  15     058  13  13     113  02  2      168  42 STO
004  39 COS     059  85  +      114  94 +/-     169  45  45
005  42 STO     060  43 RCL     115  65  ×      170  91 R/S
006  16  16     061  17  17     116  43 RCL     171  42 STO
007  33 X²      062  65  ×      117  18  18     172  46  46
008  53  (      063  43 RCL     118  34 ΓX      173  71 SBR
009  42 STO     064  14  14     119  55  ÷      174  28 LOG
010  17  17     065  54  )      120  43 RCL     175  42 STO
011  65  ×      066  55  ÷      121  11  11     176  27  27
012  43 RCL     067  43 RCL     122  55  ÷      177  43 RCL
013  12  12     068  18  18     123  43 RCL     178  46  46
014  85  +      069  54  )      124  16  16     179  91 R/S
015  43 RCL     070  45 YX      125  54  )      180  42 STO
016  13  13     071  01  1      126  22 INV     181  47  47
017  54  )      072  93  .      127  23 LNX     182  71 SBR
018  42 STO     073  05  5      128  54  )      183  28 LOG
019  18  18     074  85  +      129  65  ×      184  94 +/-
020  53  (      075  01  1      130  43 RCL     185  44 SUM
021  53  (      076  54  )      131  17  17     186  27  27
022  43 RCL     077  65  ×      132  65  ×      187  43 RCL
023  26  26     078  53  (      133  43 RCL     188  47  47
024  65  ×      079  93  .      134  16  16     189  91 R/S
025  43 RCL     080  09  9      135  55  ÷      190  42 STO
026  20  20     081  01  1      136  53  (      191  48  48
027  65  ×      082  85  +      137  43 RCL     192  75  -
028  53  (      083  01  1      138  18  18     193  09  9
029  43 RCL     084  00  0      139  45 YX      194  00  0
030  15  15     085  65  ×      140  02  2      195  95  =
031  85  +      086  53  (      141  93  .      196  94 +/-
032  43 RCL     087  03  3      142  05  5      197  71 SBR
033  27  27     088  94 +/-     143  54  )      198  28 LOG
034  54  )      089  65  ×      144  54  )      199  42 STO
035  39 COS     090  43 RCL     145  92 RTN     200  25  25
036  85  +      091  29  29     146  76 LBL     201  70 RAD
037  43 RCL     092  22 INV     147  28 LOG     202  38 SIN
038  11  11     093  39 COS     148  65  ×      203  42 STO
039  65  ×      094  54  )      149  89  π      204  20  20
040  43 RCL     095  22 INV     150  55  ÷      205  43 RCL
041  28  28     096  23 LNX     151  01  1      206  25  25
042  65  ×      097  85  +      152  08  8      207  39 COS
043  43 RCL     098  93  .      153  00  0      208  42 STO
044  16  16     099  04  4      154  95  =      209  28  28
045  54  )      100  05  5      155  92 RTN     210  43 RCL
046  55  ÷      101  65  ×      156  76 LBL     211  48  48
047  43 RCL     102  43 RCL     157  11  A      212  91 R/S
048  18  18     103  29  29     158  65  ×      213  76 LBL
049  34 ΓX      104  33 X²      159  01  1      214  13  C
050  54  )      105  54  )      160  93  .      215  43 RCL
051  42 STO     106  65  ×      161  00  0      216  23  23
052  29  29     107  53  (      162  01  1      217  42 STO
053  53  (      108  01  1      163  08  8      218  10  10
054  53  (      109  75  -      164  95  =      219  94 +/-
```

CLEAR SKY (cont.)

```
220  85  +
221  43  RCL
222  21   21
223  95  =
224  55  ÷
225  04  4
226  42  STO
227  09   09
228  95  =
229  42  STO
230  22   22
231  00  0
232  42  STO
233  19   19
234  42  STO
235  08   08
236  02  2
237  42  STO
238  07   07
239  76  LBL
240  58  FIX
241  03  3
242  42  STO
243  24   24
244  76  LBL
245  42  STO
246  02  2
247  22  INV
248  44  SUM
249  24   24
250  43  RCL
251  10   10
252  39  COS
253  42  STO
254  11   11
255  33  X²
256  42  STO
257  12   12
258  42  STO
259  14   14
260  43  RCL
261  10   10
262  38  SIN
263  42  STO
264  26   26
265  33  X²
266  42  STO
267  13   13
268  94  +/-
269  44  SUM
270  14   14
271  04  4
272  36  PGM
273  09   09
274  13  C

275  36  PGM
276  09   09
277  14  D
278  65  ×
279  43  RCL
280  13   13
281  65  ×
282  43  RCL
283  11   11
284  65  ×
285  43  RCL
286  24   24
287  95  =
288  44  SUM
289  19   19
290  22  INV
291  97  DSZ
292  09   09
293  68  NOP
294  43  RCL
295  22   22
296  44  SUM
297  10   10
298  97  DSZ
299  08   08
300  42  STO
301  06  6
302  42  STO
303  24   24
304  02  2
305  42  STO
306  08   08
307  61  GTO
308  42  STO
309  76  LBL
310  68  NOP
311  89  π
312  55  ÷
313  02  2
314  95  =
315  32  X:T
316  43  RCL
317  21   21
318  42  STO
319  10   10
320  67  EQ
321  59  INT
322  97  DSZ
323  07   07
324  58  FIX
325  76  LBL
326  59  INT
327  98  ADV
328  04  4
329  04  4

330  69  OP
331  04   04
332  43  RCL
333  37   37
334  69  OP
335  06   06
336  04  4
337  05  5
338  69  OP
339  04   04
340  43  RCL
341  36   36
342  69  OP
343  06   06
344  03  3
345  06  6
346  01  1
347  05  5
348  69  OP
349  04   04
350  43  RCL
351  19   19
352  65  ×
353  43  RCL
354  44   44
355  65  ×
356  43  RCL
357  22   22
358  55  ÷
359  03  3
360  55  ÷
361  43  RCL
362  45   45
363  65  ×
364  43  RCL
365  35   35
366  95  =
367  69  OP
368  06   06
369  92  RTN
370  76  LBL
371  19  D'
372  22  INV
373  86  STF
374  01   01
375  43  RCL
376  43   43
377  42  STO
378  06   06
379  76  LBL
380  14  D
381  43  RCL
382  42   42
383  42  STO
384  00   00

385  75  -
386  01  1
387  95  =
388  35  1/X
389  65  ×
390  53  (
391  43  RCL
392  39   39
393  75  -
394  43  RCL
395  38   38
396  42  STO
397  36   36
398  54  )
399  95  =
400  42  STO
401  39   39
402  53  (
403  43  RCL
404  41   41
405  75  -
406  43  RCL
407  40   40
408  42  STO
409  37   37
410  54  )
411  55  ÷
412  53  (
413  43  RCL
414  06   06
415  75  -
416  01  1
417  54  )
418  95  =
419  42  STO
420  41   41
421  76  LBL
422  43  RCL
423  71  SBR
424  12  B
425  61  GTO
426  44  SUM
427  76  LBL
428  24  CE
429  71  SBR
430  22  INV
431  76  LBL
432  44  SUM
433  71  SBR
434  13  C
435  22  INV
436  97  DSZ
437  00   00
438  34  √X
439  43  RCL
```

CLEAR SKY (cont.)

```
440  39  39
441  44 SUM
442  36  36
443  61 GTO
444  24 CE
445  76 LBL
446  34 √X
447  22 INV
448  97 DSZ
449  06  06
450  35 1/X
451  43 RCL
452  42  42
453  42 STO
454  00  00
455  43 RCL
456  38  38
457  42 STO
458  36  36
459  43 RCL
460  41  41
461  44 SUM
462  37  37
463  61 GTO
464  43 RCL
465  76 LBL
466  35 1/X
467  91 R/S
468  76 LBL
469  17 B'
470  86 STF
471  01  01
472  76 LBL
473  12  B
474  29 CP
475  43 RCL
476  32  32
477  75  -
478  43 RCL
479  34  34
480  95  =
481  42 STO
482  23  23
483  94 +/-
484  22 INV
485  77  GE
486  23 LNX
487  89  π
488  55  ÷
489  02  2
490  95  =
491  42 STO
492  21  21
493  61 GTO
494  33 X²
495  76 LBL
496  23 LNX
497  43 RCL
498  37  37
499  55  ÷
500  43 RCL
501  23  23
502  95  =
503  22 INV
504  30 TAN
505  42 STO
506  21  21
507  76 LBL
508  33 X²
509  43 RCL
510  37  37
511  55  ÷
512  53  (
513  43 RCL
514  33  33
515  75  -
516  43 RCL
517  34  34
518  54  )
519  95  =
520  22 INV
521  30 TAN
522  42 STO
523  23  23
524  76 LBL
525  22 INV
526  43 RCL
527  30  30
528  75  -
529  43 RCL
530  36  36
531  95  =
532  55  ÷
533  43 RCL
534  37  37
535  95  =
536  22 INV
537  30 TAN
538  42 STO
539  01  01
540  43 RCL
541  31  31
542  75  -
543  43 RCL
544  36  36
545  95  =
546  55  ÷
547  43 RCL
548  37  37
549  95  =
550  22 INV
551  30 TAN
552  42 STO
553  02  02
554  87 IFF
555  01  01
556  13  C
557  92 RTN
```

REFLECTED COMPONENT PROGRAM

```
000  76 LBL
001  33 X²
002  43 RCL
003  26  26
004  55  ÷
005  02  2
006  95  =
007  42 STO
008  09  09
009  92 RTN
010  76 LBL
011  44 SUM
012  43 RCL
013  29  29
014  85  +
015  43 RCL
016  28  28
017  95  =
018  55  ÷
019  43 RCL
020  28  28
021  95  =
022  49 PRD
023  09  09
024  92 RTN
025  76 LBL
026  11  A
027  71 SBR
028  33 X²
029  04  4
030  42 STO
031  12  12
032  01  1
033  42 STO
034  02  02
035  61 GTO
036  23 LNX
037  76 LBL
038  12  B
039  71 SBR
040  33 X²
041  43 RCL
042  28  28
043  42 STO
044  02  02
045  00  0
046  42 STO
047  12  12
048  61 GTO
049  23 LNX
050  76 LBL
051  13  C
052  71 SBR
053  33 X²
054  71 SBR
055  44 SUM
056  01  1
057  42 STO
058  02  02
059  04  4
060  42 STO
061  12  12
062  61 GTO
063  23 LNX
064  76 LBL
065  14  D
066  71 SBR
067  33 X²
068  71 SBR
069  44 SUM
070  43 RCL
071  28  28
072  42 STO
073  02  02
074  00  0
075  42 STO
076  12  12
077  76 LBL
078  23 LNX
079  43 RCL
080  27  27
081  42 STO
082  01  01
083  43 RCL
084  15  15
085  65  ×
086  43 RCL
087  16  16
088  95  =
089  42 STO
090  10  10
091  65  ×
092  53  (
093  43 RCL
094  24  24
095  75  -
096  43 RCL
097  25  25
098  54  )
099  95  =
100  42 STO
101  03  03
102  43 RCL
103  17  17
104  65  ×
105  43 RCL
106  18  18
107  95  =
108  42 STO
109  05  05
110  42 STO
111  07  07
112  42 STO
113  08  08
114  44 SUM
115  08  08
116  65  ×
117  43 RCL
118  23  23
119  95  =
120  42 STO
121  04  04
122  44 SUM
123  03  03
124  43 RCL
125  05  05
126  65  ×
127  43 RCL
128  22  22
129  95  =
130  42 STO
131  06  06
132  44 SUM
133  03  03
134  43 RCL
135  18  18
136  65  ×
137  43 RCL
138  19  19
139  65  ×
140  02  2
141  65  ×
142  42 STO
143  13  13
144  44 SUM
145  08  08
146  43 RCL
147  25  25
148  95  =
149  44 SUM
150  03  03
151  43 RCL
152  17  17
153  65  ×
154  43 RCL
155  19  19
156  65  ×
157  44 SUM
158  13  13
159  02  2
160  65  ×
161  44 SUM
162  08  08
163  43 RCL
164  25  25
165  95  =
166  44 SUM
167  03  03
168  43 RCL
169  20  20
170  85  +
171  43 RCL
172  16  16
173  55  ÷
174  02  2
175  95  =
176  55  ÷
177  43 RCL
178  19  19
179  95  =
180  42 STO
181  14  14
182  65  ×
183  43 RCL
184  13  13
185  65  ×
186  44 SUM
187  05  05
188  43 RCL
189  25  25
190  85  +
191  43 RCL
192  04  04
193  95  =
194  55  ÷
195  43 RCL
196  05  05
197  95  =
198  49 PRD
199  01  01
200  01  1
201  75  -
202  43 RCL
203  14  14
204  95  =
205  65  ×
206  43 RCL
207  13  13
208  65  ×
209  44 SUM
210  07  07
211  43 RCL
212  25  25
213  85  +
214  43 RCL
215  06  06
216  95  =
217  55  ÷
218  43 RCL
219  07  07
```

REFLECTED COMPONENT PROGRAM (cont.)

```
220  95  =
221  65  ×
222  43 RCL
223  09  09
224  85  +
225  43 RCL
226  01  01
227  95  =
228  65  ×
229  43 RCL
230  21  21
231  65  ×
232  43 RCL
233  10  10
234  55  ÷
235  53  (
236  43 RCL
237  08  08
238  75  -
239  43 RCL
240  03  03
241  54  )
242  95  =
243  65  ×
244  43 RCL
245  02  02
246  95  =
247  42 STO
248  11  11
249  98 ADV
250  03  3
251  05  5
252  01  1
253  05  5
254  69 OP
255  04  04
256  43 RCL
257  11  11
258  58 FIX
259  40 IND
260  12  12
261  69 OP
262  06  06
263  22 INV
264  58 FIX
265  98 ADV
266  91 R/S
```