DANIEL F. MERRIAM, Editor

FORTRAN IV PROGRAM FOR HARMONIC TREND ANALYSIS USING DOUBLE FOURIER SERIES AND REGULARLY GRIDDED DATA FOR THE GE 625 COMPUTER

By

JOHN W. HARBAUGH
Stanford University

and

MICHAEL J. SACKIN
Kansas Geological Survey

in cooperation with the
American Association of Petroleum Geologists
Tulsa, Oklahoma

COMPUTER CONTRIBUTION 29
State Geological Survey
The University of Kansas, Lawrence
1968

Editor's Remarks

This publication is one in a series of trend-analysis programs made available recently in the COMPUTER CONTRIBUTIONS. Each program differs in mathematical development and serves a different purpose. The program presented here, "FORTRAN IV program for harmonic trend analysis using double Fourier series and regularly gridded data for the GE 625 computer" by J.W. Harbaugh and M.J. Sackin, will be of interest to those who wish to analyze data suspected of containing oscillatory phenomena. The program is a translation of an earlier BALGOL program by Harbaugh.

Trend analysis is an important technique for geologic investigations; this importance is reflected in the number of programs issued to perform trend analysis. The following table gives the user a quick check of the COMPUTER CONTRIBUTIONS which will best fit his particular study.

	Irregularly Spaced Data	Regularly Spaced Data
Nonoscillatory	SDP 14* SDP 26* CC 3 CC 10* CC 27 CC 28	**
Oscillatory	CC 5	SDP 24 CC 29

* For small computer
** Same programs used for irregularly spaced data
SDP—Special Distribution Publication
CC—COMPUTER CONTRIBUTION

Although this version of the program was written for the GE 625 computer, users should have little difficulty adapting it to other installations. With minor modifications it should readily be usable on machines such as the IBM System/360 Model 40 and larger. The authors have used a general version of FORTRAN so the program is not machine dependent.

For a limited time the program will be available on magnetic tape for $15.00. An extra charge of $10.00 is made if punched cards are required.

---

*Active Member, ° Associate Member, +Junior Member, American Association of Petroleum Geologists.

FORTRAN IV PROGRAM FOR HARMONIC TREND ANALYSIS USING DOUBLE FOURIER SERIES AND REGULARLY GRIDDED DATA FOR THE GE 625 COMPUTER

by

J. W. Harbaugh and M.J. Sackin

INTRODUCTION

This publication describes a computer program designed for analysis of surfaces using double Fourier series. Analysis of surfaces in geology is known commonly as trend analysis; in statistics and economics, the technique is regarded as a form of regression analysis. In trend or regression analysis, a mathematical function is fitted to data points so that the function satisfies the least-squares criterion, which is a criterion of "best" fit.

Most geological applications of trend analysis have employed polynomials (for a review, see Harbaugh and Merriam, 1968, p. 62-112). A commonly used polynomial in trend analysis, for example, is

$$z = A + Bx + Cy + Dx^2 + Exy + Fy^2 + Gx^3 + Hx^2y + Ixy^2 + Jy^3,$$

where

- z = dependent variable,
- x = one of the independent variables, as for example, the east-west direction,
- y = the other independent variable, as for example, the north-south direction, and
- A to J = coefficients of the terms of the polynomial.

Such a polynomial consists of a series of terms containing regularly ascending integer powers and may be used with either regularly gridded data or irregularly spaced data. There is no inherent reason, however, why other forms of mathematical functions should not be used. Double Fourier series provide one of a number of possible alternatives and are particularly useful where oscillatory phenomena are involved. The general form of double Fourier series may be written

$$z = F(x,y) = \sum_{m=0}^{M} \sum_{n=0}^{N} \lambda_{mn} \left(a_{mn} \cos \frac{m\pi x}{L} \cos \frac{n\pi y}{H} + b_{mn} \sin \frac{m\pi x}{L} \cos \frac{n\pi y}{H} + c_{mn} \cos \frac{m\pi x}{L} \sin \frac{n\pi y}{H} + d_{mn} \sin \frac{m\pi x}{L} \sin \frac{n\pi y}{H}\right).$$

As can be seen, such a series consists of terms containing sines and cosines that represent regular wave forms which are combined algebraically. Analysis with Fourier series, then, consists essentially of decomposing the observed data into a regular succession of wave forms with different period lengths and amplitudes and may be termed harmonic analysis. As with polynomials, such a function may be used with either regularly gridded data, or with irregularly spaced data. If the function is fitted to data on a rectangular grid, the symbols in the function may be defined as

- z = dependent variable in observed function,
- $F(x,y)$ = Fourier approximation at grid point x, y,
- m = index of degree of terms pertaining to x direction,
- n = index of degree of terms pertaining to y direction,
- a_{mn} = coefficient of cosine-cosine term of degree m and n,
- b_{mn} = coefficient of sine-cosine term of degree m and n,
- c_{mn} = coefficient of cosine-sine term of degree m and n,
- d_{mn} = coefficient of sine-sine term of degree m and n,
- M = specified maximum degree of terms pertaining to x direction,
- N = specified maximum degree of terms pertaining to y direction,
- L = half of sampling length in x direction, or $k\,\Delta x/2$,
- H = half of sampling length in y direction, or $l\,\Delta y/2$,
- x_i = value of sampling interval in x direction, $i = 0,1,2,\ldots\ldots,k$,
- y_j = value of sampling interval in y direction, $j = 0,1,2,\ldots\ldots,l$,

and

$$\lambda_{mn} = 1/4,\ m = n = 0,$$
$$\lambda_{mn} = 1/2,\ m = 0,\ n > 0,\ \text{or}\ m > 0,\ n = 0,\ \text{and}$$
$$\lambda_{mn} = 1,\ m > 0,\ n > 0.$$

For further explanation of the symbols and examples of applications of double Fourier series to geological data consult Harbaugh and Merriam (1968, p. 114-154) and Harbaugh and Preston (1965).

A program for double Fourier series analysis of surfaces with irregularly spaced data has been developed by James (1966). The ability to use irregularly spaced data has many advantages, of course, because many forms of geological data tend not to be regularly spaced. If, however, data are obtainable on a regular, rectangular grid, there are important advantages because double Fourier series can be fitted that contain wave forms whose smallest period length in each direction of the grid is equal to twice the grid spacing interval in that direction, although aliasing may strongly affect the results. If the data are irregularly spaced, however, the smallest period length in a particular direction that may be effectively obtained in the decomposition process is affected by the largest space between points in that direction. An effect is to limit the usefulness of double Fourier series for surface fitting, where harmonic analysis is an objective, if the data are irregular in their spacing. Thus, there are major, inherent advantages in the use of data arranged on a rectangular grid employing a program designed specifically for use with gridded data. It should be pointed out that although the spacing between rows in one direction of a data grid need not be the same as the spacing between columns in the other direction, the between-column spacing must be consistent throughout, as must the between-row spacing.

The program described in this publication is a translation of a program written by Harbaugh in 1964 and described in the report by Preston and Harbaugh (1965). The earlier version of the program was written in BALGOL, which is a "dialect" of ALGOL-58. Though BALGOL is an exceptionally powerful and versatile language, compilers suitable for its use are now infrequently used, whereas FORTRAN IV continues to be widely used. Consequently, the program has been translated into FORTRAN IV so that its use may be extended. The program listed in this report has been tested with the GE 625 computer at The University of Kansas. It should be usable with other computers, including those of the IBM 360 series, with minor modifications.

The remainder of this report consists of a description of the computer program, including a listing of the program statements and an example of output obtained with the program, employing specific input data.

MAJOR STEPS IN PROGRAM

A listing of the program is provided in Table 1. Each line is numbered at the left. In punched card form, the line numbers would necessarily be omitted at the left, and could be placed in card columns 73 to 80. The major steps in the program are as follows:

(1) Type declaration statements: lines 4-13
(2) Set values of λ_{mn}: lines 14-17
(3) FORMAT statements: lines 18-63
(4) Read NUMBER card: line 66
(5) Read PROGRAM CONTROL and ALPHANUMERIC HEADING cards: lines 67-69
(6) Set working variables: lines 70-109
(7) If specified, read TERM cards: lines 110-113
(8) If specified, read TRIGONOMETRIC ARRAY cards: lines 116-124
(9) If specified, read PROFILE PLOT cards: lines 127-130
(10) Read DATA cards: lines 133-160
(11) If specified, multiply data values by a scale factor: lines 163-166
(12) If specified, plot raw data values: line 169
(13) If specified, provide for leveling of input data by computation of matrix equation, matrix inversion and calculation of residual values after leveling: lines 172-199 and subroutine MATINV
(14) If specified, plot leveled data points: lines 200-204
(15) If specified, fill parts of trigonometric function arrays by calculation: lines 213-232
(16) Fill remainder of trigonometric function arrays by assignment: lines 235-267
(17) If specified, print or punch arrays of trigonometric function values: lines 268-292
(18) Compute Fourier coefficients by multiplication of data values by appropriate trigonometric values and summing: lines 295-391
(19) Compute harmonic vector values: lines 393-397
(20) Print, or print and punch, arrays of Fourier coefficients, and harmonic vector magnitude values: lines 399-424
(21) Skip to step 31 if Fourier series are not to be calculated: line 430
(22) If specified restore tilt to leveled initial data and add tilt to Fourier surface data: lines 436-440
(23) Compute sums of squares of observed data values: lines 442-449

Steps 24, 25, 26, 28, 29, and 30 are repeated for each surface evaluated on current data set. Numbers of terms in x and y directions increase in successive surfaces.

(24) Evaluate Fourier series: lines 453-542
(25) Calculate least-squares fit of surface: lines 544-547
(26) If specified, plot strip maps of calculated Fourier series at data points: line 548
(27) Routine for plotting strip maps of observed data values, leveled data values, and evaluated Fourier series values: lines 554-583
(28) If specified, calculate residuals and print them out as strip maps: lines 586-604
(29) If specified plot profiles along specified horizontal and vertical rows: lines 608-723

(30) If additional terms are to be evaluated on current data set, go to step 24: line 724
(31) If additional data sets are present, go to step 5: lines 726-727.

INPUT TO PROGRAM

An example of input data is given in Table 2. The input for a run starts with a NUMBER card which gives the number of data sets in the run. Each data set that follows should contain the following forms of information:

(1) PROGRAM CONTROL CARD
(2) ALPHANUMERIC HEADING CARD
(3) TERM CARDS (optional)
(4) TRIGONOMETRIC ARRAY CARDS (optional)
(5) PROFILE PLOT CARDS (optional)
(6) DATA CARDS

The specific forms of information and their punched-card formats are as follows (in order of columns, variable, format, and description):

NUMBER Card

1-5	NUMBER	I5	Number of data sets in the run

PROGRAM Control Card

1	AST	A1	Punch an asterisk (*)
2	BL	A1	Leave blank
3	BI	A1	Punch "I"
4-10	SCALE	F7.2	If L=1 (cols. 47-49) data points will be multiplied by SCALE
11-13	NR	I3	Number of rows in data array. Should be an odd integer not greater than 71 unless array dimensions are increased
14-16	MC	I3	Number of columns in data array. Should be an odd integer not greater than 73 unless array dimensions are increased
17-19	NT	I3	Maximum number of N terms for the data set, i.e. the maximum harmonic number in the vertical (y) direction of the data array. Should not exceed 25 unless array dimensions are increased
20-22	MT	I3	Maximum number of M terms for the data set Should not exceed 25 unless array dimensions are increased
23-25	ITRGOP	I3	=1: Calculate trigonometric arrays =2: Read trigonometric arrays
26-28	JAROP	I3	=1: Output trigonometric arrays on device specified by IPCHOP (cols. 65-67) $\neq$ 1: Do not output
29-31	INTOP	I3	Specified form of data array values =1: Read as integers =2: Read as decimal-point numbers =3: Read as 0's and 1's which will be converted to -100 and +100 =4: Read as integers and reverse all algebraic signs
32-34	JVALOP	I3	=1: Read term cards and evaluate Fourier series $\neq$1: Do not read or evaluate
35-37	JPRTOP	I3	=1: Print evaluated Fourier series as strip maps $\neq$1: Print only the heading to the maps If JVALOP $\neq$ 1 the value of JPRTOP is immaterial
38-40	JRESOP	I3	=1: Calculate residuals and print as strip maps $\neq$1: Do not calculate or print
41-43	JDTOP	I3	=1: Print original data as strip maps =0: Do not print
44-46	IPCHOP	I3	=1: If JAROP = 1 print trigonometric arrays =2: If JAROP = 1, punch trigonometric arrays = other value: Arrays will not be printed or punched; if JAROP $\neq$ 1, the value of IPCHOP is immaterial
47-49	L	I3	=1: Multiply data values by SCALE $\neq$ 1: Do not multiply
50-52	JPROF	I3	=1: Read profile plot cards and (if JVALOP =1) calculate and print profiles (horizontal or vertical or both) $\neq$1: Do not read, calculate, or print
53-55	JCOFOP	I3	=2: Punch Fourier coefficient arrays and harmonic vector magnitude arrays

			≠2: Do not punch
56-58	LVLOP	I3	=1: Level the original data before computing Fourier coefficients ≠1: Do not level
59-61	JTILT	I3	=2: Restore tilt to data and to Fourier series if data points were leveled ≠2: Do not restore tilt
62-64	JPLAN	I3	=JDTOP+1: Print leveled data as strip map = JDTOP: Do not print If LVLOP≠1 the value of JPLAN is immaterial

ALPHANUMERIC HEADING Card

1-80	LA	20A4	Punch any alphanumeric information

TERM Cards

These cards should be present if and only if JVALOP = 1 (cols. 32-34 of control card).

(1) Term Card A

1-5	IR	I5	Number of times the Fourier series is to be evaluated

(2) Term Card(s) B

1-5	NTERM	16I5	Punch IR integers in nondescending order. The ith value represents the number of N terms, i.e. the maximum harmonic number in the y direction, in the ith calculation of the Fourier series (i=1,2,..., IR). The last (highest) term should not exceed NT (cols. 17-19 of control card)

(3) Term Card(s) C

1-5	MTERM	16I5	Punch IR cards in nondescending order. The ith value represents the number of M terms, i.e. the maximum harmonic number in the x direction, in the ith evaluation of the Fourier series (i=1,2,...,IR). The last (highest) term should not exceed MT (cols. 20-22 of control card)

TRIGONOMETRIC ARRAY Card

These cards should be present if and only if ITRGOP = 2 (cols. 23-25 of control card).

Insert here the trigonometric array cards punched in a previous run, in which the values of NR, MC, NT, and MT were the same as in the present run.

PROFILE PLOT Cards

These cards should be present if and only if JPROF = 1 (cols. 50-52 of control card).

(1) Profile Plot Card A

1-10	TOP	F10.2	Maximum (extreme right hand) value of the plot of observed and calculated data profiles
11-20	BASE	F10.2	Minimum plot value
21-30	AMP	F10.2	Amplitude of magnification of residual values. Gives numbers of character positions (e.g. 0.02) per unit increase in plotted residual value, where zero value is at center of plot, and width is 30 characters
31-40	VSCALE	F10.2	Width in character positions of plots of observed and calculated data profiles. Maximum value = 30.0
41-50	HP	I10	Numbers of horizontal profiles to be plotted; nonnegative
51-60	VP	I10	Number of vertical profiles to be plotted; nonnegative

(2) Profile Plot Card(s) B

1-5	IVALS	16I5	Punch the HP values specifying the row index values of the horizontal profiles to be plotted. Omit if HP = 0
6-10 etc.			

(3) Profile Plot Card(s) C

1-5	JVALS	16I5	Punch the VP values specifying the column index values of the vertical profiles to be plot-

ted. Omit if VP = 0

6-10
etc.

DATA Cards

Data values in rows, NR rows, MC columns, as specified in cols. 11-13 and 14-16 of control card. Start each row on a new card. Otherwise punch 8 data values per card. Format is 8I10 if INTOP = 1,3, or 4, and 8F10.4 if INTOP = 2.

OUTPUT FROM PROGRAM

Forms of output from the program depend upon options specified in the input data. The following forms of output data for a given input data set are obtained in the following sequence if all forms are desired (Table 3):

(1) Plot of observed data values on a rectangular grid. If array is large, output will be in the form of successive, parallel vertical strips which can be pasted together.
(2) Listing of sine and cosine values for four arrays.
(3) A, B, C, and D arrays of Fourier coefficients.
(4) Harmonic vector magnitude array.
(5) Plot of evaluated double Fourier series at each grid point for series of specified degree in each direction.
(6) Plot of residual values at each grid point obtained by subtracting evaluated series from observed value.
(7) Profiles of selected rows.
(8) Profiles of selected columns.

REFERENCES

Harbaugh, J.W., and Merriam, D.F., 1968, Computer applications in stratigraphic analysis: John Wiley & Sons, New York, 282 p.

Harbaugh, J.W., and Preston, F.W., 1965, Fourier series analysis in geology: College of Mines, Arizona Univ., v. 1, p. R-1-R-46.

James, W.R., 1966, FORTRAN IV program using double Fourier series for surface fitting of irregularly spaced data: Kansas Geol. Survey Computer Contr. 5, 19 p.

Preston, F.W., and Harbaugh, J.W., 1965, BALGOL programs and geologic applications for single and double Fourier series using IBM 7090/7094 computers: Kansas Geol. Survey Sp. Dist. Publ. 24, 72 p.

Table 1.- Listing of statements in program, including a subroutine for matrix inversion.

```
06-29-68              DOUBLE FOURIER SERIES PROGRAM FOR REGULARLY SPACED DATA

                                 POINTS ON A RECTANGULAR GRID.  FORTRAN IV.

      C             DOUBLE FOURIER SERIES PROGRAM FOR REGULARLY SPACED DATA
      C             POINTS ON A RECTANGULAR GRID.  FORTRAN IV.
      C             J. W. HARBAUGH AND M. J. SACKIN
            INTEGER AST,HP,VP,P,Q,BL,BI
            INTEGER ASTPLT(95)
            LOGICAL TWO
            DIMENSION NTERM(25),MTERM(25),LINE(73),IVALS(15),JVALS(15),LA(20)
            REAL TSINNI(25,35),TCOSNI(25,35),TSINMJ(25,36),TCOSMJ(25,36),
           1X(71,73),A(25,25),B(25,25),C(25,25),D(25,25),PS(25,25),
           2ALAM(2,2),XS(71,73),APMAT(3,3),DATVEC(3),COVEC(3)
            EQUIVALENCE (DATVEC(1),COVEC(1))
            COMMON A, B, C, D, X, ASTPLT, NTERM, MTERM, LINE, IVALS, JVALS,
           1  LA, TSINNI, TCOSNI, TSINMJ, TCOSMJ, PS, ALAM, XS
            ALAM(1,1)=0.25
            ALAM(1,2)=0.5
            ALAM(2,1)=0.5
            ALAM(2,2)=1.0
          1 FORMAT(1H1,20A4//)
          2 FORMAT(16H COSINE MJ ARRAY)
          3 FORMAT(16H SINE MJ ARRAY  )
          5 FORMAT(16H COSINE NI ARRAY)
          6 FORMAT(16H SINE NI ARRAY  )
          7 FORMAT(65H PLOT OF LEVELED ORIGINAL DATA VALUES, WITH APPROXIMATE
           1ZERO MEAN,///)
          8 FORMAT    (32H1A ARRAY OF FOURIER COEFFICIENTS//)
          9 FORMAT    (32H1B ARRAY OF FOURIER COEFFICIENTS//)
         10 FORMAT    (32H1C ARRAY OF FOURIER COEFFICIENTS//)
         11 FORMAT    (32H1D ARRAY OF FOURIER COEFFICIENTS//)
         12 FORMAT    (32H1HARMONIC VECTOR MAGNITUDE ARRAY//)
         15 FORMAT(89H VALUES OF EVALUATED DOUBLE FOURIER SERIES AT SPECIFIED
           1GRID POINTS,  NUMBER OF COLUMNS = ,I3,19H,  NUMBER OF ROWS =,I3,
           2 1H,/ 20H NUMBER OF M TERMS =, I3, 22H,  NUMBER OF N TERMS =, I3,
           3 36H,  PERCENT OF TOTAL SUM OF SQUARES =, F8.2,
           4 18H,   SCALE FACTOR =, F8.2//)
         16 FORMAT(1H0,26I5)
         17 FORMAT(10H STRIP ONE)
         18 FORMAT(10H STRIP TWO)
         19 FORMAT(12H STRIP THREE)
         20 FORMAT(1H , 7F11.2)
         21 FORMAT(11H STRIP FOUR)
         22 FORMAT(5E14.5)
         23 FORMAT  (/(9E14.5))
         25 FORMAT(38H RESIDUAL VALUES, NUMBER OF COLUMNS = I3,19H,  NUMBER OF
           1 ROWS =,I3,21H, NUMBER OF M TERMS =, I3//,
           2   21H NUMBER OF N TERMS = I3,18H,   SCALE FACTOR =, F8.2///)
         26 FORMAT(26H HORIZONTAL PROFILE OF ROW, I6)
         27 FORMAT (1H , 2F9.2, F10.3, I5, 2H I, 95A1 ///)
         28 FORMAT(27H VERTICAL PROFILE OF COLUMN, I6)
         29 FORMAT (47H PLOT OF OBSERVED DATA VALUES, NUMBER OF ROWS =, I3,
           1 22H,  NUMBER OF COLUMNS =, I3, 17H,  SCALE FACTOR =, F8.3///)
         30 FORMAT( 20A4)
         33 FORMAT(10F8.4)
         35 FORMAT(1H ,16F8.4//)
         40 FORMAT(3A1, F7.2, 23I3)
```

```
   41 FORMAT(16I5)
   43 FORMAT( 4F10.2,2I10)
   44 FORMAT(8F10.4)
   45 FORMAT(8I10)
   46 FORMAT (31H0OBSERVED  CALCULATED  RESIDUAL, 11X, 8HOBSERVED,
     1 24X, 10HCALCULATED, 22X, 8HRESIDUAL//)
   47 FORMAT(11H PLOT TOP =, F12.3, 15H,    PLOT BASE =, F12.3,
     1 12H,      SCALE =, F6.3, 1H,/ 32H RESIDUAL AMPLIFICATION FACTOR =,
     2 F6.3, 7H,    M =, I3, 7H,    N =, I3)
      ICD = 43
      NMRUNS=1
      READ(5,41) NUMBER
 5000 READ(5,40)AST,BL,BI,SCALE,NR,MC,NT,MT,ITRGOP,JAROP,INTOP,JVALOP,
     1JPRTOP,JRESOP,JDTOP, IPCHOP,L, JPROF, JCOFOP, LVLOP, JTILT, JPLAN
      READ (5,30) LA
      FMC=MC
      FNR=NR
      N1= NR-1
      N2= N1/2
      N3=NR+1
      N4= N3/2
      N5= N1/4
      M1= MC-1
      M2= M1/2
      M3= MC+1
      M4= M3/2
      M5= M1/4
      FLTM= M2
      PH = 3.1415926/FLTM
      FLTN= N2
      PL = 3.1415926/FLTN
      FLTM= M1
      FLTN= N1
      RLH = 4.0/(FLTM*FLTN)
      M9 = M5+1
      N9 = N5+1
      M7 = M4+1
      N7 = N4+1
      MTT = 2*(MT/2)
      NTT = 2*(NT/2)
      FLTN= N1
      FN5 = FLTN/4.0
      FN5F=N5
      IF(FN5.LE.FN5F) GO TO 546
      N8 = N5+1
      GO TO 547
  546 N8 = N5
  547 FLTM = M1
      FM5 = FLTM/4.0
      FM5F = M5
      M8=M5+1
      IF (FM5 .LE. FM5F) M8=M5
      DATVEC(1)=0.0
      DATVEC(2)=0.0
      DATVEC(3)=0.0
      IF(JVALOP.NE.1) GO TO 560
      READ(5,41 ) IR
      READ(5,41 )   (NTERM(IQ), IQ =1,IR)
      READ(5,41 )   (MTERM(IQ), IQ =1,IR)
  560 CONTINUE
C     READ IN VALUES FOR TRIGONOMETRIC ARRAYS IF CALLED FOR (ITRGOP =2)
```

```
      IF(ITRGOP.NE.2) GO TO 515
      DO 511 J = 1,M9
  511 READ (5,33) (TCOSMJ(M,J), M = 1,MT)
      DO 512 J =1,M9
  512 READ (5,33) (TSINMJ(M,J), M = 1,MT)
      DO 513 I =1,N9
  513 READ(5,33) (TCOSNI(N,I), N = 1,NT)
      DO 514 I = 1,N9
  514 READ (5,33) (TSINNI(N,I), N = 1,NT)
  515 CONTINUE
C     READ IN DATA TO CONTROL PROFILES IF CALLED FOR (JPROF =1)
      IF(JPROF.NE.1) GO TO 516
      READ (5,43) TOP,BASE,AMP,VSCALE, HP,VP
      IF (HP.GT.0)  READ(5,41) (IVALS(I), I=1,HP)
      IF (VP.GT.0)  READ(5,41) (JVALS(J), J=1,VP)
  516 CONTINUE
C     READ IN DATA IN INTEGER FORM IF INTOP = 1
      IF(INTOP.NE.1) GO TO 523
      DO 522 I=1,NR
      READ(5,45) (LINE(J), J=1,MC)
      DO 522 J=1,MC
  522 X(I,J) = LINE(J)
  523 CONTINUE
C     READ IN DATA POINTS IN DECIMAL-POINT FORM IF INTOP = 2
      IF(INTOP.NE.2) GO TO 525
      DO 524 I=1,NR
  524 READ(5,44) (X(I,J), J =1,MC)
C     READ IN DATA CONSISTING OF INTEGER ONES AND ZEROS AND THEN TRANS
C     FORM VALUES SO THAT 0 = -100.0, AND 1 = 100.0, IF INTOP = 3
  525 IF(INTOP.NE.3) GO TO 529
      DO 526 I=1,NR
      READ(5,45) (LINE(J), J =1,MC)
      DO 526 J = 1,MC
      IF(LINE(J).NE.0) GO TO 527
      X(I,J) = -100.0
      GO TO 526
  527 X(I,J) = 100.0
  526 CONTINUE
C     READ IN DATA IN REGULAR INTEGER FORM AND THEN REVERSE ALGEBRAIC
C     SIGN IF INTOP  = 4
  529 IF(INTOP.NE.4)GO TO 531
      DO 530 I = 1,NR
      READ(5,45)(LINE(J) , J=1,MC)
      DO 530 J=1,MC
  530 X(I,J) = -LINE(J)
  531 CONTINUE
C     MULTIPLY DATA POINT VALUES BY A SCALE FACTOR IF L =1
      IF(L.NE.1) GO TO 533
      DO 532 I =1,NR
      DO 532 J =1,MC
  532 X(I,J) =  SCALE*X(I,J)
  533 CONTINUE
C     PRINT OUT ORIGINAL DATA VALUES IF JDTOP = 1
      IF(JDTOP.EQ.1) GO TO 661
  535 CONTINUE
C     LEVEL ORIGINAL DATA IF LVLOP EQUALS 1
      IF(LVLOP.NE.1) GO TO 659
C     THIS SECTION USES PIERSONS ARITHMETIC PROGRESSION METHOD
      APMAT(1,1) =  0.16666667*FMC*FNR*(FMC-1.0)*(2.0*FMC-1.0)
      APMAT(1,2)=0.25* FNR*(FNR-1.0)*FMC*(FMC-1.0)
      APMAT(1,3)=0.5*FMC*FNR*(FMC-1.0)
```

```
      APMAT(2,1)=0.25*FNR*(FNR-1.0)*FMC*(FMC-1.0)
      APMAT(2,2) = 0.16666667*FNR*FMC*(FNR-1.0)*(2.0*FNR-1.0)
      APMAT(2,3)=0.5*FNR*FMC*(FNR-1.0)
      APMAT(3,1) = APMAT(1,3)
      APMAT(3,2)=0.5*FMC*FNR*(FNR-1.0)
      APMAT(3,3)=FNR* FMC
      DO 621 I=1,NR
      FI=I
      DO 621 J=1,MC
      FJ=J
      DATVEC(1)=DATVEC(1)+((FJ-1.0)*X(I,J))
      DATVEC(2)=DATVEC(2)+((FI-1.0)*X(I,J))
  621 DATVEC(3)=DATVEC(3)+X(I,J)
C     NEXT CALCULATE COEFFICIENTS OF LEVELING PLANE BY MATRIX INVERSION
C     CALL SUBROUTINE FOR INVERSION TO OBTAIN COLUMN VECTOR COVEC( ).
      CALL MATINV(APMAT.COVEC,3,3)
C     CALCULATE RESIDUAL VALUES FROM PLANE
      DO 622 I=1,NR
      FI = I
      DO 622 J=1,MC
      FJ=J
      X(I,J)=X(I,J)-(COVEC(1)*(FJ-1.0)) - (COVEC(2)*(FI-1.0))-COVEC(3)
  622 CONTINUE
      IF (JPLAN.NE.1 .OR. JDTOP.NE.0) GO TO 660
      JDTOP = 2
      GO TO 661
  660 IF(JPLAN.NE.2. OR.JDTOP.NE.2) GO TO 659
      JPLAN=1
  661 DO 658 I=1,NR
      DO 658 J=1,MC
  658 XS(I,J)=X(I,J)
      GO TO 9930
  659 CONTINUE
      FN4=N4
      FM4=M4
C     CALCULATE TRIGONOMETRIC ARRAY VALUES IF ITRGOP = 1
      IF(ITRGOP.NE.1) GO TO 752
C     CALCULATE VALUES FOR (N-1)/2 AND (M-1)/2 ELEMENTS OF TRIG ARRAYS,
C     FILLING MIDROWS, MIDCOLUMNS,AND ANY REMAINING ELEMENTS BY
C     ASSIGNMENT
      DO 715 N=2,NT
      FN=N
      XNPL=(FN-1.0)*PL
      DO 715 I=1,N9
      FI=I
      ARGNI= XNPL*(FN4-FI)
      TCOSNI(N,I)=   COS(ARGNI)
  715 TSINNI(N,I)=   SIN(ARGNI)
      DO 739 M=2,MT
      FM1=M-1
      XMPH=FM1*PH
      DO 739 J=1,M9
      FJ=J
      ARGMJ = XMPH * (FM4-FJ)
      TCOSMJ(M,J)=COS(ARGMJ)
  739 TSINMJ(M,J)=SIN(ARGMJ)
  752 CONTINUE
C     FILL OTHER QUARTER OF TRIGONOMETRIC ARRAYS INDEXED ON N AND I
      DO 716 N=2,NTT,2
      DO 716 I=2,N8
      N7I=N7-I
```

```
      TCOSNI(N,N7I)=-TCOSNI(N,I)
  716 TSINNI(N,N7I)= TSINNI(N,I)
      IF(NTT.LT.NT) NTTT=NT
      IF(NTT.EQ.NT) NTTT=NT-1
      DO 717 N=3,NTTT,2
      DO 717 I= 2,N8
      N7I=N7-I
      TCOSNI(N,N7I)=TCOSNI(N,I)
  717 TSINNI(N,N7I)=-TSINNI(N,I)
C     FILL TCOSNI AND TSINNI ROW AND COLUMN WHERE ZERO ARGUMENTS EXIST
      DO 722 I=1,N2
      TCOSNI(1,I)=1.0
  722 TSINNI(1,I)=0.0
C     FILL OTHER QUARTER OF MJ TRIGONOMETRIC ARRAY
      DO 740 M=2,MTT,2
      DO 740 J=2,M8
      M7J=M7-J
      TCOSMJ(M,M7J)=-TCOSMJ(M,J)
  740 TSINMJ(M,M7J)=TSINMJ(M,J)
      IF(MTT.LT.MT) MTTT=MT
      IF(MTT.EQ.MT) MTTT=MT-1
      DO 741 M=3,MTTT,2
      DO 741 J=2,M8
      M7J=M7-J
      TCOSMJ(M,M7J)=TCOSMJ(M,J)
  741 TSINMJ(M,M7J)=-TSINMJ(M,J)
C     FILL TCOSMJ AND TSINMJ ROW AND COLUMN WHERE ZERO ARGUMENTS EXIST
      DO 746 J=1,M2
      TCOSMJ(1,J)=1.0
  746 TSINMJ(1,J)=0.0
      IF(JAROP.NE.1) GO TO 956
C     OUTPUT TRIG ARRAYS ACCORDING TO OPTIONS
      WRITE (6,1) LA
      WRITE(6,2)
      DO 915 J=1,M9
      IF (IPCHOP .EQ. 2)WRITE(ICD,33) (TCOSMJ(M,J),M=1,MT)
      IF (IPCHOP .EQ. 1) WRITE (6,35) (TCOSMJ(M,J),M=1,MT)
  915 CONTINUE
      WRITE (6,1) LA
      WRITE(6,3)
      DO 928 J=1,M9
      IF (IPCHOP .EQ. 2)WRITE(ICD,33) (TSINMJ(M,J),M=1,MT)
      IF (IPCHOP .EQ. 1) WRITE (6,35) (TSINMJ(M,J),M=1,MT)
  928 CONTINUE
      WRITE (6,1) LA
      WRITE(6,5)
      DO 942 I=1,N9
      IF (IPCHOP .EQ. 2)WRITE(ICD,33) (TCOSNI(N,I),N=1,NT)
      IF (IPCHOP .EQ. 1) WRITE (6,35) (TCOSNI(N,I),N=1,NT)
  942 CONTINUE
      WRITE (6,1) LA
      WRITE(6,6)
      DO 955 I=1,N9
      IF (IPCHOP .EQ. 2)WRITE(ICD,33) (TSINNI(N,I),N=1,NT)
      IF (IPCHOP .EQ. 1) WRITE (6,35) (TSINNI(N,I),N=1,NT)
  955 CONTINUE
C     COMPUTE FOURIER COEFFICIENTS
  956 DO 1026 M=1,MT
      DO 1026 N=1,NT
      A(M,N)=0.0
      B(M,N)=0.0
```

```
          C(M,N)=0.0
          D(M,N)=0.0
          DO 1019 I=2,N2
          II=N3-I
          DO 1019 J=2,M2
          JJ=M3-J
          A(M,N)=A(M,N)+ ((X(I,J)+X(II,J)+X(I,JJ)+X(II,JJ))*
         1   (TCOSMJ(M,J)*TCOSNI(N,I)))
          IF(M.EQ.1) GO TO 1015
          B(M,N)=B(M,N)+ ((X(I,J)+X(II,J)-X(I,JJ)-X(II,JJ))*
         1   (TSINMJ(M,J)*TCOSNI(N,I)))
     1015 IF(N.EQ.1) GO TO 1019
          C(M,N)=C(M,N)+ ((X(I,J)-X(II,J)+X(I,JJ)-X(II,JJ))*
         1   (TCOSMJ(M,J)*TSINNI(N,I)))
          IF(M.EQ.1) GO TO 1019
          D(M,N)=D(M,N)+ ((X(I,J)-X(II,J)-X(I,JJ)+X(II,JJ))*
         1   (TSINMJ(M,J)*TSINNI(N,I)))
     1019 CONTINUE
    C     COMMENT CALC VALUES FOR TOP AND BOTTOM ROWS OF DATA ARRAY,
    C     OMITTING THOSE IN FIRST, MID AND LAST COLUMNS
          DO 1022 J=2,M2
          JJ=M3-J
          A(M,N)=A(M,N) + (0.5*(X(1,J)+X(1,JJ)+X(NR,J)+X(NR,JJ))*
         1   TCOSMJ(M,J)*TCOSNI(N,1))
          IF(M.EQ.1) GO TO 1023
          B(M,N)=B(M,N) + (0.5*(X(1,J)-X(1,JJ)+X(NR,J)-X(NR,JJ))*
         1TSINMJ(M,J)*TCOSNI(N,1))
     1023 IF(N.EQ.1) GO TO 1022
          C(M,N)=C(M,N) + (0.5*(X(1,J)+X(1,JJ)-X(NR,J)-X(NR,JJ))*
         1   TCOSMJ(M,J)*TSINNI(N,1))
          IF(M.EQ.1) GO TO 1022
          D(M,N)=D(M,N) + (0.5*(X(1,J)-X(1,JJ)-X(NR,J)+X(NR,JJ))*
         1TSINMJ(M,J)*TSINNI(N,1))
     1022 CONTINUE
    C     COMMENT CALC VALUES FOR FIRST AND LAST COLUMNS OF DATA ARRAY,
    C     OMITTING THOSE IN TOP,MID AND BOTTOM ROWS
          DO 1025 I=2,N2
          II=N3-I
          A(M,N)=A(M,N) + (0.5*(X(I,1)+X(II,1)+X(I,MC)+X(II,MC))*
         1   TCOSMJ(M,1)*TCOSNI(N,I))
          IF (M.EQ.1) GO TO 1024
          B(M,N)=B(M,N) + (0.5*(X(I,1)+X(II,1)-X(I,MC)-X(II,MC))*
         1   TSINMJ(M,1)*TCOSNI(N,I))
     1024 IF(N.EQ.1) GO TO 1025
          C(M,N)=C(M,N) + (0.5*(X(I,1)-X(II,1)+X(I,MC)-X(II,MC))*
         1   TCOSMJ(M,1)*TSINNI(N,I))
          IF(M.EQ.1) GO TO 1025
          D(M,N)=D(M,N) + (0.5*(X(I,1)-X(II,1)-X(I,MC)+X(II,MC))*
         1   TSINMJ(M,1)*TSINNI(N,I))
     1025 CONTINUE
    C     COMMENT CALC VALUES FOR FOUR CORNERS OF DATA ARRAY
          A(M,N)=A(M,N) + (0.25*(X(1,1)+X(1,MC)+X(NR,1)+X(NR,MC))*
         1   TCOSMJ(M,1)*TCOSNI(N,1))
          IF(M.EQ.1) GO TO 1027
          B(M,N)=B(M,N) + (0.25*(X(1,1)-X(1,MC)+X(NR,1)-X(NR,MC))*
         1   TSINMJ(M,1)*TCOSNI(N,1))
     1027 IF(N.EQ.1) GO TO 1028
          C(M,N)=C(M,N) + (0.25*(X(1,1)+X(1,MC)-X(NR,1)-X(NR,MC))*
         1   TCOSMJ(M,1)*TSINNI(N,1))
          IF(M.EQ.1) GO TO 1028
          D(M,N)=D(M,N) + (0.25*(X(1,1)-X(1,MC)-X(NR,1)+X(NR,MC))*
```

```
      1   TSINMJ(M,1)*TSINNI(N,1))
 1028 CONTINUE
C     COMMENT CALC VALUES FOR MID-COLUMN AND MIDROW, OMITTING THOSE AT
C     EDGES AND CENTER OF DATA ARRAY
      DO 1030 J=2,M2
      JJ = M3-J
      A(M,N)=A(M,N) +((X(N4,J) + X(N4,JJ))*TCOSMJ(M,J))
      IF(M.EQ.1) GO TO 1030
      B(M,N)=B(M,N) + ((X(N4,J) - X(N4,JJ))*TSINMJ(M,J))
 1030 CONTINUE
      DO 1031 I=2,N2
      II = N3-I
      A(M,N)=A(M,N) +((X(I,M4) + X(II,M4))*TCOSNI(N,I))
      IF(N.EQ.1) GO TO 1031
      C(M,N)=C(M,N) +((X(I,M4) - X(II,M4))*TSINNI(N,I))
 1031 CONTINUE
C     COMMENT CALC VALUE FOR MIDPOINT
      A(M,N)=A(M,N) + X(N4,M4)
C     COMMENT CALC VALUES IN MID-COLUMN AND MIDROW ON OUTER EDGES
C     OF DATA ARRAY
      A(M,N)=A(M,N) +(0.5*(X(1,M4) + X(NR,M4))*TCOSNI(N,1))
      A(M,N)=A(M,N) + (0.5*(X(N4,1) + X(N4,MC))*TCOSMJ(M,1))
      IF(M.EQ.1) GO TO 1033
      B(M,N)=B(M,N) + (0.5*(X(N4,1) - X(N4,MC))*TSINMJ(M,1))
 1033 IF(N.EQ.1) GO TO 1032
      C(M,N)=C(M,N) + (0.5*(X(1,M4) + X(NR,M4))*TSINNI(N,1))
 1032 CONTINUE
C     COMMENT MULTIPLY BY RECIPROCAL OF L TIMES H
      A(M,N) = RLH*A(M,N)
      B(M,N) = RLH*B(M,N)
      C(M,N) = RLH*C(M,N)
      D(M,N) = RLH*D(M,N)
C     COMMENT COMPUTE VECTOR MAGNITUDE VALUES
      PS(M,N) = SQRT(((A(M,N)*A(M,N))+(B(M,N)*B(M,N))+(C(M,N)*C(M,N))
     1  +(D(M,N)*D(M,N))))
 1026 CONTINUE
C     COMPUTE ZERO/ZERO POWER SPECTRUM SQUAREROOT VALUE
      PS(1,1) = PS(1,1)*0.25
C     OUTPUT COEFFICIENT ARRAYS AND POWER SPECTRUM SQUARE ROOTS
      WRITE(6,8)
      DO 1101 N=1,NT
 1101 WRITE (6,23)  (A(M,N), M=1,MT)
      WRITE(6,9)
      DO 1102 N=1,NT
 1102 WRITE (6,23)  (B(M,N), M=1,MT)
      WRITE(6,10)
      DO 1103 N=1,NT
 1103 WRITE (6,23)  (C(M,N), M=1,MT)
      WRITE(6,11)
      DO 1104 N=1,NT
 1104 WRITE (6,23)  (D(M,N), M=1,MT)
      WRITE(6,12)
      DO 1105 N=1,NT
 1105 WRITE (6,23) (PS(M,N), M=1,MT)
      IF(JCOFOP.NE.2) GO TO 1119
      DO 1111 N=1,NT
 1111 WRITE (ICD,22)  (A(M,N), M=1,MT)
      DO 1112 N=1,NT
 1112 WRITE (ICD,22)  (B(M,N), M=1,MT)
      DO 1113 N=1,NT
 1113 WRITE (ICD,22)  (C(M,N), M=1,MT)
```

```
      DO 1114 N=1,NT
 1114 WRITE (ICD,22)  (D(M,N), M=1,MT)
      DO 1115 N=1,NT
 1115 WRITE (ICD,22) (PS(M,N), M=1,MT)
 1119 CONTINUE
C     COMMENT CALCULATE SUM OF DATA VALUES AND SUM OF SQUARED DATA VALUES
C     COMMENT CLEAR DATA ARRAY,XS(I,J)TO ZERO TO USE FOR STORAGE OF
C     EVALUATED FOURIER SERIES TO NT AND MT ORDER
      JPLAN = 0
      IF(JVALOP.NE.1) GO TO 2334
      DO 1202 I=1,NR
      DO 1202 J=1,MC
 1202 XS(I,J)=0.0
C     COMMENT THIS SECTION RESTORES TILT TO ORIGINAL DATA AND TO
C     FOURIER TRANSFORM VALUES AT DATA POINTS
      IF(JTILT.NE.2) GO TO 1210
      DO 1759 I=1,NR
      DO 1759 J=1,MC
      X(I,J)=X(I,J)+COVEC(1)*FLOAT(J-1)+COVEC(2)*FLOAT(I-1)+COVEC(3)
      XS(I,J)=XS(I,J)+COVEC(1)*FLOAT(J-1)+COVEC(2)*FLOAT(I-1)+COVEC(3)
 1759 CONTINUE
 1210 SUMX=0.0
      SUMY2=0.0
      DO 1290 I=1,NR
      DO 1290 J=1,MC
      SUMX =SUMX  +  X(I,J)
 1290 SUMY2=SUMY2+X(I,J)*X(I,J)
      GRID= FNR*FMC
      ZOR=SUMY2-SUMX*SUMX/GRID
C     COMMENT EVALUATE FOURIER SERIES AT EACH GRID POINT IF JVALOP = 1
C     COMMENT EVLAUATE FOURIER SERIES FOR IR DIFFERENT NUMBERS OF TERMS
C     AS SPECIFIED IN NTERM( ) ARRAYS
      IQ = 0
      LSTMT=0
      LSTNT=0
 4000 CONTINUE
      IQ = IQ + 1
      ISTMT= LSTMT+1
      ISTNT= LSTNT+1
      LSTMT= MTERM(IQ)
      LSTNT= NTERM(IQ)
      TWO = .FALSE.
      IF (ISTMT.GT.LSTMT .OR. ISTNT.EQ.1) GO TO 1730
      IM = ISTMT
      LM = LSTMT
      IN = 1
      LN = ISTNT - 1
      GO TO 1680
 1681 IM = 1
      LM = LSTMT
      IN = ISTNT
      LN = LSTNT
      TWO = .TRUE.
 1680 K=0
      SUMVAL=0.0
      SMVAL2=0.0
      DO 1740 I=1,N2
      L=0
      K=K+2
      IB=I+N4
```

```
      II=IB-K
      DO 1740 J=1,M2
      L=L+2
      JB=J+M4
      JJ=JB-L
      DO 1740 M=IM,LM
      IF(M.NE.1) GO TO 1690
      P=1
      GO TO 1691
 1690 P=2
 1691 DO 1740 N=IN,LN
      IF(N.NE.1) GO TO 1692
      Q=1
      GO TO 1693
 1692 Q=2
 1693 CONTINUE
      XS(I,J) =XS(I,J) +(ALAM(P,Q)*( TCOSNI(N,I)*((A(M,N)*
     1 TCOSMJ(M,J)) + (B(M,N)*TSINMJ(M,J))) + (TSINNI(N,I)*
     2  ((C(M,N)*TCOSMJ(M,J)) + (D(M,N)*TSINMJ(M,J))))))
      XS(IB,JB)=XS(IB,JB)+(ALAM(P,Q)* (TCOSNI(N,II)*((A(M,N)*
     1   TCOSMJ(M,JJ))-(B(M,N)*TSINMJ(M,JJ)))-(TSINNI(N,II)*
     2   ((C(M,N)*TCOSMJ(M,JJ)) - (D(M,N)*TSINMJ(M,JJ))))))
      XS(IB,J )=XS(IB,J )+(ALAM(P,Q)*(TCOSNI(N,II)*((A(M,N)*
     1   TCOSMJ(M,J))+ (B(M,N)*TSINMJ(M,J )))-(TSINNI(N,II)*
     2   ((C(M,N)*TCOSMJ(M,J )) + (D(M,N)*TSINMJ(M,J))))))
      XS(I ,JB)=XS(I ,JB)+(ALAM(P,Q)*(TCOSNI(N,I )*((A(M,N)*
     1 TCOSMJ(M,JJ))-(B(M,N)*TSINMJ(M,JJ))) +(TSINNI(N,I)*
     2 ((C(M,N)*TCOSMJ(M,JJ)) - (D(M,N)*TSINMJ(M,JJ))))))
 1740 CONTINUE
      DO 1729 M=IM,LM
      IF(M.NE.1) GO TO 1694
      P=1
      GO TO 1695
 1694 P=2
 1695 DO 1729 N=IN,LN
      IF(N.NE.1) GO TO 1696
      Q=1
      GO TO 1697
 1696 Q=2
 1697 K=0
      DO 1717 I=1,N2
      K=K+2
      IB=I+N4
      II=IB-K
      XS(I,M4)=XS(I,M4)+(ALAM(P,Q)*((TCOSNI(N,I)*A(M,N))+
     1   (TSINNI(N,I)*C(M,N))))
      XS(IB,M4)=XS(IB,M4)+(ALAM(P,Q)*((TCOSNI(N,II)*A(M,N))-
     1  (TSINNI(N,II)*C(M,N))))
 1717 CONTINUE
      K=0
      DO 1727 J=1,M2
      K=K+2
      JB=J+M4
      JJ=JB-K
      XS(N4,J) = XS(N4,J) + (ALAM(P,Q)* ((A(M,N)*TCOSMJ(M,J))
     1  + (B(M,N)*TSINMJ(M,J))))
      XS(N4,JB) = XS(N4,JB) + (ALAM(P,Q)*((A(M,N)*TCOSMJ(M,JJ))
     1  - (B(M,N)*TSINMJ(M,JJ))))
 1727 CONTINUE
      XS(N4,M4) = XS(N4,M4) + (ALAM(P,Q)*A(M,N))
 1729 CONTINUE
```

```
 1730 IF (ISTNT.LE.LSTNT .AND. .NOT.TWO) GO TO 1681
C     COMPUTE TOTAL SUM OF SQUARES
      DO 1737 I=1,NR
      DO 1737 J=1,MC
 1737 SUMVAL = SUMVAL + (X(I,J)-XS(I,J))**2
      PCTS=100.0*(1.0 -(SUMVAL/ZOR))
      IF(JPRTOP.EQ.1) GO TO 9930
      WRITE (6,1) LA
      WRITE(6,15)MC,NR,LSTMT,LSTNT,PCTS,SCALE
      GO TO 1847
C  PLOT STRIP MAPS OF OBSERVED DATA VALUES, LEVELLED DATA VALUES, OR
C  EVALUATED DOUBLE FOURIER SERIES
 9930 DO 9931 K=1,4
      WRITE (6,1) LA
      IF (JDTOP.NE.1) GO TO 9932
      WRITE(6,29) NR,MC,SCALE
      GO TO 9933
 9932 IF (JPLAN.NE.1) GO TO 9934
      WRITE(6,7)
      GO TO 9933
 9934 WRITE(6,15) MC,NR,LSTMT,LSTNT,PCTS,SCALE
 9933 GO TO (9917,9918,9919,9921), K
 9917 WRITE(6,17)
      GO TO 9935
 9918 WRITE(6,18)
      GO TO 9935
 9919 WRITE(6,19)
      GO TO 9935
 9921 WRITE(6,21)
 9935 M=26*K - 25
      MH = MIN0(M+25,MC)
      DO 9936 I=1,NR
      DO 9937 J=M,MH
 9937 LINE(J) = XS(I,J)
 9936 WRITE(6,16) (LINE(J),J=M,MH)
      IF (MH.EQ.MC) GO TO 1845
 9931 CONTINUE
 1845 CONTINUE
      IF(JDTOP.NE.1) GO TO 1846
      JDTOP=2
      GO TO 535
 1846 IF(JPLAN.EQ.1) GO TO 659
 1847 CONTINUE
C     IF JRESOP=1, CALCULATE AND PRINT RESIDUALS
      IF(JRESOP.NE.1) GO TO 1949
      DO 1901 K=1,4
      WRITE (6,1) LA
      WRITE(6,25) MC,NR,LSTMT,LSTNT,SCALE
      GO TO (1917,1918,1919,1921), K
 1917 WRITE(6,17)
      GO TO 1902
 1918 WRITE(6,18)
      GO TO 1902
 1919 WRITE(6,19)
      GO TO 1902
 1921 WRITE(6,21)
 1902 M = 26*K - 25
      MH = MIN0(M+25,MC)
      DO 1903 I=1,NR
      DO 1904 J=M,MH
 1904 LINE(J)=X(I,J)-XS(I,J)
```

```
 1903 WRITE(6,16) (LINE(J),J=M,MH)
      IF (MH.EQ.MC) GO TO 1949
 1901 CONTINUE
 1949 CONTINUE
C     PRINT PROFILES IF JPROF =1
      IF(JPROF.NE.1) GO TO 2333
      DIFF = TOP-BASE
      BD=BASE/DIFF
C     PRINT HORIZONTAL PROFILES
      IF (HP.EQ.0) GO TO 3598
      DO 2220 I=1,HP
      IH=IVALS(I)
      WRITE (6,1) LA
      WRITE (6,26) IH
      WRITE(6,47)    TOP,BASE,VSCALE,AMP,LSTMT,LSTNT
      WRITE(6,46)
      DO 2220 J=1,MC
      K=M4-J
      IT= ((X(IH,J)/DIFF)-BD)*VSCALE
      IF(IT.GT.30) IT=30
      IF(IT.LT.0) IT=0
      KCAL=((XS(IH,J)/DIFF)-BD)*VSCALE
      KB1= 30-IT
      IF(KCAL.GT.30) KCAL=30
      IF(KCAL.LT.0) KCAL=0
      KB2= 30-KCAL
      RESID = X(IH,J)-XS(IH,J)
      KRES=(RESID*AMP)+15.0
      IF(KRES.GT.30) KRES=30
      IF(KRES.LT.0) KRES=0
C     FILL PLTAST( )ARRAY FOR PLOTTING OF ASTERISKS
      DO 3500 JJ=1,IT
 3500 ASTPLT(JJ)=BL
      IT1=IT+1
      ASTPLT(IT1)=AST
      IT2=IT+2
      KBT=KB1+IT1
      DO 3501 JJ=IT2,KBT
 3501 ASTPLT(JJ)=BL
      KBT=KBT+1
      ASTPLT(KBT)=BI
      KCAL=KCAL+KBT
      KBT=KBT+1
      DO 3502 JJ=KBT,KCAL
 3502 ASTPLT(JJ)=BL
      KBT=KCAL+1
      ASTPLT(KBT)=AST
      KB2=KBT+KB2
      KBT=KBT+1
      DO 3503 JJ=KBT,KB2
 3503 ASTPLT(JJ)=BL
      KBT=KB2+1
      ASTPLT(KBT)=BI
      KRES=KRES+KBT
      KBT=KBT+1
      DO 3504 JJ=KBT,KRES
 3504 ASTPLT(JJ)=BL
      KBT=KRES+1
      ASTPLT(KBT)=AST
      KBT=KBT+1
```

```
      IF (KBT .GT. 95) GO TO 2220
      DO 3505 JJ=KBT,95
 3505 ASTPLT(JJ)=BL
 2220 WRITE(6,27) X(IH,J),XS(IH,J),RESID,K, ASTPLT
C     PRINT VERTICAL PROFILES
 3598 IF (VP.EQ.0) GO TO 3698
      DO 2221 J=1,VP
      WRITE (6,1) LA
      IH=JVALS(J)
      WRITE (6,28) IH
      WRITE(6,47)                TOP,BASE,VSCALE,AMP,LSTMT,LSTNT
      WRITE (6,46)
      DO 2221 I=1,NR
      K=N4-I
      IT=(((X(I,IH)/DIFF)-BD)*VSCALE)
      IF(IT.GT.30) IT=30
      IF(IT.LT.0) IT=0
      KCAL=((XS(I,IH)/DIFF)-BD)*VSCALE
      KB1=30-IT
      IF(KCAL.GT.30) KCAL=30
      IF(KCAL.LT. 0)KCAL=0
      KB2=30-KCAL
      RESID=X(I,IH)-XS(I,IH)
      KRES=RESID*AMP + 15.0
      IF(KRES.GT.30) KRES=30
      IF(KRES.LT.0) KRES=0
C     FILL PLTAST( ) ARRAY FOR PLOTTING OF ASTERISKS
      DO 3600 JJ=1,IT
 3600 ASTPLT(JJ)=BL
      IT1=IT+1
      ASTPLT(IT1)=AST
      IT2=IT+2
      KBT=KB1+IT1
      DO 3601 JJ=IT2,KBT
 3601 ASTPLT(JJ)=BL
      KBT=KBT+1
      ASTPLT(KBT)=BI
      KCAL=KCAL+KBT
      KBT=KBT+1
      DO 3602 JJ=KBT,KCAL
 3602 ASTPLT(JJ)=BL
      KBT=KCAL+1
      ASTPLT(KBT)=AST
      KB2=KBT+KB2
      KBT=KBT+1
      DO 3603 JJ=KBT,KB2
 3603 ASTPLT(JJ)=BL
      KBT=KB2+1
      ASTPLT(KBT)=BI
      KRES=KRES+KBT
      KBT=KBT+1
      DO 3604 JJ=KBT,KRES
 3604 ASTPLT(JJ)=BL
      KBT=KRES+1
      ASTPLT(KBT)=AST
      KBT=KBT+1
      IF (KBT .GT. 95) GO TO 2221
      DO 3605 JJ=KBT,95
 3605 ASTPLT(JJ)=BL
 2221 WRITE (6,27) X(I,IH),XS(I,IH),RESID,K,ASTPLT
```

```
 2333 CONTINUE
 3698 IF (IQ .LT. IR) GO TO 4000
 2334 NMRUNS=NMRUNS+1
      IF (NMRUNS .GT. NUMBER) CALL EXIT
      GO TO 5000
      END
```

```
      SUBROUTINE MATINV(A,B,N,NS)
C
C     OF ORDER N, BY THE GAUSS-JORDAN METHOD. A-INVERSE REPLACES A
C     THE VECTOR B CONTAINS THE CONSTANT VECTOR WHEN MATINV IS
C     CALLED, AND THIS IS REPLACED WITH THE SOLUTION VECTOR.
C     N IS NOT TO EXCEED 20.
C     A, N, AND B IN THE ARGUMENT LIST ARE DUMMY VARIABLES
C
      DIMENSION IPIVOT(50),INDEX(50,2)
      DIMENSION A(NS,NS),B(NS),PIVOT(50)
      EQUIVALENCE(IROW,JROW),(ICOLUM,JCOLUM),(AMAX,T,SWAP)
C     INITIALIZATION
      DO 20 J=1,N
   20 IPIVOT(J)=0
      DO 550 I=1,N
C     SEARCH FOR PIVOT ELEMENT
      AMAX=0.
      DO 105 J=1,N
      IF(IPIVOT(J)-1)60,105,60
   60 DO 100 K=1,N
      IF(IPIVOT(K)-1)80,100,740
   80 IF (ABS(AMAX)-ABS(A(J,K))) 85,100,100
   85 IROW=J
      ICOLUM=K
      AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C     INTERCHANGE ROWS TO PUT PIVOT ELEMNT ON DIAGONAL
      IF(IROW-ICOLUM)140,260,140
  140 DO 200 L=1,N
      SWAP=A(IROW,L)
      A(IROW,L)=A(ICOLUM,L)
  200 A(ICOLUM,L)=SWAP
      SWAP = B(IROW)
      B(IROW) = B(ICOLUM)
      B(ICOLUM) = SWAP
  260 INDEX(I,1)=IROW
      INDEX(I,2)=ICOLUM
      PIVOT(I)=A(ICOLUM,ICOLUM)
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
      A(ICOLUM,ICOLUM)=1.
      DO 350 L=1,N
```

```
  350 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
      B(ICOLUM) = B(ICOLUM) / PIVOT(I)
C     REDUCE NON-PIVOT ROWS
  380 DO 550 L1=1,N
      IF(L1-ICOLUM)400,550,400
  400 T=A(L1,ICOLUM)
      A(L1,ICOLUM)=0.
      DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
      B(L1) = B(L1) - B(ICOLUM)*T
  550 CONTINUE
C     INTERCHANGE COLUMNS
      DO 710 I=1,N
      L=N+1-I
      IF(INDEX(L,1)-INDEX(L,2))630,710,630
  630 JROW=INDEX(L,1)
      JCOLUM=INDEX(L,2)
      DO 705 K=1,N
      SWAP=A(K,JROW)
      A(K,JROW)=A(K,JCOLUM)
      A(K,JCOLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 RETURN
      END
```

Table 2.– Listing of example input data used to obtain output listed in Table 3. Each line represents a card.

```
     1
*  I    1.00 31 25  5  5  1  1  2  1  1  1  1  1  0  1  1  2  1  1
TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1
     1
     5
     5
  4000.00   -2000.00       0.02      30.00          1          1
   15
   12
   23.7500    -9.4705   -31.9506   -13.7170    28.4269    46.7962    15.7500   -33.8360
  -38.4295    34.7266   146.4506   211.0958   169.7499    44.4083   -78.2570  -119.7830
  -73.0705     0.2659    31.7500     6.3341   -33.9269   -40.2267    -7.2430    26.4060
   23.7500
    1.2480    -0.7639    -2.9288    -3.2206    -1.6179    -0.4109    -2.0634    -6.6353
  -11.3292   -12.7450    -9.8065    -4.6382    -0.6055     0.5924     0.0588     0.1449
    1.8980     4.0680     4.5594     2.7298     0.1382    -1.0090    -0.0879     1.3510
    1.2480
  -22.1925     8.9446    28.5818     9.3627   -31.2124   -47.8086   -18.1457    25.9395
   23.8190   -52.5850  -161.5206  -219.0329  -170.6374   -41.7620    80.9778   121.8046
   75.8619     4.4156   -26.2394    -2.4344    34.8493    39.2833     6.8338   -25.1516
  -22.1926
  -26.6869    11.7371    36.0726    13.1337   -35.7868   -55.5265   -18.6869    36.5932
   36.9434   -52.3067  -181.9416  -251.7014  -196.1821   -45.3782    97.7005   143.2368
   86.3041     0.6692   -34.6869    -4.4440    41.2867    46.6837     7.4209   -30.9398
  -26.6869
   -6.4192     4.7760    10.8076     3.7125    -9.3416   -13.1755    -1.5119    14.1415
   14.1456    -9.3568   -41.9269   -57.3439   -40.5801    -1.9925    30.9132    36.8700
   17.9784    -4.6212   -11.3266    -0.9215    11.4907    11.6437     0.3183    -9.1849
   -6.4192
   25.0477    -7.2053   -30.3879   -12.9878    29.8529    50.4299    21.5836   -26.8819
  -30.5728    45.2430   161.9519   231.4733   190.7887    59.5687   -73.5693  -124.9065
  -82.6087    -7.5306    28.5118     6.1876   -34.1830   -42.1808    -9.7654    25.4401
   25.0478
   43.8292   -14.9621   -56.2302   -24.6247    51.4936    86.5887    32.9231   -55.5561
  -64.1876    68.1029   272.3838   393.3487   321.4016    93.0961  -135.1476  -218.1235
 -138.5276    -5.7094    54.7354    11.8643   -60.6264   -73.7334   -15.2816    46.4742
   43.8293
   33.3798   -11.4506   -43.9887   -21.5532    35.5589    62.6948    22.1725   -47.1590
  -58.8627    35.5507   187.5093   281.7429   234.4169    69.7274   -97.4890  -158.6462
  -99.4073    -0.3735    44.5872    11.7715   -43.8091   -54.8722   -11.5147    35.1206
   33.3798
   -1.4743     2.4054     1.4767    -4.9123   -10.7442   -10.0524    -4.5474    -3.5144
  -14.8817   -35.7492   -52.2427   -50.1617   -27.3741     3.4184    24.4459    26.6578
   15.4891     4.1785     1.5988     5.9184     8.9810     5.7951    -0.7356    -3.9920
   -1.4743
  -34.5729    17.1070    46.7254    12.3091   -53.9986   -77.8500   -26.5729    43.8050
   34.5035   -95.1899  -271.4541  -356.5585  -267.1558   -52.1568   144.1232   201.8919
  120.2879     3.3721   -42.5729    -0.4874    59.4986    63.2803     8.3139   -42.3975
  -34.5729
  -33.8446    20.0268    49.2121    12.7026   -54.4651   -76.2448   -21.3086    51.3514
   41.6067   -89.3796  -264.5711  -345.3073  -251.2420   -35.9313   154.3179   202.6134
  113.7811    -4.3007   -46.3805     0.0684    61.1349    62.8007     5.7013   -44.4574
  -33.8446
   17.0902     3.7065   -14.3000   -13.9379     7.1654    26.3743    20.1811    -7.5875
  -24.3012     1.2828    65.1275   124.6829   132.6960    78.5185    -1.2971   -53.4870
  -51.9784   -15.6799    13.9994    12.3813    -9.8049   -23.3350   -12.8437     8.8154
   17.0902
```

105.1890	-28.3394	-128.7938	-62.2994	113.6060	202.1038	84.8783	-122.0178
-152.8399	144.7900	623.2530	923.7742	779.5943	258.7927	-282.3591	-497.8032
-330.5818	-24.3228	125.4998	34.5899	-134.4943	-172.5510	-42.0049	104.2296
105.1891							
191.8821	-62.3398	-244.8525	-112.3669	216.9064	372.6844	142.9056	-244.4543
-292.3239	271.5666	1157.5930	1695.0824	1401.8507	424.9572	-564.0974	-932.8117
-597.1133	-24.2033	240.8586	58.0780	-257.5424	-319.0056	-68.7479	200.1320
191.8822							
233.4031	-81.4940	-304.5298	-139.6027	264.1974	451.1854	163.7033	-315.2358
-375.6287	313.3057	1393.6456	2044.8924	1682.2596	491.8305	-703.8224	-1137.2126
-714.8726	-13.4901	303.1029	71.6502	-316.4935	-388.4724	-79.2345	248.3736
233.4033							
205.7499	-75.5193	-274.2735	-128.7077	228.1295	391.8551	133.7499	-296.0641
-357.5782	243.2851	1192.7735	1768.6156	1455.7498	417.6724	-622.7441	-992.7923
-613.9219	3.9916	277.7500	67.6855	-277.6294	-340.7852	-66.7560	221.7627
205.7501							
119.0905	-46.7160	-164.9074	-82.6730	123.3829	217.7153	64.9554	-192.5125
-241.4035	93.1666	636.2030	974.3337	809.0922	229.6447	-353.1657	-555.5957
-333.4799	20.6314	173.2257	46.6084	-156.2232	-193.9830	-35.8521	130.2979
119.0906							
12.6226	-8.7876	-26.2417	-21.5170	-1.0950	8.6291	-11.5902	-51.5896
-77.9595	-64.4627	-17.8391	26.5626	36.1515	10.0610	-21.5853	-26.8921
-1.5756	29.1886	36.8354	16.9241	-8.5866	-15.0709	-0.0216	16.0695
12.6226							
-67.1612	20.9015	80.6187	28.6436	-89.5646	-143.2163	-62.8505	64.3621
62.1127	-157.3356	-478.6878	-656.9816	-525.3435	-148.6667	222.4243	359.1803
236.1974	26.7472	-71.4720	-9.2778	99.4529	117.2638	25.6609	-70.2330
-67.1612							
-91.7123	30.9262	116.5713	49.6563	-110.0369	-183.5323	-71.6811	111.7040
126.6186	-153.4077	-582.0333	-832.8879	-677.1237	-193.4196	288.4385	463.4032
295.8383	16.1059	-111.7435	-22.7078	128.5727	155.4844	32.6049	-97.0111
-91.7123							
-64.1554	21.4985	83.5711	40.1947	-69.6350	-121.9320	-44.6913	87.1648
107.7189	-75.4977	-368.2122	-548.2942	-454.7581	-134.9530	189.2987	308.4892
194.8933	3.8365	-83.6196	-21.4002	84.9650	106.0765	22.6821	-67.1257
-64.1555							
-13.9271	3.0484	18.8361	14.4680	-6.3194	-19.4065	-5.9271	24.9243
40.8913	17.0796	-37.1075	-82.0394	-81.3443	-34.4102	22.5870	48.3310
31.3172	-3.7041	-21.9272	-10.8459	11.8193	19.8299	5.9758	-12.4009
-13.9272							
23.3141	-11.0355	-30.8272	-7.8207	36.6659	52.9214	18.9981	-27.6356
-20.7546	66.9882	185.9978	243.5536	183.2925	37.8159	-95.7426	-136.2649
-82.4522	-3.9136	27.6301	0.0609	-39.9827	-42.6934	-5.9733	28.1897
23.3141							
27.3311	-12.6945	-37.6604	-13.6074	36.9299	56.7955	18.0620	-39.3629
-39.6140	52.6562	186.1119	257.2824	199.3614	44.1138	-102.0154	-147.1097
-87.1923	1.0697	36.6001	4.5453	-42.7572	-47.8819	-7.0393	32.3112
27.3311							
3.1429	-3.3379	-6.7946	-3.1560	3.5316	5.0697	-1.9510	-11.5577
-13.4442	-3.2192	12.2509	20.1830	13.3476	-3.0920	-15.9844	-15.8172
-4.7292	6.3466	8.2367	1.5085	-5.3989	-5.3175	0.6921	5.2892
3.1429							
-26.0477	8.4197	32.0481	12.3309	-33.3170	-54.0938	-22.5836	27.9393
29.1086	-53.8998	-177.6122	-247.8792	-199.7887	-57.3190	83.7653	135.5632
88.0727	7.7304	-29.5119	-4.8528	37.6471	44.8376	9.5692	-27.4265
-26.0478							
-36.8309	13.4370	47.7496	19.8040	-45.1124	-74.0503	-27.5690	47.0405
52.1839	-62.4092	-236.0199	-335.9837	-270.7403	-73.9955	119.7762	187.9144
117.9167	4.3870	-46.0929	-8.7152	52.7046	62.7528	12.2777	-39.9384
-36.8310							

-21.8131	8.4183	29.4888	13.6434	-24.5312	-41.7299	-13.8131	32.1361
38.4514	-25.8035	-126.6199	-186.8963	-152.3180	-41.1888	69.0097	106.9860
65.3010	-1.0012	-29.8131	-6.8893	30.0312	36.4265	6.8689	-23.8586
-21.8131							
6.6091	-2.2598	-7.4358	-1.0749	11.2515	16.1259	7.6170	-3.9502
-0.3828	25.6463	59.9476	76.1840	58.1874	15.0016	-25.6465	-39.9694
-26.5390	-4.4683	5.6012	-0.7973	-11.4133	-12.3328	-2.3707	7.3206
6.6091							
26.6583	-10.2276	-34.5606	-13.1034	34.6404	55.1133	20.5134	-33.1835
-34.3411	52.3455	180.2983	251.4190	199.7523	52.2765	-90.8567	-139.9514
-87.3568	-3.7203	32.8032	4.9806	-39.6619	-46.0963	-8.5065	29.5298
26.6583							
23.7500	-9.4705	-31.9506	-13.7170	28.4269	46.7963	15.7500	-33.8360
-38.4295	34.7267	146.4506	211.0959	169.7500	44.4083	-78.2571	-119.7830
-73.0705	0.2659	31.7500	6.3341	-33.9269	-40.2267	-7.2430	26.4060
23.7500							

Table 3. - Output from program obtained with data listed in Table 2.

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

PLOT OF OBSERVED DATA VALUES, NUMBER OF ROWS = 31, NUMBER OF COLUMNS = 25, SCALE FACTOR = 1.000

STRIP ONE

23	-9	-31	-13	28	46	15	-33	-38	34	146	211	169	44	-78	-119	-73	0	31	6	-33	-40	-7	26	23
1	0	-2	-3	-1	0	-2	-6	-11	-12	-9	-4	0	0	0	0	1	4	4	2	0	-1	0	1	1
-22	8	28	9	-31	-47	-18	25	23	-52	-161	-219	-170	-41	80	121	75	4	-26	-2	34	39	6	-25	-22
-26	11	36	13	-35	-55	-18	36	36	-52	-181	-251	-196	-45	97	143	86	0	-34	-4	41	46	7	-30	-26
-6	4	10	3	-9	-13	-1	14	14	-9	-41	-57	-40	-1	30	36	17	-4	-11	0	11	11	0	-9	-6
25	-7	-30	-12	29	50	21	-26	-30	45	161	231	190	59	-73	-124	-82	-7	98	6	-34	-42	-9	25	25
43	-14	-56	-24	51	86	32	-55	-64	68	272	393	321	93	-135	-218	-138	-5	54	11	-60	-73	-15	45	43
33	-11	-43	-21	35	62	22	-47	-58	35	187	281	234	69	-97	-158	-99	0	44	11	-43	-54	-11	35	33
-1	2	1	-4	-10	-10	-4	-3	-14	-35	-52	-50	-27	3	24	26	15	4	1	5	8	5	0	-3	-1
-34	17	46	12	-53	-77	-26	43	34	-95	-271	-356	-267	-52	144	201	120	3	-42	0	59	63	8	-42	-34
-33	20	49	12	-54	-76	-21	51	41	-89	-264	-345	-251	-35	154	202	113	-4	-46	0	61	62	5	-44	-33
17	3	-14	-13	7	26	20	-7	-24	1	65	124	132	78	-1	-53	-51	-15	13	12	-9	-23	-12	8	17
105	-28	-128	-62	113	202	84	-122	-152	144	623	923	779	258	-282	-497	-330	-24	125	34	-134	-172	-42	104	105
191	-62	-244	-112	216	372	142	-244	-292	271	1157	1695	1401	424	-564	-932	-597	-24	240	58	-257	-319	-68	200	191
233	-81	-304	-139	264	451	163	-315	-375	313	1393	2044	1682	491	-703	-1137	-714	-13	303	71	-316	-388	-79	248	233
205	-75	-274	-128	228	391	133	-296	-357	243	1192	1768	1455	417	-622	-992	-613	3	277	67	-277	-340	-66	221	205
119	-46	-164	-82	123	217	64	-192	-241	93	636	974	809	229	-353	-553	-333	20	173	46	-156	-193	-35	130	119
12	-8	-26	-21	-1	8	-11	-51	-77	-64	-17	26	36	10	-21	-26	-1	29	36	16	-8	-15	0	16	12
-67	20	80	28	-89	-143	-62	64	62	-157	-478	-656	-525	-148	222	359	236	26	-71	-9	99	117	25	-70	-67
-91	30	116	49	-110	-183	-71	111	126	-153	-582	-832	-677	-193	288	463	295	16	-111	-22	128	155	32	-97	-91
-64	21	83	40	-69	-121	-44	87	107	-75	-368	-548	-454	-134	189	308	194	3	-83	-21	84	106	22	-67	-64
-13	3	18	14	-6	-19	-5	24	40	17	-37	-82	-81	-34	22	48	31	-3	-21	-10	11	19	5	-12	-13
23	-11	-30	-7	36	52	18	-27	-20	66	185	243	183	37	-95	-136	-82	-3	27	0	-39	-42	-5	28	23
27	-12	-37	-13	36	56	18	-39	-39	52	186	257	199	44	-102	-147	-87	1	36	4	-42	-47	-7	32	27
3	-3	-6	-3	3	5	-1	-11	-13	-3	12	20	13	-3	-15	-15	-4	6	8	1	-5	-5	0	5	3
-26	8	32	12	-33	-54	-22	27	29	-53	-177	-247	-199	-57	83	135	88	7	-29	-4	37	44	9	-27	-26
-36	13	47	19	-45	-74	-27	47	52	-62	-236	-335	-270	-73	119	187	117	4	-46	-8	52	62	12	-39	-36
-21	8	29	13	-24	-41	-13	32	38	-25	-126	-186	-152	-41	69	106	65	-1	-29	-6	30	36	6	-23	-21
6	-2	-7	-1	11	16	7	-3	0	25	59	76	58	15	-25	-39	-26	-4	5	0	-11	-12	-2	7	6
26	-10	-34	-13	34	55	20	-33	-34	52	180	251	199	52	-90	-139	-87	-3	32	4	-39	-46	-8	29	26
23	-9	-31	-13	28	46	15	-33	-38	34	146	211	169	44	-78	-119	-73	0	31	6	-33	-40	-7	26	23

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

COSINE MJ ARRAY

1.0000	-1.0000	1.0000	-1.0000	1.0000
1.0000	-0.9659	0.8660	-0.7071	0.5000
1.0000	-0.8660	0.5000	0.0000	-0.5000
1.0000	-0.7071	-0.0000	0.7071	-1.0000
1.0000	-0.5000	-0.5000	1.0000	-0.5000
1.0000	-0.2588	-0.8660	0.7071	0.5000
1.0000	0.0000	-1.0000	-0.0000	1.0000

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

SINE MJ ARRAY

0.	0.0000	-0.0000	0.0000	-0.0000
0.	0.2588	-0.5000	0.7071	-0.8660
0.	0.5000	-0.8660	1.0000	-0.8660
0.	0.7071	-1.0000	0.7071	0.0000
0.	0.8660	-0.8660	-0.0000	0.8660
0.	0.9659	-0.5000	-0.7071	0.8660
0.	1.0000	0.0000	-1.0000	-0.0000

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

COSINE NI ARRAY

1.0000	-1.0000	1.0000	-1.0000	1.0000
1.0000	-0.9781	0.9135	-0.8090	0.6691
1.0000	-0.9135	0.6691	-0.3090	-0.1045
1.0000	-0.8090	0.3090	0.3090	-0.8090
1.0000	-0.6691	-0.1045	0.8090	-0.9781
1.0000	-0.5000	-0.5000	1.0000	-0.5000
1.0000	-0.3090	-0.8090	0.8090	0.3090
1.0000	-0.1045	-0.9781	0.3090	0.9135

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

SINE NI ARRAY

0.	0.0000	-0.0000	0.0000	-0.0000
0.	0.2079	-0.4067	0.5878	-0.7431
0.	0.4067	-0.7431	0.9511	-0.9945
0.	0.5878	-0.9511	0.9511	-0.5878
0.	0.7431	-0.9945	0.5878	0.2079
0.	0.8660	-0.8660	-0.0000	0.8660
0.	0.9511	-0.5878	-0.5878	0.9511
0.	0.9945	-0.2079	-0.9511	0.4067

HARMONIC VECTOR MAGNITUDE ARRAY

0.10750E 02	0.67201E 02	0.80802E 02	0.94403E 02	0.10800E 03
0.52479E 02	0.81982E 02	0.96390E 02	0.11086E 03	0.12536E 03
0.57428E 02	0.90559E 02	0.10474E 03	0.11903E 03	0.13340E 03
0.62626E 02	0.99604E 02	0.11354E 03	0.12763E 03	0.14183E 03
0.68015E 02	0.10900E 03	0.12268E 03	0.13656E 03	0.15058E 03

A ARRAY OF FOURIER COEFFICIENTS

0.43000E 02	0.54000E 02	0.65000E 02	0.76000E 02	0.87000E 02
0.45000E 02	0.56000E 02	0.67000E 02	0.78000E 02	0.89000E 02
0.47000E 02	0.58000E 02	0.69000E 02	0.80000E 02	0.91000E 02
0.49000E 02	0.60000E 02	0.71000E 02	0.82000E 02	0.93000E 02
0.51000E 02	0.62000E 02	0.73000E 02	0.84000E 02	0.95000E 02

B ARRAY OF FOURIER COEFFICIENTS

0.	0.40000E 02	0.48000E 02	0.56000E 02	0.64000E 02
0.	0.44000E 02	0.52000E 02	0.60000E 02	0.68000E 02
0.	0.48000E 02	0.56000E 02	0.64000E 02	0.72000E 02
0.	0.52000E 02	0.60000E 02	0.68000E 02	0.76000E 02
0.	0.56000E 02	0.64000E 02	0.72000E 02	0.80000E 02

C ARRAY OF FOURIER COEFFICIENTS

0.	0.	0.	0.	0.
0.27000E 02	0.32000E 02	0.37000E 02	0.42000E 02	0.47000E 02
0.33000E 02	0.38000E 02	0.43000E 02	0.48000E 02	0.53000E 02
0.39000E 02	0.44000E 02	0.49000E 02	0.54000E 02	0.59000E 02
0.45000E 02	0.50000E 02	0.55000E 02	0.60000E 02	0.65000E 02

D ARRAY OF FOURIER COEFFICIENTS

0.	0.	0.	0.	0.
0.	0.25000E 02	0.27000E 02	0.29000E 02	0.31000E 02
0.	0.33000E 02	0.35000E 02	0.37000E 02	0.39000E 02
0.	0.41000E 02	0.43000E 02	0.45000E 02	0.47000E 02
0.	0.49000E 02	0.51000E 02	0.53000E 02	0.55000E 02

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

VALUES OF EVALUATED DOUBLE FOURIER SERIES AT SPECIFIED GRID POINTS, NUMBER OF COLUMNS = 25, NUMBER OF ROWS = 31,
NUMBER OF M TERMS = 5, NUMBER OF N TERMS = 5, PERCENT OF TOTAL SUM OF SQUARES = 100.00, SCALE FACTOR = 1.00

STRIP ONE

23	-9	-31	-13	28	46	15	-33	-38	34	146	211	169	44	-78	-119	-73	0	31	6	-33	-40	-7	26	23
1	0	-2	-3	-1	0	-2	-6	-11	-12	-9	-4	0	0	0	0	1	4	4	2	0	-1	0	1	1
-22	8	28	9	-31	-47	-18	25	23	-52	-161	-219	-170	-41	80	121	75	4	-26	-2	34	39	6	-25	-22
-26	11	36	13	-35	-55	-18	36	36	-52	-181	-251	-196	-45	97	143	86	0	-34	-4	41	46	7	-30	-26
-6	4	10	3	-9	-13	-1	14	14	-9	-41	-57	-40	-1	30	36	17	-4	-11	0	11	11	0	-9	-6
25	-7	-30	-12	29	50	21	-26	-30	45	161	231	190	59	-73	-124	-82	-7	28	6	-34	-42	-9	25	25
43	-14	-56	-24	51	86	32	-55	-64	68	272	393	321	93	-135	-218	-138	-5	54	11	-60	-73	-15	46	43
33	-11	-43	-21	35	62	22	-47	-58	35	187	281	234	69	-97	-158	-99	0	44	11	-43	-54	-11	35	33
-1	2	1	-4	-10	-10	-4	-3	-14	-35	-52	-50	-27	3	24	26	15	4	1	5	8	5	0	-3	-1
-34	17	46	12	-53	-77	-26	43	34	-95	-271	-356	-267	-52	144	201	120	3	-42	0	59	63	8	-42	-34
-33	20	49	12	-54	-76	-21	51	41	-89	-264	-345	-251	-35	154	202	113	-4	-46	0	61	62	5	-44	-33
17	3	-14	-13	7	26	20	-7	-24	1	65	124	132	78	-1	-53	-31	-15	13	12	-9	-23	-12	8	17
105	-28	-128	-62	113	202	84	-122	-152	144	623	923	779	258	-282	-497	-330	-24	125	34	-134	-172	-42	104	105
191	-62	-244	-112	216	372	142	-244	-292	271	1157	1695	1401	424	-564	-932	-597	-24	240	58	-257	-319	-68	200	191
233	-81	-304	-139	264	451	163	-315	-375	313	1393	2044	1682	491	-703	-1137	-714	-13	303	71	-316	-388	-79	248	233
205	-75	-274	-128	228	391	133	-296	-357	243	1192	1768	1455	417	-622	-992	-613	3	277	67	-277	-340	-66	221	205
119	-46	-164	-82	123	217	64	-192	-241	93	636	974	809	229	-353	-555	-333	20	173	46	-156	-193	-35	130	119
12	-8	-26	-21	-1	8	-11	-51	-77	-64	-17	26	36	10	-21	-26	-1	29	36	16	-8	-15	0	16	12
-67	20	80	28	-89	-143	-62	64	62	-157	-478	-656	-525	-148	222	359	236	26	-71	-9	99	117	25	-70	-67
-91	30	116	49	-110	-183	-71	111	126	-153	-582	-832	-677	-193	288	463	295	16	-111	-22	128	155	32	-97	-91
-64	21	83	40	-69	-121	-44	87	107	-75	-368	-548	-454	-134	189	308	194	3	-83	-21	84	106	22	-67	-64
-13	3	18	14	-6	-19	-5	24	40	17	-37	-82	-81	-34	22	48	31	-3	-21	-10	11	19	5	-12	-13
23	-11	-30	-7	36	52	18	-27	-20	66	185	243	183	37	-95	-136	-82	-3	27	0	-39	-42	-5	28	23
27	-12	-37	-13	36	56	18	-39	-39	52	186	257	199	44	-102	-147	-87	1	36	4	-42	-47	-7	32	27
3	-3	-6	-3	3	5	-1	-11	-13	-3	12	20	13	-3	-15	-15	-4	6	8	1	-5	-5	0	5	3
-26	8	32	12	-33	-54	-22	27	29	-53	-177	-247	-199	-57	83	135	88	7	-29	-4	37	44	9	-27	-26
-36	13	47	19	-45	-74	-27	47	52	-62	-236	-335	-270	-73	119	187	117	4	-46	-8	52	62	12	-39	-36
-21	8	29	13	-24	-41	-13	32	38	-25	-126	-186	-152	-41	69	105	65	-1	-29	-6	30	36	6	-23	-21
6	-2	-7	-1	11	16	7	-3	0	25	59	76	58	15	-25	-39	-26	-4	5	0	-11	-12	-2	7	6
26	-10	-34	-13	34	55	20	-33	-34	52	180	251	199	52	-90	-139	-87	-3	32	4	-39	-46	-8	29	26
23	-9	-31	-13	28	46	15	-33	-38	34	146	211	169	44	-78	-119	-73	0	31	6	-33	-40	-7	26	23

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

RESIDUAL VALUES; NUMBER OF COLUMNS = 25, NUMBER OF ROWS = 31, NUMBER OF M TERMS = 5

NUMBER OF N TERMS = 5, SCALE FACTOR = 1.00

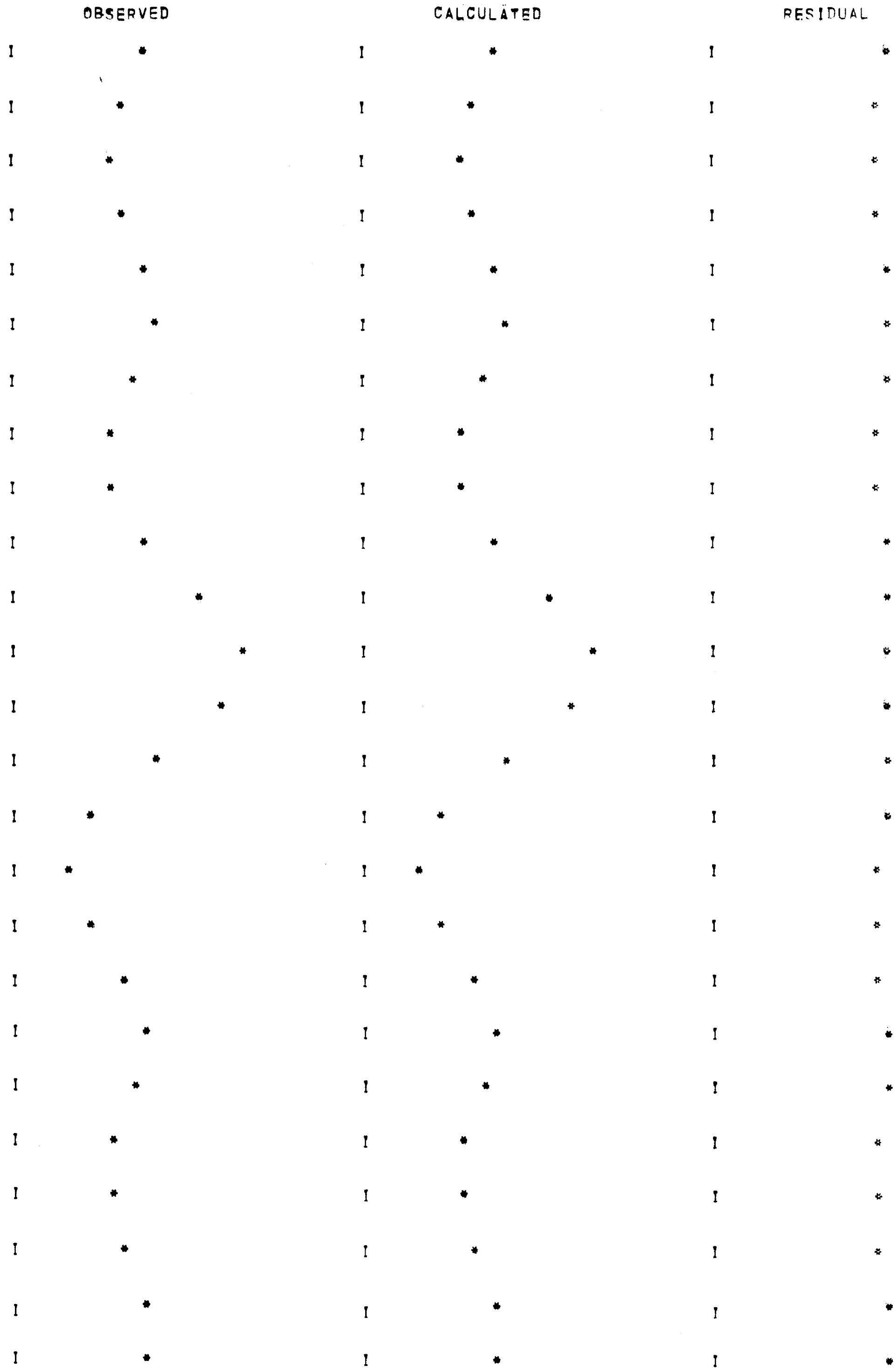
STRIP ONE

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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

HORIZONTAL PROFILE OF ROW 15
PLOT TOP = 4000.000, PLOT BASE = -2000.000, SCALE =30.000,
RESIDUAL AMPLIFICATION FACTOR = 0.020, M = 5, N = 5

OBSERVED	CALCULATED	RESIDUAL	
233.40	233.40	0.000	12
-81.49	-81.49	-0.000	11
-304.53	-304.53	-0.000	10
-139.60	-139.60	-0.000	9
264.20	264.20	0.000	8
451.19	451.19	0.000	7
163.70	163.70	0.000	6
-315.24	-315.24	-0.000	5
-375.63	-375.63	-0.000	4
313.31	313.31	0.000	3
1393.65	1393.64	0.001	2
2044.89	2044.89	0.001	1
1682.26	1682.26	0.001	0
491.83	491.83	0.001	-1
-703.82	-703.82	0.000	-2
-1137.21	-1137.21	-0.001	-3
-714.87	-714.87	-0.000	-4
-13.49	-13.49	-0.000	-5
303.10	303.10	0.000	-6
71.65	71.65	0.000	-7
-316.49	-316.49	-0.000	-8
-388.47	-388.47	-0.000	-9
-79.23	-79.23	-0.000	-10
248.37	248.37	0.000	-11
233.40	233.40	0.000	-12



TRIAL RUN OF DOUBLE FOURIER SERIES PROGRAM WITH SYNTHETIC DATA 1

VERTICAL PROFILE OF COLUMN 12
PLOT TOP = 4000.000, PLOT BASE = -2000.000, SCALE =30.000,
RESIDUAL AMPLIFICATION FACTOR = 0.020, M = 5, N = 5

OBSERVED	CALCULATED	RESIDUAL	
211.10	211.10	0.000	15
-4.64	-4.64	0.000	14
-219.03	-219.03	-0.000	13
-251.70	-251.70	-0.000	12
-57.34	-57.34	-0.000	11
231.47	231.47	0.000	10
393.35	393.35	0.000	9
281.74	281.74	0.000	8
-50.16	-50.16	-0.000	7
-356.56	-356.56	-0.000	6
-345.31	-345.31	-0.000	5
124.68	124.68	0.000	4
923.77	923.77	0.000	3
1695.08	1695.08	0.001	2
2044.89	2044.89	0.001	1
1768.62	1768.61	0.001	0
974.33	974.33	0.001	-1
26.56	26.56	0.000	-2
-656.98	-656.98	-0.000	-3
-832.89	-832.89	-0.000	-4
-548.29	-548.29	-0.000	-5
-82.04	-82.04	-0.000	-6
243.55	243.55	0.000	-7
257.28	257.28	0.000	-8
20.18	20.18	0.000	-9
-247.88	-247.88	-0.000	-10
-335.98	-335.98	-0.000	-11
-186.90	-186.90	-0.000	-12
76.18	76.18	0.000	-13
251.42	251.42	0.000	-14
211.10	211.10	0.000	-15

OBSERVED CALCULATED RESIDUAL

KANSAS GEOLOGICAL SURVEY COMPUTER PROGRAM
THE UNIVERSITY OF KANSAS, LAWRENCE

PROGRAM ABSTRACT

Title (If subroutine state in title):

FORTRAN IV program for harmonic trend analysis using double Fourier series and regularly gridded data for the GE 625 computer

Date: June, 1968

Author, organization: John W. Harbaugh, Stanford University, and Michael J. Sackin, Kansas Geological Survey

Direct inquiries to: Authors or

Name: D.F. Merriam

Address: Kansas Geological Survey
University of Kansas
Lawrence, Kansas 66044

Purpose/description: Computes coefficients of Fourier series, and evaluates and plots the function. Also computes and plots residual values.

Mathematical method:

Restrictions, range: Allows up to 71 x 73 grid points and up to 25th harmonic in both directions.

Computer manufacturer: General Electric

Model: 625

Programming language: FORTRAN IV

Memory required: K

Approximate running time:

Special peripheral equipment required:

Remarks (special compilers or operating systems, required word lengths, number of successful runs, other machine versions, additional information useful for operation or modification of program) All options have been tested on a wide variety of data sets. When adapting the program to another machine, set ICD to device number of card punch. Number is 43 on GE 625. If different on other machine, change statement on line 64 accordingly.

COMPUTER CONTRIBUTIONS

Kansas Geological Survey

Computer Contribution

1. Mathematical simulation of marine sedimentation with IBM 7090/7094 computers, by J.W. Harbaugh, 1966 . . . . . $1.00
2. A generalized two-dimensional regression procedure, by J.R. Dempsey, 1966 . . . . . $0.50
3. FORTRAN IV and MAP program for computation and plotting of trend surfaces for degrees 1 through 6, by Mont O'Leary, R.H. Lippert, and O.T. Spitz, 1966 . . . . . $0.75
4. FORTRAN II program for multivariate discriminant analysis using an IBM 1620 computer, by J.C. Davis and R.J. Sampson, 1966 . . . . . $0.50
5. FORTRAN IV program using double Fourier series for surface fitting of irregularly spaced data, by W.R. James, 1966. . . . . . $0.75
6. FORTRAN IV program for estimation of cladistic relationships using the IBM 7040, by R.L. Bartcher, 1966 . . . . . $1.00
7. Computer applications in the earth sciences: Colloquium on classification procedures, edited by D.F. Merriam, 1966 . . . . . $1.00
8. Prediction of the performance of a solution gas drive reservoir by Muskat's Equation, by Apolonio Baca, 1967. . . . . . $1.00
9. FORTRAN IV program for mathematical simulation of marine sedimentation with IBM 7040 or 7094 computers, by J.W. Harbaugh and W.J. Wahlstedt, 1967. . . . . . $1.00
10. Three-dimensional response surface program in FORTRAN II for the IBM 1620 computer, by R.J. Sampson and J.C. Davis, 1967 . . . . . $0.75
11. FORTRAN IV program for vector trend analyses of directional data, by W.T. Fox, 1967 . . $1.00
12. Computer applications in the earth sciences: Colloquium on trend analysis, edited by D.F. Merriam and N.C. Cocke, 1967 . . . . . $1.00
13. FORTRAN IV computer programs for Markov chain experiments in geology, by W.C. Krumbein, 1967 . . . . . $1.00
14. FORTRAN IV programs to determine surface roughness in topography for the CDC 3400 computer, by R.D. Hobson, 1967 . . . . . $1.00
15. FORTRAN II program for progressive linear fit of surfaces on a quadratic base using an IBM 1620 computer, by A.J. Cole, C. Jordan, and D.F. Merriam, 1967 . . . . . $1.00
16. FORTRAN IV program for the GE 625 to compute the power spectrum of geological surfaces, by J.E. Esler and F.W. Preston, 1967. . . . . . $0.75
17. FORTRAN IV program for Q-mode cluster analysis of nonquantitative data using IBM 7090/7094 computers, by G.F. Bonham-Carter, 1967 . . . . . $1.00
18. Computer applications in the earth sciences: Colloquium on time-series analysis, D.F. Merriam, editor, 1967 . . . . . $1.00
19. FORTRAN II time-trend package for the IBM 1620 computer, by J.C. Davis and R.J. Sampson, 1967 . . . . . $1.00
20. Computer programs for multivariate analysis in geology, D.F. Merriam, editor, 1968 . . . $1.00
21. FORTRAN IV program for computation and display of principal components, by W.J. Wahlstedt and J.C. Davis, 1968 . . . . . $1.00
22. Computer applications in the earth sciences: Colloquium on simulation, D.F. Merriam and N.C. Cocke, editors, 1968 . . . . . $1.00
23. Computer programs for automatic contouring, by D.B. McIntyre, D.D. Pollard, and R. Smith, 1968 . . . . . $1.50
24. Mathematical model and FORTRAN IV program for computer simulation of deltaic sedimentation, by G.F. Bonham-Carter and A.J. Sutherland, 1968 . . . . . $1.00
25. FORTRAN IV CDC 6400 computer program for analysis of subsurface fold geometry, by E.H.T. Whitten, 1968 . . . . . $1.00
26. FORTRAN IV computer program for simulation of transgression and regression with continuous-time Markov models, by W.C. Krumbein, 1968 . . . . . $1.00
27. Stepwise regression and nonpolynomial models in trend analysis, by A.T. Miesch and J.J. Connor, 1968 . . . . . $1.00
28. KWIKR8 a FORTRAN IV program for multiple regression and geologic trend analysis, by J.E. Esler, P.F. Smith, and J.C. Davis, 1968 . . . . . $1.00
29. FORTRAN IV program for harmonic trend analysis using double Fourier series and regularly gridded data for the GE 625 computer, by J.W. Harbaugh and M.J. Sackin, 1968 . . . $1.00