HEWLETT-PACKARD CALCULATOR

9830A STAT PAC
VOLUME 1

Program Listing

File Description

File Number	Description	File Size
1	F-PROB	654
2	T-PROB	642
3	One Way AOV: Data Entry, Add, Delete, Cell Stat	601
4	One Way AOV: Table, Bartlett's Test, F-PROB	1106
5	One Way AOV: F-PROB and Contrasts	850
6	Two Way AOV: Starts program and contains pointers for specific operations	79
7	Two Way AOV: Data Entry, Correct, Cell Stat, Overall Mean, Row Means, Column Means	949
8	Two Way AOV: Tables and Tukey's Test	845
9	Two Way AOV: Row and Column Contrasts	439
10	Polynomial Regression: Starts program and contains pointers for specific operations	108
11	Polynomial Regression: Plot Axes	925
12	Polynomial Regression: Enter T-Codes	327
13	Polynomial Regression: Enter Data	970
14	Polynomial Regression: Means, Variances, and Correlation	554
15	Polynomial Regression: Square Root and Inverse of XX'	385
16	Polynomial Regression: Preliminary AOV	366
17	Polynomial Regression: AOV and Coefficients	848
18	Polynomial Regression: Estimate Y and Calculate Residuals	971
19	Polynomial Regression: Correct and Delete Data on Tape	379
20	Polynomial Regression: Load Data from Tape	955
21–272	Data Files	16/file

MODEL 30

Errata

September 25, 1973

Stat Pac Volume I

Ploynomial Regression Program

p23 file 17 Insert the following program line

45 B(1) = 1

Two Way Analysis of Variance

p55 file 9 Insert the following program lines

275 IF V = 0 then 290

285 Go to 300

To correct the error in Bartlett's test, One-Way AOV, make the following correction to Key File 4 (SF key 2):

140 B = A9/(1 - A + 2/A9)

If you want the X^2 value in addition to the F statistic add:

192 WRITE (15, 195) "DF =" B9, "CHI-SQUARED ="
M/(1 + A)

195 FORMAT /, F13.2, F12.4

Introduction

This family of statistical programs for the Model 9830 results from several years' experience in providing statistical solutions to our customers. We have attempted to incorporate all those desirable features and options suggested to us by general statistical practitioners. As a result, the special function keys have been applied to offer a wide choice of problem solutions. The "Special Function" templates should illustrate the flexibility of these programs.

These programs were written by Bob Kopitzke of Colorado State University, Statistics Laboratory. Additional statistical packages will be developed in the future.

PROGRAM SUBMISSIONS

You are invited to submit statistical programs to us for inclusion in future statistical pacs and our Catalog of Calculator Programs. Details for submitting programs for this catalog are found near the back of this pac. Please use the prepared forms for your program submittal.

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Statistics Applications
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Commentary

In writing the programs for this package, it has been assumed that the user is familiar with the basic keyboard operations of the 9830, and also with some of the elementary programming concepts such as data entry, use of the Special Function Keys (SFK) and defined function utilization.

There are several general comments which are applicable to most of the programs in this package and which should aid the user in running those programs. These comments have been collected in this section for easy reference, and to reduce the length of the operating instructions for the individual programs. It is recommended that the user read this section before running the various programs in this package.

1. SCRATCH A should be executed prior to loading any of the programs for running. This assures that no extraneous program lines or variables are left in the memory from the previous program, which could cause program malfunction.

2. Many of the programs which operate from the Special Function Keys (SFK) require that RUN, START (where START is one of the predefined SFK's) be pressed to initiate program operation. It is the purpose of the START key in these programs to initialize certain variables and to dimension the arrays which the program will use. If START is pressed without previously pressing the RUN key in these programs, ERROR 41 (array or string has not been initialized) will result.

3. Most of the programs require data input at various points throughout the running. When data entry is required, the display will show some indication of the particular data being requested, followed by a question mark. The user should enter the desired number(s) and press EXECUTE. If more than one number is requested, the user may enter the numbers one at a time, pressing EXECUTE after each entry; or he may enter all the numbers at once, separated by commas, and then press EXECUTE. If an error is made in entering the number(s), press CLEAR and enter the numbers again. The program does not accept the input until EXECUTE is pressed.

When entering lists of data (such as x and y values of data points), the program sometimes must do a considerable amount of computation between entries. As a result, the user may enter the points faster than the program can process them. Be sure to wait until the question mark appears in the display before entering the next value.

4. Most of the programs give printed results of the computations that are performed. In many cases, the user can control the format of these results by placing the calculator in the appropriate format mode (FIXED N, FLOAT N, or STANDARD). In addition, by placing the calculator in the PRINT ALL mode, a record of the data entered will also be printed. (Note that some programs already print out data entry. For these programs, the PRINT ALL mode should be OFF.) The user may exercise these options at his own discretion to obtain a printout which suits his needs.

Each of the programs is followed by an example case. There are some items printed in these cases (such as which key is to be pressed next) that will not appear on the printout when the program is run. These are intended to aid the user in running the example case, and the fact that the non-numeric portion of the printout obtained does not identically match the example case should not be cause for concern.

MODEL 30

POLYNOMIAL REGRESSION

DESCRIPTION:

This program will fit a least squares polynomial of degree k where $k \leq 9$ to data points (x, y).

The user has the following options:

1. Transform either x or y, or both x and y.
2. Plot input data.
3. Print means, variances, and correlation coefficient of input data, and of transformed data.
4. Calculate and print a preliminary analysis of variance table to aid in the selection of regression degree.
5. Select or change degree of regression for any degree up to, and including, a specified maximum.
6. Calculate and print an analysis of variance table for the selected degree.
7. Calculate and print regression coefficients for a selected degree of regression, together with their standard error and t-value.
8. Calculate and print R-square, the multiple correlation coefficient.
9. Plot a regression equation.
10. The user may correct incorrectly entered data.
11. A table of residuals may be calculated and printed for a given degree of regression.
12. Standardized residuals may be plotted.
13. The Durbin-Watson statistic may be calculated and printed.
14. The plot range may be changed for doing different regressions over different ranges of x without replotting the axes.

METHODS:

A triangular factorization of the $X'X$ matrix is utilized to calculate the AOV tables and regression coefficients.

SYSTEM SPECIFICATIONS:

9830 (2K or 4K R/W)
9866 Printer or 9861 Typewriter

SPECIAL CONSIDERATIONS:

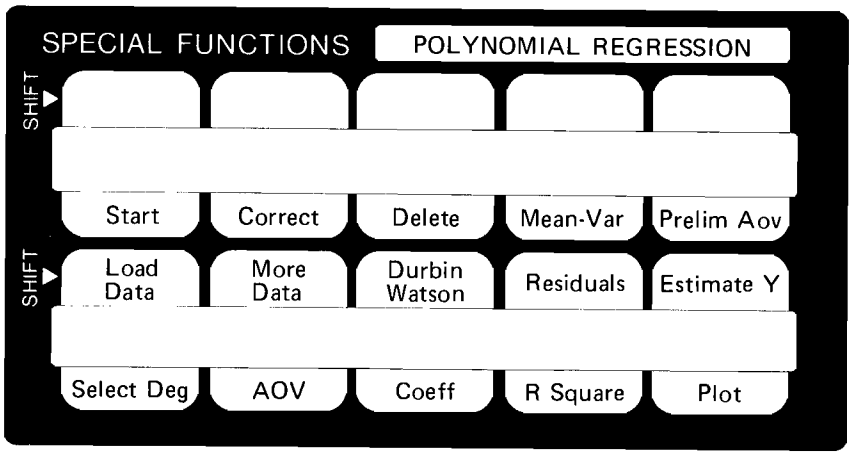
Since arithmetic is performed on numbers ranging in magnitude from Σx to Σx^{2k}, where k is the input maximum degree, some caution must be exercised in selecting k, otherwise a singular matrix will result due to roundoff error. It is suggested that k be made as small as possible within a problem specification.

ACKNOWLEDGMENTS:

Robert W. Kopitzke, Hewlett-Packard

REFERENCES:

Graybill, F. A., An Introduction to Linear Statistical Models, Vol. I (New York: McGraw-Hill Book Company, 1961).



OPERATION:

1. Type SCRATCH A, press EXECUTE.
2. Type LOADKEY 10, press EXECUTE.
3. Press START [SF Key 0].
4. The display reads, "MAX DEG REG = ?". Enter maximum degree regression desired, press EXECUTE.
5. The display reads, "ENT 1 TO PLOT?". If it is not desired to plot the input data or regression curve, enter 0; press EXECUTE; go to step 10. Otherwise, enter 1; press EXECUTE; go to step 6.
6. The display reads, "X MIN, X MAX?". Enter x_{min}, x_{max}; press EXECUTE.
7. The display reads, "Y MIN, Y MAX?". Enter y_{min}, y_{max}; press EXECUTE.
8. The display reads, "# X DIVISIONS, # Y DIVISIONS?". Enter # of x divisions, # of y divisions desired on the plot of the x and y axes, press EXECUTE.
9. The display reads, "ENT 1 FOR GRAPH PAPER?". If graph paper is used and it is desired to have the axis and tic marks fall on a major division, enter 1; press EXECUTE; go to step 10. Otherwise, enter 0; press EXECUTE.
10. The display reads, "ENT 1 FOR TRANSFORMATIONS?". If it is desired to transform the input data, enter 1; press EXECUTE; go to step 11. Otherwise, enter 0; press EXECUTE; go to step 13.
11. The display reads, "FOR X, ENT: T CODE, C?". Enter the transformation code and the constant for transforming x from Table 1; press EXECUTE.
12. The display reads, "FOR Y, ENT: T CODE, C?". Enter the tranformation code and the constant for transforming y from Table 1; press EXECUTE.
13. The display reads, "X(I)?". Enter x_i, press EXECUTE.
14. The display reads, "Y(I)?". Enter y_i, press EXECUTE.

Repeat steps 13 and 14 for each data point.

Error Correction During Data Entry: If during data entry, it is discovered that a point was entered incorrectly, this point may be corrected as follows:

15. Press either CORRECT [SF Key 1], or DELETE [SF Key 2].
16. The display reads, "CORRECT DATA SET #?". Enter the number of the data set to be corrected; press EXECUTE.

17. The display reads, "X = ?". Enter the correct x, press EXECUTE.

18. The display reads, "Y = ?". Enter the correct y, press EXECUTE; go to step 13.

19. After all data has been entered and stored on tape, use any of the special function keys described below.

20. To run another case, go to step 3.

SPECIAL FUNCTIONS:

CORRECT [SF Key 1]:
This key allows incorrect data on tape to be corrected. To use:

1. Press CORRECT [SF Key 1].
2. The display reads, "CORRECT DATA SET #?". Enter the number of the data set to be corrected, press EXECUTE.
3. The display reads, "X = ?". Enter the correct x value for the data set, press EXECUTE.
4. The display reads, "Y = ?". Enter the correct y value for the data set, press EXECUTE; go to step 2.

DELETE [SF Key 2]:
This key allows data stored on tape to be deleted from tape. To use:

1. Press DELETE [SF Key 2].
2. The display reads, "DELETE DATA SET #?". Enter number of the data set to be deleted, press EXECUTE. Repeat step 2 as often as desired.

Note: If either CORRECT [SF Key 1] or DELETE [SF Key 2] is used after data entry is completed, only data stored on tape is corrected. Data summaries in the 9830 internal memory are not changed. To run a model on the correct data, use LOAD DATA [SF Key 15].

MEAN VAR [SF Key 3]:
Prints means, variances, and simple correlation of input data and transformed data if data transformations are performed. CAUTION: means and variances are lost if any other analysis is performed; so if means and variances are desired, they must be printed before any other analysis is performed.

PRELIM AOV [SF Key 4]:
This key aids in the selection of the degree regression to be performed by printing independent F-tests for the inclusion of the highest order term in a model. The degrees of freedom for the test and R-square for the degree of regression are printed.

SELECT DEG [SF Key 5]:
This key allows the user to select the degree of regression desired.

AOV [SF Key 6]:
This key calculates the analysis of variance table for the degree regression previously selected with SELECT DEG [SF Key 5] key.

COEFF [SF Key 7]:
This key calculates and prints the coefficients for the degree regression previously selected with SELECT DEG [SF Key 5] key. The standard error and t-value for each coefficient are printed.

PLOT [SF Key 9]:
This key allows the regression equation to be plotted for the degree regression selected previously with SELECT DEG [SF Key 5] key. To use:

1. Press PLOT [SF Key 9].
2. The display reads, "ENT 1 TO CHANGE PLOT RANGE?".
3. If it is not desired to change the range that the regression equation is plotted over, enter 0; press EXECUTE; go to step 6. Otherwise, enter 1; press EXECUTE; go to step 4.
4. The display reads, "X MIN = ?". Enter the minimum value for the plot of the regression equation, press EXECUTE.
5. The display reads, "X MAX = ?". Enter the maximum value for the plot of the regression equation, press EXECUTE.
6. The regression equation is plotted.

R SQUARE [SF Key 8]:
Calculates and prints the multiple correlation coefficient for the degree regression selected previously with SELECT DEG [SF Key 5] key.

ESTIMATE Y [SF Key 19]:
This key permits the user to estimate y for any x value, for the degree regression previously selected with SELECT DEG [SF Key 5].

1. Press ESTIMATE Y [SF Key 19].
2. The display reads, "ESTIMATE Y FOR X = ?". Enter the x value for which it is desired to estimate y, press EXECUTE. Repeat step 2 as often as desired.

RESIDUALS [SF Key 18]:
This key allows the user to calculate and print the residuals for the degree regression previously selected with SELECT DEG [SF Key 5]. The user may plot the standardized residuals.

1. Press RESIDUALS [SF Key 18].
2. The display reads, "ENT 1 TO PLOT RESIDUALS?"
3. If it is desired to plot residuals, change plot paper; enter 1; press EXECUTE; go to step 4. Otherwise, enter 0; press EXECUTE; go to step 4.
4. The residuals are calculated, printed and plotted.

D-W [SF Key 17]:
This key prints the Durbin-Watson statistic for serial correlation. This key must be preceded by RESIDUALS [SF Key 18].

MORE DATA [SF Key 16]:
This key allows the user to enter data over portions of the range specified in step 6 of the operation instructions, and do different regressions over different ranges for x on the same axis plot. To use, press MORE DATA [SF Key 16] and go to step 13 of the operating instructions.

LOAD DATA [SF Key 15]:
This key allows data previously stored on tape to be reentered and transformations performed if desired. To use:

1. Press LOAD DATA [SF Key 15].
2. The display reads, "ENT 1 FOR TRANSFORMATIONS?". If it is desired to transform the data, enter 1; press EXECUTE; go to step 3. Otherwise, enter 0; press EXECUTE; go to step 5.
3. The display reads, " FOR X, ENT: T CODE, C?". Enter T code and C from Table 1 to transform x, press EXECUTE.
4. The display reads, "FOR Y, ENT: T CODE, C?". Enter T code and C from Table 1 to transform y, press EXECUTE.
5. The display reads, "ENT 1 TO PLOT AXES?". If it is desired to plot new axes, enter 1, press EXECUTE. If it is not desired to plot the axes, enter 0, press EXECUTE. (Note: If transformations are specified, the original axes may be off scale and it is suggested that new axes be plotted.)
6. The data is read in from tape and plotted, if plotting was specified in step 5 of the operating instructions above.
7. Use any of the special function keys described above.

TRANSFORMATIONS:

Transformations may be performed on either x or y, or x and y. The transformations are performed by entering two numbers; the first number specifies the type of transformation to be performed, and the second specifies a constant associated with the transformation. These two numbers are called T CODE and C, respectively.

TABLE 1

T CODE	C	Description
0	0	Enters variable Z unchanged
1	0	Enters logarithm to base 10 of variable Z
2	C	Adds constant C to variable Z
3	C	Multiplies variable Z by constant C
4	C	Raises constant C to variable Z power
5	C	Raises variable Z to constant C power
6	0	Enters natural logarithm of variable Z
7	0	Enters exponential of variable Z

where variable Z is either x or y, depending upon the time of entry of T CODE and C in steps 11 and 12 of the operating instructions.

If transformations are specified, the point x and transformed y is plotted. If transformations are specified, the plotted curve residuals, estimated y and Durbin-Watson test are all calculated in terms of the transformed variables, and the transformed model is plotted.

TRANSFORMATION EXAMPLE

It is desired to fit a power curve of the form $y = ax^b$. To perform the analysis, the equation is linearized by taking logarithms of both sides to get

$$\log y = \log a + b \log x.$$

So, the model becomes

$$y' = b_0 + bx'$$

where

$$y' = \log y$$

$$b_0 = \log a$$

$$x' = \log x$$

Since b_0 and b are calculated to find the value of a, set $a = 10^{b_0}$.

Fit a power curve to the data:

x	y
1.	3.1
2.1	4.26
2.95	5.22
4.05	6.05

The transformation codes are:

For x: T CODE = 1
C = 0

For y: T CODE = 1
C = 0

The coefficients are:

$b_0 = \log a = .4867$

$b = .4812$

thus, $a = 10^{.4867} = 3.067$

so the model is $y = 3.067\,x^{.4812}$

The residuals are printed for the transformed model. To get the true residuals, the appropriate transformations must be made. For example, for the point (1, 3.1), the transformed data is (1, .4914) and y hat = .4867. The residual for the transformed model is .0047, while the residual for the original model is

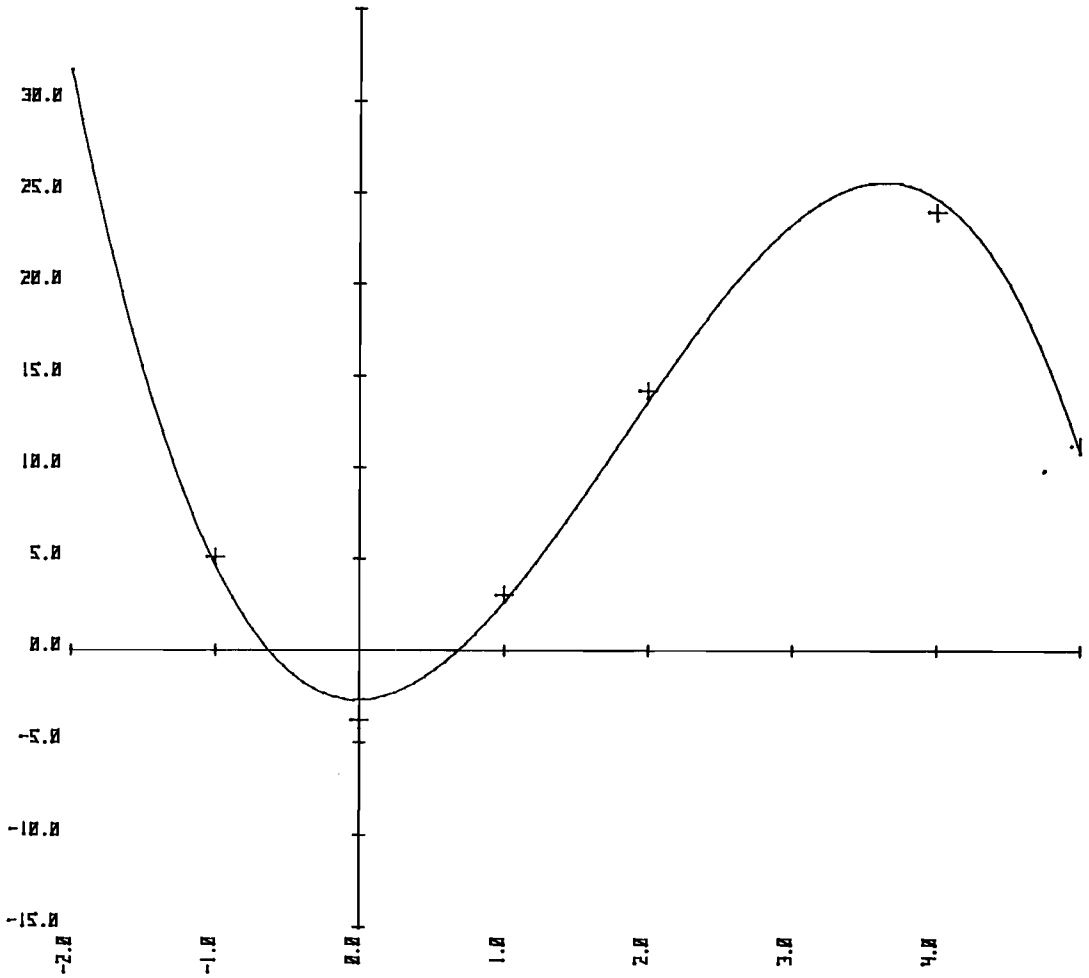
$$10^{.4914} - 10^{.4867} = 3.1 - 3.067 = .0331$$

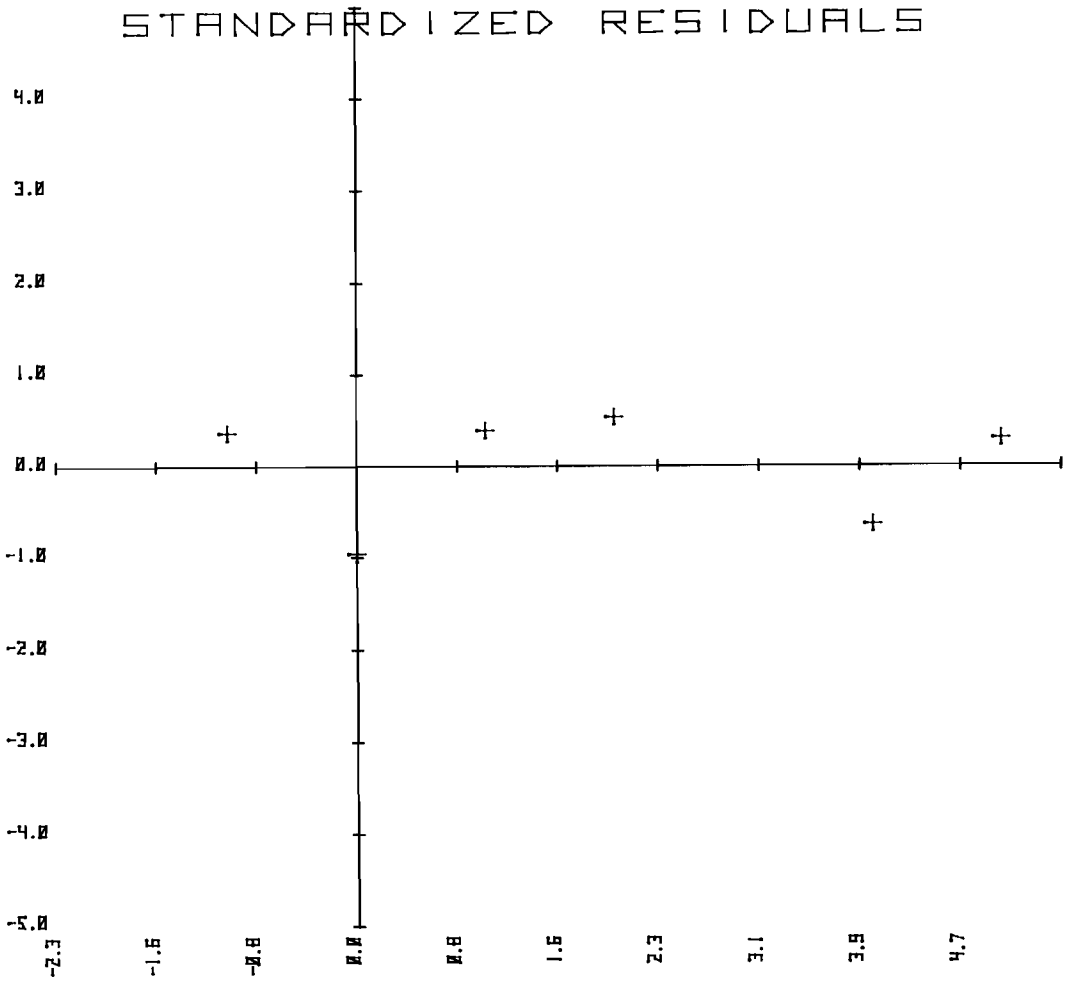
EXAMPLE

```
MAX DEG = 5
XMIN =      -2.0000 XMAX =       5.0000
YMIN =     -15.0000 YMAX =      35.0000


 I          X            Y
   1      -1.0000       5.1000
   2       0.0000      -3.8000
   3       1.0000       3.0500
   4       2.0000      14.2000
   5       4.0000      23.9500
   6       5.0000      11.2000


MEANS,VARIANCES,CORRELATION
X MEAN =        1.8333
VAR(X) =        5.3667

Y MEAN =        8.9500
VAR(Y) =       93.9640


RXY =        0.7098




          PRELIMINARY AOV TABLE


SOURCE          SS                  F       DF          R**2
TOTAL          950.4350
MEAN           480.6150
TOT ADJ        469.8200
 X**  1         236.7239     4.0623    (1,    4)     0.5039
 X**  2           6.4441     0.0853    (1,    3)     0.5176
 X**  3         224.0022   169.0678    (1,    2)     0.9944
 X**  4           2.4655    13.3716    (1,    1)     0.9996
 X**  5           0.1844     0.0000    (1,    0)     1.0000




DEGREE REGRESSION= 3
```

```
     ANALYSIS OF VARIANCE

SOURCE    DF         SS              MS          F
TOTAL      5       469.8200
REG        3       467.1702       155.7234     117.5337
RESID      2         2.65           1.32



COEFFICIENTS
                B(I)     STD ERR0R        T

B(   0)=      -2.6983        0.7882      -3.4232
B(   1)=       0.1264        0.6759       0.1870
B(   2)=       6.3323        0.5273      12.0081
B(   3)=      -1.1630        0.0894     -13.0026



ESTIMATE Y FOR GIVEN X
FOR X=        1.5000 ;YHAT=        7.8137
FOR X=        3.0000 ;YHAT=       23.2696
FOR X=        4.5000 ;YHAT=       20.1176


RESIDUALS
   I            X            Y          YHAT      RESIDUAL
    1      -1.0000       5.1000        4.6707        0.4293
    2       0.0000      -3.8000       -2.6983       -1.1017
    3       1.0000       3.0500        2.5974        0.4526
    4       2.0000      14.2000       13.5794        0.6206
    5       4.0000      23.9500       24.6896       -0.7396
    6       5.0000      11.2000       10.8612        0.3388



DURBIN-WATSON STATISTIC =       0.0000
```

EXAMPLE




STANDARDIZED RESIDUALS
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-2.3
-1.6
-0.8
0.0
0.8
1.6
2.3
3.1
3.9
4.7

```
      FILE 11
      PLOT AXES

30 FORMAT 2F12.4
40 DIM A[21],B[4],C[66],D[6],E[11]
45 PRINT TAB11"POLYNOMIAL REGRESSION"
46 PRINT
50 DISP "MAX DEG REG =";
60 INPUT D[2]
70 PRINT "MAX DEG ="D[2]
80 D[1]=D[4]=D[5]=D[6]=0
90 DISP "ENT 1 TO PLOT";
100 INPUT A[1]
110 IF A[1]=0 THEN 640
120 DISP "XMIN,XMAX";
130 INPUT A,B
140 A[2]=A
150 A[3]=B
160 WRITE (15,30)"XMIN ="A" XMAX ="B
170 DISP "YMIN,YMAX";
180 INPUT A[8],A[9]
190 WRITE (15,30)"YMIN ="A[8]" YMAX ="A[9]
200 DISP "# X DIVISIONS,# Y DIVISIONS";
210 INPUT A[6],A[7]
220 DISP "ENT 1 FOR GRAPH PAPER";
230 INPUT G
240 GOSUB 660
250 T=A
260 A=A[8]
270 A[8]=T
280 T=B
290 B=A[9]
300 A[9]=T
310 T=A[6]
320 A[6]=A[7]
330 A[7]=T
340 I=Y
350 GOSUB 660
360 Y=Z=0
370 IF A <= 0 THEN 390
380 Y=A
390 IF A[8] <= 0 THEN 410
400 Z=A[8]
410 B[1]=0.1*(A[9]-A[8])*(G=0)
420 X=0.1*(B-A)*(G=0)
430 SCALE A[8],A[9]+B[1],A,B+X
440 OFFSET B[1],X
450 XAXIS Y,I,A[8],A[9]
460 YAXIS Z,Y,A,B
470 T=1
```

```
480 IF (10↑T) >= A[7] THEN 510
490 T=T+1
500 GOTO 480
510 FOR J=0 TO A[7]-1 STEP T
520 PLOT A[8]+I*J,(A-X)*(G=0)+Y*(G=1),1
530 CPLOT 1.1*(G=1),0.1*(G=1)
531 IF I>0.1 THEN 540
533 LABEL (651,1.1,2,PI/2)A[8]+I*J
535 GOTO 550
540 LABEL (650,1.1,2,PI/2)A[8]+I*J
550 NEXT J
560 T=1
570 IF (10↑T) >= A[6] THEN 590
580 T=T+1
590 FOR J=0 TO A[6]-1 STEP T
600 PLOT (A[8]-B[1])*(G=0)+Z*(G=1),A+Y*J,1
610 CPLOT 0.1,0
611 IF Y>0.1 THEN 620
613 LABEL (651,1.1,2,0)A+Y*J
615 GOTO 630
620 LABEL (650,1.1,2,0)A+Y*J
630 NEXT J
635 LABEL (*,1.5,1,0)
640 LINK 12,10,10
650 FORMAT F9.1
651 FORMAT F8.2
660 Y=(B-A)/A[6]
670 IF A >= 0 THEN 760
680 X=0
690 IF X*Y >= ABSA THEN 730
700 X=X+1
710 IF X>A[6] THEN 740
720 GOTO 690
730 IF (A[6]-X)*Y >= B THEN 760
740 Y=1.1*Y
750 GOTO 680
760 IF INTY=Y THEN 890
770 T=1
780 IF Y>1 THEN 820
790 IF Y*(10↑T)>10 THEN 820
800 T=T+1
810 GOTO 790
820 Y=INT(Y*(10↑T)+1)/(10↑T)
830 IF A >= 0 THEN 880
840 A=-Y*X
850 B=(A[6]-X)*Y
860 GOTO 890
870 Y=INT(Y*(10↑T)+1)/(10↑T)
880 B=A[6]*Y+A
890 RETURN
```

```
     FILE 12
     ENTER T-CODES

10 IF D[1]=0 THEN 22
20 LINK 18,10,456
22 IF D[5]#1 THEN 30
23 LINK 20,10,210
30 FOR I=1 TO 66
40 C[I]=0
50 NEXT I
52 PRINT
54 PRINT
60 D[3]=0
70 FOR I=6 TO 20
80 A[I]=0
90 NEXT I
100 D[2]=D[2]+1
110 A[4]=0
120 D1=0
130 E[1]=B[1]=B[2]=B[3]=B[4]=1
140 FOR I=2 TO 11
150 E[I]=0
160 NEXT I
163 DISP "ENT 1 FOR TRANSFORMATIONS";
166 INPUT D
169 IF D#1 THEN 210
170 DISP "FOR X,ENT:TCODE,C";
180 INPUT A[6],A[7]
190 DISP "FOR Y,ENT:TCODE,C";
200 INPUT A[8],A[9]
210 IF (A[1]=0) OR (A[6]+A[8]=0) THEN 240
240 PRINT " I";TAB10"X";"           Y";
250 IF A[6]=0 THEN 270
260 PRINT "             XT";
270 IF A[8]=0 THEN 290
280 PRINT "             YT";
290 PRINT
300 LINK 13,10,30
310 END

      FILE 13
      ENTER DATA

 10 GOTO 850
 11 GOTO 850
 12 LINK 14,10,30
 13 LINK 16,10,30
 14 LINK 17,10,14
 15 LINK 17,10,15
 16 LINK 17,10,16
```

```
17 LINK 17,10,17
29 LINK 17,10,16
30 FORMAT F4.0,2F12.4
40 FORMAT F12.4
45 FIND 21
50 DISP "X("C[1]+1")";
60 INPUT B[2]
62 DISP "Y("C[1]+1")";
64 INPUT B[3]
70 Y=1
75 B[1]=1
80 WRITE (15,30)C[1]+1,B[2],B[3];
90 Z=B[3]
100 T=2
110 IF A[8]=0 THEN 130
120 GOSUB 940
130 Y=Z
140 Z=B[2]
150 T=0
160 IF A[6]=0 THEN 180
170 GOSUB 940
180 X=Z
190 IF Y=-1 THEN 520
200 IF A[6]=0 THEN 220
210 WRITE (15,40)X;
220 IF A[8]=0 THEN 240
230 WRITE (15,40)Y;
240 PRINT
250 D[3]=D[3]+1
260 GOTO 510
280 DISP "X =";
290 INPUT B[2]
300 T=0
310 Z=B[2]
315 IF A[6]=0 THEN 330
320 GOSUB 940
330 X=Z
340 WRITE (15,40)"X ="B[2];
350 IF A[6]=0 THEN 370
360 WRITE (15,40)" ;XT ="X;
370 PRINT
390 DISP "Y =";
400 INPUT B[3]
410 T=2
420 Z=B[3]
425 IF A[8]=0 THEN 440
430 GOSUB 940
440 Y=Z
450 WRITE (15,40)"Y ="B[3];
460 IF A[8]=0 THEN 480
```

```
470 WRITE (15,40)" ;YT ="Y;
480 PRINT
495 IF B[1]=1 THEN 510
498 B[1]=1
500 STORE  DATA D+20,B
505 GOTO 520
510 STORE  DATA 20+D[3],B
520 E[2]=X
530 FOR I=1 TO D[2]-1
540 E[I+1]=E[I]*E[2]
550 NEXT I
560 E[D[2]+1]=Y
570 A=0
580 FOR I=1 TO D[2]+1
590 FOR J=I TO D[2]+1
600 A=A+1
610 C[A]=C[A]+E[I]*E[J]*V
620 NEXT J
630 NEXT I
640 IF A[1]=0 THEN 740
680 PLOT B[2],Y,1
690 CPLOT -0.3,-0.3
700 IF V=-1 THEN 730
710 LABEL (*)"+"
720 GOTO 740
730 LABEL (*)"X"
740 A[11]=A[11]+V*X
750 A[12]=A[12]+V*X*X
760 A[13]=A[13]+V*Y
770 A[14]=A[14]+V*Y*Y
780 A[15]=A[15]+V*X*Y
790 A[16]=A[16]+V*B[2]
800 A[17]=A[17]+V*B[2]*B[2]
810 A[18]=A[18]+V*B[3]
820 A[19]=A[19]+V*B[3]*B[3]
830 A[20]=A[20]+V*B[2]*B[3]
835 IF V#-1 THEN 50
840 V=1
845 GOTO 280
850 DISP "CORRECT DATA SET #";
860 INPUT D
870 PRINT "ON DATA SET"D
880 V=-1
890 LOAD  DATA D+20,B
920 B[1]=-1
930 GOTO 90
940 GOTO A[6+T] OF 950,970,990,1010,1030,1050,1070
950 Z=LGTZ
960 RETURN
970 Z=Z+A[7+T]
```

```
980 RETURN
990 Z=Z*A[7+T]
1000 RETURN
1010 Z=A[7+T]↑Z
1020 RETURN
1030 Z=Z↑A[7+T]
1040 RETURN
1050 Z=LOGZ
1060 RETURN
1070 Z=EXPZ
1080 RETURN

     FILE 14
     PRINT MEANS,VARIANCES AND CORRELATION

10 LINK 19,10,10
11 LINK 19,10,11
12 GOTO 30
13 LINK 16,10,30
14 LINK 17,10,14
15 LINK 17,10,15
16 LINK 17,10,16
17 LINK 17,10,17
29 LINK 17,10,16
30 N=C[1]
31 PRINT
32 PRINT
33 IF D[4]=1 THEN 320
34 PRINT
35 FORMAT F12.4
38 PRINT "MEANS,VARIANCES,CORRELATION"
40 WRITE (15,35)"X MEAN ="A[16]/N
45 S=A[17]-A[16]*A[16]/N
50 WRITE (15,35)"VAR(X) ="S/(N-1)
60 PRINT
70 WRITE (15,35)"Y MEAN ="A[18]/N
75 V=A[19]-A[18]*A[18]/N
80 WRITE (15,35)"VAR(Y) ="V/(N-1)
90 PRINT
100 PRINT
101 WRITE (15,35)"RXY ="(A[20]-A[18]*A[16]/N)/SQR(S*V)
102 PRINT
103 PRINT
104 T=A[12]-A[11]*A[11]/N
105 Y=A[14]-A[13]*A[13]/N
110 IF A[6]=0 THEN 150
120 WRITE (15,35)"XT MEAN ="A[11]/N
130 WRITE (15,35)"VAR(XT) ="T/(N-1)
140 PRINT
150 IF A[8]=0 THEN 200
```

```
160 WRITE (15,35)"YT MEAN ="A[13]/N
170 WRITE (15,35)"VAR(YT) ="Y/(N-1)
180 PRINT
190 X=(A[15]-A[13]*A[11]/N)/SQR(T*Y)
200 IF A[6]+A[8]=0 THEN 280
210 GOTO (A[6]#0)+2*(A[8]#0) OF 220,240,260
220 PRINT "R(XT,Y) =";
230 GOTO 270
240 PRINT "R(X,YT) =";
250 GOTO 270
260 PRINT "R(XT,YT) =";
270 WRITE (15,35)X
280 PRINT
290 PRINT
300 DISP "DONE";
310 END
320 DISP "MEANS AND VARIANCES ARE LOST"
330 END
     FILE 15
     SQUARE ROOT AND INVERSE OF XX'

10 FOR I=1 TO D[2]
15 A[10+I]=C[I+1]/C[1]
20 NEXT I
25 D[4]=1
30 P=1
35 N=C[1]
40 FOR J=1 TO D[2]
50 C[P]=SQR(C[P]
60 FOR I=1 TO D[2]-J+1
70 C[P+I]=C[P+I]/C[P]
80 NEXT I
90 R=P+I
100 S=R
110 FOR L=1 TO D[2]-J
120 P=P+1
130 FOR M=1 TO D[2]+2-J-L
140 C[R+M-1]=C[R+M-1]-C[P]*C[P+M-1]
150 NEXT M
160 R=R+M-1
170 NEXT L
180 P=S
190 NEXT J
200 T=(D[2]+1)*(D[2]+2)/2
210 FOR I=1 TO D[2]-1
220 T=T-1-I
230 C[T]=1/C[T]
240 FOR J=1 TO D[2]-I
250 P=D[2]+1-I-J
260 P=P*(D[2]+1-(P-1)/2)-I
```

```
270 R=P-J
280 S=0
290 Z=I+J+1
300 V=P
310 FOR M=1 TO J
320 V=V+Z-M
330 S=S-C[R+M]*C[V]
340 NEXT M
350 C[P]=S/C[R]
360 NEXT J
370 NEXT I
380 C[1]=1/C[1]
390 GOTO A[4] OF 400,410,420,430
400 LINK 16,10,30
410 LINK 17,10,150
420 LINK 17,10,320
430 LINK 17,10,520

     FILE 16
     PRINT PRELIMINARY AOV

10 LINK 19,10,10
11 LINK 19,10,11
14 LINK 17,10,14
15 LINK 17,10,15
16 LINK 17,10,16
17 LINK 17,10,17
29 LINK 17,10,30
30 IF A[4]>0 THEN 60
35 FORMAT F14.4
40 A[4]=1
50 LINK 15,10,10
60 T0=C[(D[2]+1)*(D[2]+2)/2]
62 PRINT
64 PRINT
70 PRINT TAB10"PRELIMINARY AOV TABLE"
80 PRINT
90 PRINT
100 PRINT "SOURCE         SS"," F      DF ","   R**2"
110 WRITE (15,35)"TOTAL    "T0
120 T1=C[D[2]+1]↑2
130 WRITE (15,35)"MEAN     "T1
140 WRITE (15,35)"TOT ADJ "T0-T1
150 P=N
160 B=0
170 T=T0-T1
180 FOR I=2 TO D[2]
190 A=C[I*(D[2]+1-(I-1)/2)]↑2
200 B=B+A
210 T=T-A
```

```
220 WRITE (15,230)" X**"I-1,A,A*(P-I)/T,"   (1,"P-I")  ",B/(T0-T1)
230 FORMAT F3.0,F16.4,F10.4,F4.0,F8.4
240 NEXT I
241 PRINT
242 PRINT
243 PRINT
244 PRINT
245 DISP "DONE"
250 END

     FILE 17
     PRINT AOV AND COEFFICIENTS

10 LINK 19,10,10
11 LINK 19,10,11
14 GOTO 30
15 GOTO 90
16 GOTO 480
17 GOTO 280
18 B[1]=B[1]+1
19 B[1]=B[1]+1
20 B[1]=B[1]+1
21 GOTO 750
22 LINK 19,10,22
23 LINK 20,10,30
30 PRINT
31 PRINT
34 DISP "DEG REGRESSION =";
40 FORMAT F14.4
50 INPUT D1
52 IF D1<D[2] THEN 60
54 PRINT "DEG REG MUST BE LESS THAN"D[2]
56 GOTO 34
60 PRINT "DEGREE REGRESSION="D1
70 PRINT
75 DISP "DONE"
80 END
90 IF D1=0 THEN 30
120 IF A[4]>0 THEN 150
130 A[4]=2
140 LINK 15,10,10
150 PRINT "     ANALYSIS OF VARIANCE"
160 PRINT
170 PRINT "SOURCE   DF","    SS","    MS","F"
180 GOSUB 400
190 WRITE (15,200)"TOTAL "N-1,T0
200 FORMAT F4.0,F14.4
210 WRITE (15,220)"REG  "D1,T1,T1/D1,T1/(S*D1)
220 FORMAT F5.0,2F14.4,F12.4
230 WRITE (15,240)"RESID"N-1-D1,T0-T1,S
```

45 - B(1)=1

```
240 FORMAT F4.0,2F14.2
250 PRINT
260 PRINT
270 STOP
280 IF D1=0 THEN 30
290 IF A[4]>0 THEN 320
300 A[4]=3
310 LINK 15,10,10
320 PRINT
321 PRINT
330 PRINT
340 GOSUB 400
350 WRITE (15,360)"R SQUARE ="T1/T0
360 FORMAT F8.4
370 PRINT
380 PRINT
390 STOP
400 T0=C[(D[2]+1)*(D[2]+2)/2]
410 T0=T0-C[D[2]+1]↑2
420 T1=0
430 FOR I=2 TO D1+1
440 T1=T1+C[I*(D[2]+1-(I-1)/2)]↑2
450 NEXT I
460 S=(T0-T1)/(N-1-D1)
470 RETURN
480 IF D1=0 THEN 30
490 IF A[4]>0 THEN 520
500 A[4]=4
510 LINK 15,10,10
520 PRINT
525 A[4]=4
530 PRINT
540 PRINT "COEFFICIENTS"
550 PRINT TAB13"B(I)    STD ERROR       T"
560 PRINT
570 GOSUB 400
580 T=0
590 FOR I=1 TO D1+1
600 E[I]=0
610 Z=0
620 FOR J=1 TO D1-I+2
630 R=(I+J-1)*(D[2]+2-(I+J)/2)
640 E[I]=E[I]+C[T+J]*C[R]
650 Z=Z+C[T+J]↑2
660 NEXT J
670 T=I*(D[2]+(3-I)/2)
680 WRITE (15,690)"B("I-1")="E[I],SQR(Z*S),E[I]/SQR(Z*S)
690 FORMAT F3.0,3F12.4
700 NEXT I
710 PRINT
```

```
720 PRINT
740 END
750 IF A[4]=4 THEN 780
760 B[1]=1
770 GOTO 480
780 GOTO B[1] OF 790,800,810,820
790 LINK 18,10,380
800 LINK 18,10,20
810 LINK 18,10,19
820 LINK 18,10,30
830 END
```

```
     FILE 18
     ESTIMATE Y CALCULATE RESIDUALS
```

```
10 LINK 19,10,10
11 LINK 19,10,11
12 LINK 14,10,30
13 LINK 16,10,30
14 LINK 17,10,14
15 LINK 17,10,15
16 LINK 17,10,16
17 LINK 17,10,17
18 GOTO 30
19 GOTO 270
20 GOTO 380
21 LINK 19,10,21
22 LINK 12,10,30
23 LINK 20,10,30
30 A=A[2]
40 B=A[3]
50 DISP "ENT 1 TO CHANGE PLOT RANGE";
60 INPUT D
70 IF D#1 THEN 120
80 DISP "X MIN=";
90 INPUT A
100 DISP "X MAX=";
110 INPUT B
120 T=0
130 R=(B-A)/100
140 Z=A
150 GOSUB 720
160 X=A
170 PLOT A,Y,1
180 FOR I=1 TO 100
190 X=X+R
200 Z=X
210 GOSUB 720
220 PLOT X,Y,2
230 NEXT I
```

```
240 PEN
250 DISP "DONE"
260 END
270 PRINT
280 PRINT
290 PRINT "ESTIMATE Y FOR GIVEN X"
300 DISP "ESTIMATE Y FOR X=";
310 INPUT X
320 Z=X
330 T=0
340 GOSUB 720
350 FORMAT 2F12.4
360 WRITE (15,350)"FOR X="X;" ,YHAT="Y
370 GOTO 300
380 PRINT
390 PRINT
400 PRINT "RESIDUALS"
410 DISP "ENT 1 TO PLOT RESIDUALS";
420 INPUT D[1]
430 IF D[1]#1 THEN 500
440 A[5]=A[8]
442 D=A[9]
444 A[8]=-5
445 A=A[2]
446 B=A[3]
447 A[9]=5
448 T0=A[6]
450 T1=A[7]
452 A[6]=A[7]=10
454 LINK 11,30,240
456 A[8]=A[5]
458 A[9]=D
460 A[6]=T0
462 A[7]=T1
468 PLOT A[2],5,-1
472 CPLOT 1,-1
476 LABEL (*,2,1,0)"STANDARDIZED RESIDUALS"
480 LABEL (*,1.5,1,0)
500 PRINT "  I            X";
510 IF A[8]=0 THEN 540
520 PRINT "           YT";
530 GOTO 550
540 PRINT "           Y";
550 PRINT "         YHAT      RESIDUAL"
551 A=E[1]
552 FOR I=1 TO D1
553 A=A+E[I]*A[10+I]
554 NEXT I
555 A=A-A[10+D[2]]
556 B=D=0
```

```
560 FOR I=1 TO D[3]
570 LOAD  DATA 20+I,B
575 IF B[1]=0 THEN 670
580 Z=B[2]
590 T=0
600 GOSUB 720
620 Z=B[3]
630 T=2
640 GOSUB 720
650 WRITE (15,660)I,B[2],Z,Y,Z-Y
651 IF D[1]=0 THEN 661
655 PLOT B[2],(Z-Y)/SQRS,1
656 CPLOT -0.3,-0.3
657 LABEL (*)"+"
660 FORMAT F4.0,4F12.4
661 B=B+(Z-Y+A)↑2
662 IF I=1 THEN 664
663 D=D+(Y-Z+Y)↑2
664 Y=Z-Y
670 NEXT I
680 PRINT
690 PRINT
700 DISP "DONE"
710 END
720 GOTO A[6+T]+1 OF 730,740,760,780,800,820,840,860
730 GOTO 870
740 Z=LGTZ
750 GOTO 870
760 Z=Z+A[7+T]
770 GOTO 870
780 Z=Z*A[7+T]
790 GOTO 870
800 Z=A[7+T]↑2
810 GOTO 870
820 Z=Z↑A[7+T]
830 GOTO 870
840 Z=LOGZ
850 GOTO 870
860 Z=EXPZ
870 IF T=2 THEN 920
880 Y=E[1]
890 FOR J=1 TO D1
900 Y=Y+E[J+1]*(Z↑J)
910 NEXT J
920 RETURN

     FILE 19
     CORRECT,DELETE DATA ON TAPE
```

```
10 GOTO 200
11 GOTO 130
14 LINK 17,10,14
15 LINK 17,10,15
16 LINK 17,10,16
17 LINK 17,10,17
18 LINK 18,10,18
19 LINK 18,10,19
21 GOTO 30
22 GOTO 340
23 LINK 20,10,30
30 PRINT
40 PRINT
50 WRITE (15,60)"DURBIN-WATSON STATISTIC ="D/B
60 FORMAT F12.4
70 PRINT
80 PRINT
90 PRINT
100 PRINT
110 DISP "DONE"
120 END
130 DISP "DELETE DATA SET #";
140 INPUT D
150 LOAD  DATA 20+D,B
160 B[1]=0
170 STORE  DATA 20+D,B
180 PRINT "DELETE SET "D
190 GOTO 130
200 DISP "CORRECT DATA SET#";
210 INPUT D
230 LOAD  DATA 20+D,B
240 DISP "X=";
250 INPUT B[2]
260 DISP "Y=";
270 INPUT B[3]
280 PRINT "DATA SET "D" IS NOW"
290 WRITE (15,300)"     X="B[2]" ,Y="B[3]
300 FORMAT 2F12.4
310 B[1]=1
320 STORE  DATA 20+D,B
330 GOTO 200
340 D[4]=D[3]=0
350 FOR I=1 TO 66
360 C[I]=0
370 NEXT I
380 FOR I=11 TO 21
390 A[I]=0
400 NEXT I
410 D1=A[4]=0
```

```
415 E[1]=B[1]=1
420 LINK 12,10,240
430 END

     FILE 20
     LOAD DATA FROM TAPE

10 LINK 19,10,10
11 LINK 19,10,11
12 LINK 14,10,30
13 LINK 16,10,30
14 LINK 17,10,14
15 LINK 17,10,15
16 LINK 17,10,16
17 LINK 17,10,17
30 D[5]=D[6]=D[4]=A[4]=0
40 DISP "ENT 1 FOR TRANSFORMATIONS";
50 INPUT D
60 IF D#1 THEN 120
70 DISP "FOR X,ENT:TCODE,C";
80 INPUT A[11],A[12]
90 DISP "FOR Y, ENT: TCODE,C";
100 INPUT A[13],A[14]
110 GOTO 130
120 A[11]=A[12]=A[13]=A[14]=0
130 DISP "ENT 1 TO PLOT AXES";
140 INPUT D[5]
160 DISP "ENT 1 TO PRINT";
170 INPUT D[6]
180 IF D[5]#1 THEN 210
190 D[1]=0
200 LINK 11,30,120
210 IF D[6]#1 THEN 270
220 PRINT "  I        X           Y";
230 IF A[11]=0 THEN 250
240 PRINT "         XT";
250 IF A[13]=0 THEN 270
260 PRINT "           YT";
270 PRINT
280 A[6]=A[11]
290 A[7]=A[12]
300 A[8]=A[13]
310 A[9]=A[14]
320 E[1]=1
330 FOR I=1 TO 66
340 C[I]=0
350 NEXT I
360 FOR I=11 TO 21
370 A[I]=0
380 NEXT I
```

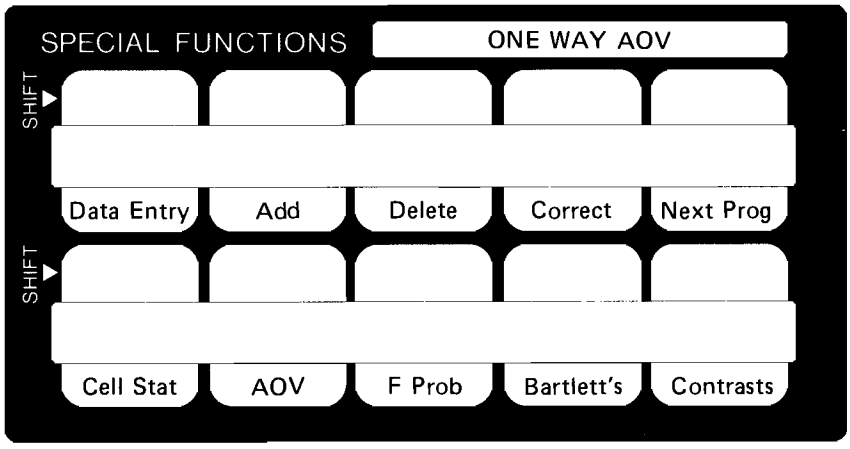
```
390 FOR I=1 TO D[3]
400 LOAD  DATA 20+I,B
405 IF B[1]=0 THEN 790
410 T=0
420 Z=B[2]
430 GOSUB 820
440 E[2]=Z
450 T=2
460 Z=B[3]
470 GOSUB 820
480 IF D[6]#1 THEN 570
490 WRITE (15,500)I,B[2],B[3];
500 FORMAT F4.0,2F12.4
510 IF A[6]=0 THEN 540
520 WRITE (15,530)E[2];
530 FORMAT F12.4
540 IF A[8]=0 THEN 560
550 WRITE (15,530)Z;
560 PRINT
570 FOR M=1 TO D[2]-1
580 E[M+1]=E[M]*E[2]
590 NEXT M
600 D=0
605 E[D[2]+1]=Z
610 FOR M=1 TO D[2]+1
620 FOR J=M TO D[2]+1
630 D=D+1
640 C[D]=C[D]+E[M]*E[J]
650 NEXT J
660 NEXT M
665 IF A[1]#1 THEN 690
670 PLOT B[2],Z,1
675 CPLOT -0.3,-0.3
680 LABEL (*,1.5,1,0)"+"
690 A[11]=A[11]+E[2]
700 A[12]=A[12]+E[2]*E[2]
710 A[13]=A[13]+Z
720 A[14]=A[14]+Z*Z
730 A[15]=A[15]+E[2]*Z
740 A[16]=A[16]+B[2]
750 A[17]=A[17]+B[2]*B[2]
760 A[18]=A[18]+B[3]
770 A[19]=A[19]+B[3]*B[3]
780 A[20]=A[20]+B[2]*B[3]
790 NEXT I
800 DISP "DONE"
810 END
820 GOTO A[6+T]+1 OF 830,840,860,880,900,920,940,960
830 RETURN
```

```
840 Z=LGTZ
850 RETURN
860 Z=Z+A[7+T]
870 RETURN
880 Z=Z*A[7+T]
890 RETURN
900 Z=A[7+T]↑Z
910 RETURN
920 Z=Z↑A[7+T]
930 RETURN
940 Z=LOGZ
950 RETURN
960 Z=EXPZ
970 RETURN
```

MODEL 30

ONE WAY AOV

DESCRIPTION:	This program analyzes data from an unbalanced one way classification. The user has the following options: 1. Print cell statistics 2. Bartlett's test for homogeneity of variance 3. A complete analysis of variance table 4. F-prob for calculated F values 5. Comparisons between means (Contrasts) 6. Ability to add, delete or correct incorrectly entered data
METHODS:	See reference.
SPECIAL CONSIDERATIONS:	The number of treatments must be less than 21.
ACKNOWLEDGMENTS:	Robert W. Kopitzke, Hewlett-Packard
REFERENCES:	Snedecor, G.W., and Cochran, W.G., Statistical Methods, sixth edition (Ames, Iowa: Iowa State University Press, 1967), Chapter 10.
SYSTEM SPECIFICATIONS:	9830 (2K or 4K R/W) 9866 Printer or 9861 Typewriter



OPERATION:

1. Type SCRATCH A, press EXECUTE.
2. Type LOADKEY 3, press EXECUTE.
3. Press RUN, DATA ENTRY [SF Key 0] keys.
4. The display reads, "NO TREATS = ?". Enter T, the number of treatments, press EXECUTE.
5. The display reads "NO OBS ON TREAT I = ?". Enter the number of observations for treatment i, press EXECUTE.
6. The display reads, "Y(J) = ". Enter observation number j on treatment number i, press EXECUTE.

Repeat steps 5 and 6 until all data is entered. The display reads, "ALL DATA ENTERED". Then, use the following four keys in any sequence.

SPECIAL FUNCTIONS:

ADD [SF Key 1]:
The ADD key allows the addition of one or more data points to any treatment or combination of treatments. To use:

1. Press ADD key.
2. The display reads, "ADD: TRT NO = ?". Enter the treatment number to which a data point is to be added. Press EXECUTE.
3. The display reads, "TRT NO = VALUE = ?". Enter the value to be added, press EXECUTE. Repeat steps 1, 2, and 3 as often as required.

DELETE [SF Key 2]:
This key allows an incorrectly entered data point to be deleted from any treatment. To use:

1. Press DELETE key.
2. The display reads, "DELETE: TRT NO = ?". Enter treatment number from which a point is to be deleted. Press EXECUTE.
3. The display reads, "TRT NO VALUE = ?". Enter value to be deleted, press EXECUTE. Repeat steps 1, 2, and 3 as often as required.

CORRECT [SF Key 3]:
This key allows an incorrectly entered point to be changed for any treatment. To use:

1. Press CORRECT key.
2. The display reads, "CORRECT: TRT NO = ?". Enter the treatment number to be corrected. Press EXECUTE.
3. The display reads, "TRT NO WRONG VALUE = ?". Enter the incorrect value, press EXECUTE.
4. The display reads, "WRONG = VALUE = ?". Enter the correct value, press EXECUTE. Repeat steps 1, 2, 3, and 4 as often as required.

CELL STAT [SF Key 5]:
Prints treatment means and within treatment variances.

After the above keys have been exercised, press NEXT PROG key. This key calls in the AOV, Bartlett's test and F-prob programs.

The keys may be used in any sequence with the restriction that the F-prob may be used only after an F-ratio is calculated.

AOV [SF Key 6]:
Prints Analysis of Variance table

BARTLETT'S [SF Key 8]:
Prints F-ratio and degrees of freedom for Bartlett's test.

F-PROB [SF Key 7]:
Prints probability of a calculated F-ratio.

After the above programs have been exercised, press NEXT PROG key and the contrasts program is called in.

CONTRASTS [SF Key 9]:
This key allows contrasts to be run between treatment means. To use:

1. Press CONTRASTS key.
2. The display reads, "C(I) = ?". Enter c(i), the i^{th} coefficient of the contrast. Repeat step 2 for i = 1 to T.
3. Print the comparison, contrast SS, and F-ratio.

If the F-prob is desired, press F-prob key. Repeat as often as desired.

```
ONE WAY AOV

TREAT # 1
      5.6000       5.7000       5.2000

TREAT # 2
      4.2000       4.8000       4.3000

TREAT # 3
      5.8000       6.1000       6.0000

TRT #   N        MEAN      VARIANCE
  1     3       5.5000       0.0700
  2     3       4.4333       0.1033
  3     3       5.9667       0.0233


                 AOV
SOURCE     DF        SS           MS             F
TOTAL       8       4.1000
TREATS      2       3.7067       1.8533      28.2712
ERROR       6       0.3933       0.0656

DF NUM =    2,DF DEN =    6,F=      28.2712
PROB F GREATER THAN     28.2712=    0.0009


BARTLETT'S TEST
DF NUM=      2.00,DF DEN=     81.00,F=       5.7169
PROB F GREATER THAN       5.7169=    0.0048

      1.0000       0.0000      -1.0000
COMPARISON=      -0.4667,CONTRAST SS=       0.3267,F=       4.9831

      1.0000      -2.0000       1.0000
COMPARISON=       2.6000,CONTRAST SS=       3.3800,F=      51.5593
```

```
     FILE 3
      DATA ENTRY

1 FORMAT F12.4
10 DIM A[20],B[20],C[20],D[6]
15 A[1]=0
17 PRINT "ONE WAY ANOV"
20 DISP "NO TREATS =";
30 INPUT T
40 FOR L=1 TO T
50 K=A[L]=C[L]=0
60 DISP "NO OBS ON TRT NO"L;"=";
70 INPUT B[L]
75 PRINT
80 PRINT "TREAT #"L
90 FOR J=1 TO B[L]
100 DISP "Y("J")=";
110 INPUT X
120 K=K+1
130 A[L]=A[L]+X
140 C[L]=C[L]+X↑2
150 D[K]=X
160 IF ((K=5)+(J=B[L]))=0 THEN 210
170 FOR P=1 TO K
180 WRITE (15,1)D[P],
190 NEXT P
195 PRINT
200 K=0
210 NEXT J
220 NEXT L
225 DISP "ALL DATA ENTERED";
230 END


10 PRINT "ADD:     ";
20 Z=FNZ1
30 END


10 PRINT "DELETE: ";
20 Z=FNZ(-1)
30 END


10 PRINT "CORRECT:";
20 Z=FNZ0
30 END


1 FORMAT F3.0,F5.0,2F12.4
10 PRINT
```

```
20 PRINT "TRT #""  N ""       MEAN""      VARIANCE"
30 FOR I=1 TO T
31 IF B[I]=1 THEN 37
33 S=(C[I]-(A[I]↑2)/B[I])/(B[I]-1)
35 GOTO 40
37 S=0
40 WRITE (15,1)I,B[I],A[I]/B[I],S
50 NEXT I
55 DISP "ALL TREATS LISTED"
60 END


10 DEF FNZ(X)
20 DISP "TRT NO=";
30 INPUT T0
40 PRINT "TRT NO.=";T0;
50 W=0
60 IF X#0 THEN 100
70 DISP "WRONG VALUE =";
80 INPUT W
90 PRINT "WRONG=";W;
100 DISP "VALUE=";
110 INPUT V
120 PRINT "VALUE=";V
130 A[T0]=A[T0]+V*SGN(X+0.1)-W
140 B[T0]=B[T0]+X
150 C[T0]=C[T0]+(V*V)*SGN(X+0.1)-W*W
160 RETURN 0
```

FILE 4

```
10 DEF FNX(X)
30 FORMAT F6.0,3F12.4
50 FORMAT F8.3
60 FORMAT 2F3.0,F7.4
70 PRINT
80 PRINT
90 PRINT TAB15"AOV"
100 PRINT "SOURCE    DF","    SS"," MS","F"
110 X=U=V=W=0
120 FOR I=1 TO T
130 V=V+A[I]
140 W=W+C[I]
150 U=U+B[I]
160 X=(A[I]↑2)/B[I]+X
170 NEXT I
190 S=W-V*V/U
200 WRITE (15,30)"TOTAL "U-1,S
220 R=X-V*V/U
230 B9=T-1
```

```
240 A9=U-T
250 F9=(R/(W-X))*(A9/B9)
260 WRITE (15,30)"TREATS"B9,R,R/B9,F9
270 S9=(W-X)/A9
280 WRITE (15,30)"ERROR "A9,W-X,S9
290 PRINT
295 Z=1
300 RETURN 0


10 DEF FNW(X)
20 E=F=G=H=0
30 FOR I=1 TO T
40 E=E+B[I]-1
50 D=(C[I]-(A[I]↑2)/B[I])/(B[I]-1)
60 F=F+(B[I]-1)*LOGD
70 G=G+(B[I]-1)*D
80 H=H+1/(B[I]-1)
90 NEXT I
100 M=E*LOG(G/E)-F
110 A=(1/(3*(T-1)))*(H-1/E)
120 B9=T-1
130 A9=INT((T+1)/(A↑2))
140 B=A9/(1-A+2/A)
150 F9=A9*M/(B9*(B-M))
155 PRINT
160 PRINT "BARTLETT'S TEST"
170 Z=0
180 FORMAT 2F9.2,F12.4
190 WRITE (15,180)"DF NUM="B9",DF DEN="A9",F="F9
200 RETURN 0
210 END


10 DEF FNY(X)
20 IF Z=0 THEN 60
30 FORMAT 2F4.0,F12.4
40 FORMAT F12.4,F9.4
50 WRITE (15,30)"DF NUM ="B9",DF DEN ="A9",F="F9
60 A9=A9/2
70 B9=B9/2
80 T9=F9
90 X9=A9/(A9+B9*F9)
100 Z9=X9
110 X9=X9/(1-X9)
120 E9=2*((A9>B9)*A9+(B9 >= A9)*B9)
130 E9=20+(E9<50)*E9+(E9 >= 50)*50
140 J9=E9
150 D9=1
160 FOR I9=1 TO J9-1
```

140 B = A9/(1 - A + 2/A9)

FOR X^2 VALUE

192 WRITE(15,195)"DF="B9,"CHI-SQUARED="M/(1+A)

195 FORMAT/, F13.2, F12.4

```
170 E8=E9/2
180 E7=INT(E8)
190 E6=(A9+E9-2)*(A9+E9-1)
200 IF E8=E7 THEN 230
210 Y9=E7*(A9+B9-1+E7)
220 GOTO 240
230 Y9=(A9+E7-1)*(E7-B9)
240 Y9=(Y9/E6)*X9
250 D9=1+Y9/D9
260 E9=E9-1
270 NEXT I9
280 D9=1/D9
290 A4=1
300 A5=(INT(A9)=A9)
310 B5=(INT(B9)=B9)
320 F5=(INT(A9+B9)=A9+B9)
330 IF (A5+B5)>0 THEN 350
340 A4=A4*PI
350 F9=A9+B9
360 A8=(2-SGNA5)*INTA9
370 B8=(2-SGNB5)*INTB9
380 F8=(2-SGNF5)*INTF9
390 A7=2-A5-(A9=0.5)
400 B7=2-B5-(B9=0.5)
410 F7=2-F5
420 A6=B6=F6=1
430 A4=A6*A4/A7
440 A6=A6+A7
450 IF A8>A6 THEN 470
460 A6=A7=A8=1
470 A4=B6*A4/B7
480 B6=B6+B7
490 IF B8>B6 THEN 510
500 B6=B7=B8=1
510 B4=0
520 A4=A4*F7/F6
530 F6=F6+F7
540 B4=B4+1
550 IF F8>F6 THEN 570
560 F6=F7=F8=1
570 IF ((F8=1)+(A8=1)+(B8=1))=3 THEN 610
580 IF ((A8=1)+(B8=1))>0 THEN 430
590 IF B4=2 THEN 430
600 GOTO 520
610 A4=A4*A9
620 A4=(EXP(A9*LOGZ9))/A4
630 A4=A4*EXP((B9-1)*LOG(1-Z9))
640 P=A4*D9
650 WRITE (15,40)"PROB F GREATER THAN"T9"="P
660 PRINT
```

```
670 RETURN 0


10 Y=FNX0
15 DISP "AOV COMPLETE";
20 END


10 Y=FNY1
20 END


10 Y=FNW0
20 END


      FILE 5


10 DEF FNY(X)
20 FORMAT 2F4.0,F12.4
30 FORMAT F12.4,F9.4
100 WRITE (15,20)"DF NUM ="B9",DF DEN ="A9",F="F9
110 A9=A9/2
120 B9=B9/2
130 T9=F9
150 X9=A9/(A9+B9*F9)
210 Z9=X9
220 X9=X9/(1-X9)
230 E9=2*((A9>B9)*A9+(B9 >= A9)*B9)
240 E9=20+(E9<50)*E9+(E9 >= 50)*50
250 J9=E9
260 D9=1
270 FOR I9=1 TO J9-1
280 E8=E9/2
290 E7=INT(E8)
300 E6=(A9+E9-2)*(A9+E9-1)
310 IF E8=E7 THEN 340
320 Y9=E7*(A9+B9-1+E7)
330 GOTO 350
340 Y9=(A9+E7-1)*(E7-B9)
350 Y9=(Y9/E6)*X9
360 D9=1+Y9/D9
370 E9=E9-1
380 NEXT I9
390 D9=1/D9
400 A4=1
410 A5=(INT(A9)=A9)
420 B5=(INT(B9)=B9)
430 F5=(INT(A9+B9)=A9+B9)
```

```
440 IF (A5+B5)>0 THEN 460
450 A4=A4*PI
460 F9=A9+B9
470 A8=(2-SGNA5)*INTA9
480 B8=(2-SGNB5)*INTB9
490 F8=(2-SGNF5)*INTF9
500 A7=2-A5-(A9=0.5)
510 B7=2-B5-(B9=0.5)
520 F7=2-F5
530 A6=B6=F6=1
540 A4=A6*A4/A7
550 A6=A6+A7
560 IF A8>A6 THEN 580
570 A6=A7=A8=1
580 A4=B6*A4/B7
590 B6=B6+B7
600 IF B8>B6 THEN 620
610 B6=B7=B8=1
620 B4=0
630 A4=A4*F7/F6
640 F6=F6+F7
650 B4=B4+1
660 IF F8>F6 THEN 680
670 F6=F7=F8=1
680 IF ((F8=1)+(A8=1)+(B8=1))=3 THEN 720
690 IF ((A8=1)+(B8=1))>0 THEN 540
700 IF B4=2 THEN 540
710 GOTO 630
720 A4=A4*A9
730 A4=(EXP(A9*LOGZ9))/A4
740 A4=A4*EXP((B9-1)*LOG(1-Z9))
750 P=A4*D9
770 WRITE (15,30)"PROB F GREATER THAN"T9"="P
775 PRINT
780 RETURN 0


10 Y=FNY1
20 END

10 FORMAT 6F12.4
20 X=1
30 K=0
40 Y=0
50 Y1=0
60 Y2=0
70 Y3=0
80 FOR I=1 TO T
90 DISP "C";I;"=";
100 INPUT X
```

```
110 Y=B[I]*X+Y
120 Y1=B[I]*X*X+Y1
130 Y2=A[I]*X+Y2
140 Y3=A[I]*X/B[I]+Y3
150 K=K+1
160 D[K]=X
170 IF ((K=6)+(I=T))=0 THEN 220
180 FOR P=1 TO K
190 WRITE (15,10)D[P];
200 NEXT P
210 K=0
220 NEXT I
230 PRINT
240 IF Y=0 THEN 280
250 PRINT "INVALID CONTRAST"
260 PRINT
270 GOTO 30
280 Y2=Y2↑2
290 Y1=Y2/Y1
300 F9=Y1/S9
310 WRITE (15,10)"COMPARISON="Y3",CONTRAST SS="Y1",F="F9
320 PRINT
330 B9=1
340 A9=U-T
350 DISP "EOC"
360 STOP
370 END
```

MODEL 30

TWO WAY AOV

DESCRIPTION:

This program analyzes the source of variation in a two way table of data with one or more replications.

The user has the following options:

1. Correct incorrectly entered data.
2. Print cell means and variances.
3. Print the overall mean.
4. Print row means.
5. Print column means.
6. Print AOV Table, including interaction sum of squares and F-test for interaction.
7. Print AOV Table, pooling interaction sum of squares and error sum of squares.
8. If the number of replications is equal to one, calculate and print Tukey's test for interaction.
9. Calculate and print row contrasts.
10. Calculate and print column contrasts.

METHODS:

See reference.

SPECIAL CONSIDERATIONS:

The product of the number of rows and the number of columns must be less than, or equal to, 50 for a 2K calculator. For a 4K calculator, change the dimension statement in line 70 from A(50), B(50) to A(300), B(300), and the product of the number of rows times the number of columns must then be less than 300.

ACKNOWLEDGMENTS:

Robert W. Kopitzke, Hewlett-Packard

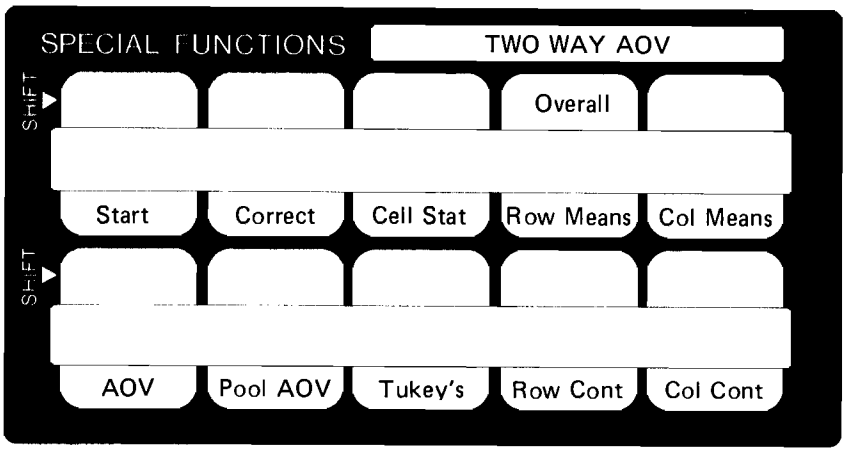
REFERENCES:

Graybill, F. A., An Introduction to Linear Statistical Models, Vol. I (New York: McGraw-Hill Book Company, 1961), pp. 324 - 332.

Snedecor, G. W., and Cochran, W. G., Statistical Methods, sixth edition (Ames, Iowa: Iowa State University Press, 1967), Chapter 11.

SYSTEM SPECIFICATIONS:

9830 (2K or 4K R/W)
9866 Printer or 9861 Typewriter



OPERATION:

1. Type SCRATCH A, press EXECUTE.
2. Type LOADKEY 6, press EXECUTE.
3. Press START [SF Key 0].
4. The display reads, "NO OF ROWS = ?". Enter number of rows, press EXECUTE.
5. The display reads, "NO OF COLUMNS = ?". Enter number of columns, press EXECUTE.
6. The display reads, "NO OF REPS = ?". Enter the number of replications, press EXECUTE.
7. The display reads, "Y(I, J, K) = ?". Enter y_{ijk}, press EXECUTE.

Repeat step 7 for each data point.

After all data is entered, any combination of the following operations may be used with the restriction that an analysis of variance table must be printed before row and column contrasts are printed.

SPECIAL FUNCTIONS:

CORRECT [SF Key 1]:

This key allows incorrectly entered data to be corrected. To use:

1. Press CORRECT [SF Key 1].
2. The display reads, "CORRECT: ROW #, COL #?". Enter row number, column number of the cell to be corrected, press EXECUTE.
3. The display reads, "ROW r COL c WRONG VALUE = ?". Enter the value to be deleted in row r, column c, press EXECUTE.
4. The display reads, "CORRECT VALUE = ?". Enter the correct value, press EXECUTE.
5. The display reads, "READY".

Repeat steps 1 through 4 as often as required.

CELL STAT [SF Key 2]:
This key prints cell means and within cell variances.

OVERALL [SF Key 13]:
This key prints overall mean.

ROW MEANS [SF Key 3]:
This key prints row means.

COL MEANS [SF Key 4]:
This key prints column means.

AOV [SF Key 5]:
This key prints AOV Table. If the number of replications is greater than 1, the interaction sum of squares, mean square and F-ratio are printed.

POOL AOV [SF Key 6]:
This key prints AOV Table pooling interaction sum of squares and degrees of freedom, with error sum of squares and degrees of freedom.

TUKEY'S [SF Key 7]:
This key prints Tukey's test for interaction if the number of replications is equal to one. If the number of replications is greater than one, this key prints an AOV Table as described under AOV [SF Key 5].

ROW CONT [SF Key 8]:
This key prints a contrast of row means. To use:

1. Press ROW CONT [SF Key 8].
2. The display reads, "C(I) = ?". Input c_i where c_i is the i^{th} coefficient of the contrast, press EXECUTE. Repeat step 2 for $i = 1, \ldots, r$.
3. If $\Sigma c_i \neq 0$, then the message, "INVALID CONTRAST" is typed; otherwise, the comparison of the means is printed and contrast sum of squares and F-ratio are printed.

(Note: The F-ratio uses the error mean square from the last printed analysis of variance table.)

Repeat steps 1 to 3 as often as required.

COL CONT [SF Key 9]:
This key allows a contrast of column means to be calculated and printed. To use:

1. Press COL CONT [SF Key 9].
2. The display reads, "C(I) = ?". Enter c_i where c_i is the i^{th} coefficient in the contrast, press EXECUTE. Repeat step 2 for $i = 1, \ldots, c$.
3. If $\Sigma c_i \neq 0$, then the message, "INVALID CONTRAST", is printed; otherwise, the comparison of means contrast, S. S., and F-ratio are printed.

(Note: The F-ratio uses the error mean square from the last printed AOV Table).

Repeat steps 1 through 3 as often as desired.

```
R= 3      ,C= 3      ,N= 2
ROW  COL    OBESERVATIONS

   1    1        3.0000        3.0000
        2        4.0000        3.0000
        3        3.0000        4.0000

   2    1        6.0000        4.0000
        2        6.0000        7.0000
        3        8.0000        5.0000

   3    1        3.0000        4.0000
        2        6.0000        7.0000
        3        5.0000        6.0000



ROW  COL  CELL MEAN  CELL VARIANCE

   1    1        3.0000        0.0000
        2        3.5000        0.5000
        3        3.5000        0.5000

   2    1        5.0000        2.0000
        2        6.5000        0.5000
        3        6.5000        4.5000

   3    1        3.5000        0.5000
        2        6.5000        0.5000
        3        5.5000        0.5000



OVERALL MEAN =       4.8333


ROW MEANS:
ROW     MEAN

   1       3.3333
   2       6.0000
   3       5.1667
```

```
COLUMN MEANS:
COL     MEAN

   1      3.8333
   2      5.5000
   3      5.1667


          ANALYSIS OF VARIANCE

SOURCE    DF          SS             MS              F
TOTAL     17        44.5000
ROWS       2        22.3333        11.1667       10.5789
COLS       2         9.3333         4.6667        4.4211
RXC        4         3.3333         0.8333        0.7895
ERROR      9         9.5000         1.0556


          ANALYSIS OF VARIANCE

SOURCE    DF          SS             MS              F
TOTAL     17        44.5000
ROWS       2        22.3333        11.1667       11.3117
COLS       2         9.3333         4.6667        4.7273
ERROR     13        12.8333         0.9872


  ROW CONTRAST:
  1.0000,  0.0000, -1.0000,
   COMPARISON =      -1.8333
   CONTRAST SS =      10.0833 FRATIO =      10.2143

  ROW CONTRAST:
  1.0000, -2.0000,  1.0000,
   COMPARISON =      -3.5000
   CONTRAST SS =      12.2500 FRATIO =      12.4091

   COLUMN CONTRAST
  1.0000,  0.0000, -1.0000,
   COMPARISON =      -1.3333
   CONTRAST SS =       5.3333 FRATIO =       5.4026

   COLUMN CONTRAST
  1.0000, -2.0000,  1.0000,
   COMPARISON =      -2.0000
   CONTRAST SS =       4.0000 FRATIO =       4.0519
```

FILE 7

DATA ENTRY

```
10 GOTO 530
12 GOTO 770
14 GOTO 940
15 GOTO 1230
16 GOTO 1070
17 LINK 8,10,17
19 LINK 8,10,19
30 FORMAT F4.0,F12.4
40 FORMAT F4.0
50 FORMAT F12.4
60 FORMAT 2F4.0,2F12.4
70 DIM A[50],B[50],D[5]
80 PRINT
90 PRINT TAB15"TWO WAY ADV"
100 PRINT
110 DISP "NO. OF ROWS =";
120 INPUT R
130 DISP "NO. OF COLUMNS =";
140 INPUT C
150 DISP "NO. OF REPS =";
160 INPUT T
165 PRINT "R="R" ,C="C" ,N="T
170 FOR I=1 TO R*C
180 A[I]=0
190 B[I]=0
200 NEXT I
210 PRINT "ROW  COL   OBESERVATIONS"
220 PRINT
230 E=0
240 E=0
250 FOR I=1 TO R
260 WRITE (15,40)I;
270 FOR J=1 TO C
280 PRINT TAB4*(J#1);
290 WRITE (15,40)J;
300 F=0
310 FOR K=1 TO T
320 DISP
330 DISP "Y("I","J","K") =";
340 INPUT A
350 D[K+5*(INT(-K/5)+1)]=A
360 D=(I-1)*C+J
370 V=1
380 GOSUB 700
390 F=F+1
```

```
400 IF (F<5) AND (K<T) THEN 470
410 FOR L=1 TO F
420 WRITE (15,50)D[L];
430 NEXT L
440 PRINT
450 PRINT TAB8*(K<T-1);
460 F=0
470 NEXT K
480 NEXT J
490 PRINT
500 NEXT I
520 GOTO 1170
530 DISP "CORRECT:ROW#,COL#";
540 INPUT I,J
541 IF (I<R+1) AND (J<C+1) THEN 550
542 DISP "R,C MUST BE <"R","C"RESP";
543 END
550 DISP "ROW"I"COL"J"WRONG VALUE =";
560 INPUT A
570 V=-1
580 D=(I-1)*C+J
590 GOSUB 700
600 PRINT
610 WRITE (15,60)"ON ROW "I" ,COL"J" CHANGE "A" ,TO";
620 DISP "CORRECT VALUE =";
630 INPUT A
640 V=1
650 GOSUB 700
660 WRITE (15,50)A
670 PRINT
680 DISP "READY"
690 END
700 A[D]=A[D]+V*A
710 B[D]=B[D]+V*A*A*(T>1)
720 E=E+V*A
730 B=B+V*A*A
740 RETURN
770 PRINT "ROW  COL  CELL MEAN  CELL VARIANCE"
780 PRINT
790 FOR I=1 TO R
800 WRITE (15,40)I;
810 FOR J=1 TO C
820 PRINT TAB4*(J#1);
830 D=(I-1)*C+J
840 WRITE (15,30)J,A[D]/T;
850 IF T=1 THEN 870
860 WRITE (15,50)(B[D]-A[D]*A[D]/T)/(T-1);
870 PRINT
880 NEXT J
890 PRINT
```

```
900 NEXT I
910 GOTO 1170
940 PRINT "ROW MEANS:"
950 PRINT "ROW     MEAN"
960 PRINT
970 FOR I=1 TO R
980 A=0
990 FOR J=1 TO C
1000 A=A+A[(I-1)*C+J]
1010 NEXT J
1020 WRITE (15,30)I,A/(T*C)
1030 NEXT I
1040 GOTO 1170
1070 PRINT "COLUMN MEANS:"
1080 PRINT "COL     MEAN"
1090 PRINT
1100 FOR I=1 TO C
1110 A=0
1120 FOR J=1 TO R
1130 A=A+A[(J-1)*C+I]
1140 NEXT J
1150 WRITE (15,30)I,A/(T*R)
1160 NEXT I
1170 PRINT
1180 PRINT
1190 PRINT
1210 DISP "DONE"
1220 END
1230 WRITE (15,50)"OVERALL MEAN ="E/(R*C*T)
1240 GOTO 1170
1250 END
```

```
    FILE 8
     PRINT AOV TABLES

10 LINK 7,10,10
12 LINK 7,10,12
14 LINK 7,10,14
15 LINK 7,10,15
16 LINK 7,10,16
17 U=0
18 GOTO 30
19 U=1
20 GOTO 30
21 U=3
22 GOTO 30
23 LINK 9,10,23
25 LINK 9,10,25
```

```
30 FORMAT F4.0,F14.4
40 FORMAT F4.0,2F14.4,F12.4
50 FORMAT F4.0,2F14.4
60 X=Y=Z=F=0
61 IF T>1 THEN 70
62 FOR I=1 TO C
63 B[I]=0
64 NEXT I
70 FOR I=1 TO R
80 D=0
90 FOR J=1 TO C
100 D=D+A[(I-1)*C+J]
110 NEXT J
120 X=X+D*D
121 IF T>1 THEN 130
123 FOR L=1 TO C
125 B[L]=B[L]+A[(I-1)*C+L]*D
127 NEXT L
130 NEXT I
140 X=X/(C*T)
150 FOR I=1 TO C
160 D=0
170 FOR J=1 TO R
180 V=A[(J-1)*C+I]
190 D=D+V
200 Z=Z+V*V
210 NEXT J
211 IF T>1 THEN 220
212 F=B[I]*D+F
220 Y=Y+D*D
230 NEXT I
240 Z=Z/T
250 Y=Y/(R*T)
255 Z=Z-X-Y
260 D=E*E/(R*C*T)
270 V=B-D
275 W=B-X-Y+D
280 X=(X-D)/(R-1)
290 Y=(Y-D)/(C-1)
300 Z=Z+D
310 W=W-Z*(T>1)*(U#1)
320 PRINT TAB10"ANALYSIS OF VARIANCE";
322 IF (T>1) OR (U<3) THEN 330
323 PRINT " FOR NON-ADDITIVITY";
330 PRINT
335 PRINT
340 PRINT "SOURCE   DF","     SS","     MS","     F"
342 IF (T=1) AND (U=3) THEN 480
350 WRITE (15,30)"TOTAL  "R*C*T-1,Y
360 A=(R-1)*(C-1)*((T=1)+(U=1)-(U=1)*(T=1))+R*C*(T-1)
```

```
370 WRITE (15,40)"ROWS    "R-1,(R-1)*X,X,X*A/W
380 WRITE (15,40)"COLS    "C-1,(C-1)*Y,Y,Y*A/W
390 IF (U=1)+(T=1)>0 THEN 420
400 N=(R-1)*(C-1)
410 WRITE (15,40)"RXC     "N,Z,Z/N,Z*A/(W*N)
420 WRITE (15,50)"ERROR   "A,W,W/A
430 PRINT
440 PRINT
450 PRINT
460 DISP "DONE"
470 END
480 WRITE (15,50)"ERROR   "(R-1)*(C-1),W,W/((R-1)*(C-1))
490 D=X*(R-1)+Y*(C-1)+E*E/(R*C*T)
500 D=D*E
501 D=F-D
505 D=D*D
506 D=D/(R*(R-1)*X)
507 D=D/(C*(C-1)*Y)
510 V=W-D
520 M=(R-1)*(C-1)-1
530 WRITE (15,40)"NONADD "T,D,D,D*M/V
540 WRITE (15,50)"BALANCE"M,V,V/M
550 GOTO 430
```

```
     FILE 9
     PRINT ROW AND COLUMN CONTRASTS
```

```
10 LINK 7,10,10
12 LINK 7,10,12
14 LINK 7,10,14
15 LINK 7,10,15
16 LINK 7,10,16
17 LINK 8,10,17
19 LINK 8,10,19
21 LINK 8,10,21
23 V=1
24 GOTO 30
25 V=0
26 GOTO 30
30 FORMAT F12.4
35 FORMAT 2F12.4
40 FORMAT 2F8.4
50 U=R*(V=1)+C*(V=0)
60 G=R*(V=0)+C*(V=1)
70 F=X=Y=D=Z=0
80 IF V=0 THEN 110
90 PRINT "  ROW CONTRAST:"
100 GOTO 120
```

```
110 PRINT "   COLUMN CONTRAST"
120 FOR I=1 TO U
130 DISP
140 DISP "C("I") =";
150 INPUT D
160 D[I+5*(INT(-I/5)+1)]=D
170 F=F+1
180 IF (F<5) AND (I<U) THEN 250
190 FOR J=1 TO F
200 WRITE (15,40)D[J]",";
210 NEXT J
220 F=0
230 PRINT
240 PRINT TAB3;
250 X=X+D
260 M=0
270 FOR K=1 TO G
280 M=M+A[(I-1)*C+K]*(V=1)
290 M=M+A[(K-1)*C+I]*(V=0)
300 NEXT K
310 Y=Y+D*M
320 Z=Z+D*D
330 NEXT I
340 IF X#0 THEN 400
350 X=Y*Y/(T*G*Z)
360 WRITE (15,30)"COMPARISON ="Y/(T*G)
365 WRITE (15,35)"   CONTRAST SS ="X" FRATIO ="X*A/W
370 PRINT
380 DISP "READY"
390 END
400 PRINT "INVALID CONTRAST"
410 GOTO 380
```

275 IF V=0 THEN 290
285 GO TO 300

F-PROB

DESCRIPTION:

Given numerator degrees of freedom, v_1, and denominator degrees of freedom, v_2, and an F-value, this program calculates the probability that an F random variable has a value greater than, or equal to, the input value.

METHODS:

A continued fraction approximation is used to calculate the probability. The number of convergents used is: $\min [70, 20 + \max \{v_1, v_2\}]$.

SPECIAL CONSIDERATIONS:

The degrees of freedom must satisfy:

$$10^{-198} < \left[\frac{\max(v_1, v_2)}{v_1 + v_2}\right]^{(v_1 + v_2)}$$

ACKNOWLEDGMENTS:

Robert W. Kopitzke, Hewlett-Packard

REFERENCES:

Abramowitz, M. and Stegun, I. A., Handbook of Mathematical Functions (National Bureau of Standards, 1968), p. 944.

SYSTEM SPECIFICATIONS:

9830 (2K or 4K R/W)
9866 Printer or 9861 Typewriter

OPERATION:

1. Type SCRATCH A, press EXECUTE.
2. Type LOAD 1, press EXECUTE.
3. Press RUN, EXECUTE.
4. The display reads, "NUM DF = ?".
5. Enter numerator degrees of freedom, press EXECUTE.
6. The display reads, "DEN DF = ?". Enter denominator degrees of freedom, press EXECUTE.
7. The display reads, "F = ?". Enter F, press EXECUTE. The df and F are printed, and the calculated F-prob is printed.
8. To run another case, go to step 3.

EXAMPLE

```
DF NUM =   1,DF DEN =    3,F=      34.1200
PROB F GREATER THAN      34.1200=   0.0100

DF NUM =  30,DF DEN =   21,F=       2.7000
PROB F GREATER THAN       2.7000=   0.0104

DF NUM = 100,DF DEN = 150,F=        1.5100
PROB F GREATER THAN       1.5100=   0.0111

DF NUM = 100,DF DEN = 150,F=        1.2300
PROB F GREATER THAN       1.2300=   0.1249
```

```
10 FORMAT 2F4.0,F12.4
20 FORMAT F12.4,F9.4
30 DISP "NUM DF=";
40 INPUT B9
50 DISP "DEN DF=";
60 INPUT A9
70 DISP "F=";
80 INPUT F9
90 WRITE (15,10)"DF NUM ="B9",DF DEN ="A9",F="F9
100 A9=A9/2
110 B9=B9/2
120 T9=F9
130 C9=0
140 X9=A9/(A9+B9*F9)
150 IF X9<(1/2) THEN 200
160 C9=A9
170 A9=B9
180 B9=C9
190 X9=1-X9
200 Z9=X9
210 X9=X9/(1-X9)
220 E9=2*((A9>B9)*A9+(B9 >= A9)*B9)
230 E9=20+(E9<50)*E9+(E9 >= 50)*50
240 J9=E9
250 D9=1
260 FOR I9=1 TO J9-1
270 E8=E9/2
280 E7=INT(E8)
290 E6=(A9+E9-2)*(A9+E9-1)
300 IF E8=E7 THEN 330
310 Y9=E7*(A9+B9-1+E7)
320 GOTO 340
330 Y9=(A9+E7-1)*(E7-B9)
340 Y9=(Y9/E6)*X9
350 D9=1+Y9/D9
360 E9=E9-1
370 NEXT I9
380 D9=1/D9
390 A4=1
400 A5=(INT(A9)=A9)
410 B5=(INT(B9)=B9)
420 F5=(INT(A9+B9)=A9+B9)
430 IF (A5+B5)>0 THEN 450
440 A4=A4*PI
450 F9=A9+B9
460 A8=(2-SGNA5)*INTA9
470 B8=(2-SGNB5)*INTB9
480 F8=(2-SGNF5)*INTF9
490 A7=2-A5-(A9=0.5)
500 B7=2-B5-(B9=0.5)
```

```
510 F7=2-F5
520 A6=B6=F6=1
530 A4=A6*A4/A7
540 A6=A6+A7
550 IF A8>A6 THEN 570
560 A6=A7=A8=1
570 A4=B6*A4/B7
580 B6=B6+B7
590 IF B8>B6 THEN 610
600 B6=B7=B8=1
610 B4=0
620 A4=A4*F7/F6
630 F6=F6+F7
640 B4=B4+1
650 IF F8>F6 THEN 670
660 F6=F7=F8=1
670 IF ((F8=1)+(A8=1)+(B8=1))=3 THEN 710
680 IF ((A8=1)+(B8=1))>0 THEN 530
690 IF B4=2 THEN 530
700 GOTO 620
710 A4=A4*A9
720 A4=(EXP(A9*LOGZ9))/A4
730 A4=A4*EXP((B9-1)*LOG(1-Z9))
740 P=A4*D9
750 P=SGN(C9)*(1-P)+(1-SGNC9)*P
760 WRITE (15,20)"PROB F GREATER THAN"T9"="P
770 PRINT
780 DISP "DONE"
790 END
```

T-PROB

DESCRIPTION:

Given a t-value with n degrees of freedom, this program calculates the probability that a T random variable is greater than, or equal to, the input value.

METHODS:

A continued fraction approximation is used to calculate the probability. The number of convergents used is: min [70, 20 + df].

Graphically, the probability calculated is the shaded area below:

If a t-prob is desired for a two sided test, then double the calculated t-probability.

SPECIAL CONSIDERATIONS:

None

ACKNOWLEDGMENTS:

Robert W. Kopitzke, Hewlett-Packard

REFERENCES:

Abramowitz, M. and Stegun, I. A., Handbook of Mathematical Functions (National Bureau of Standards, 1968), p. 944.

SYSTEM SPECIFICATIONS:

9830 (2K or 4K R/W)
9866 Printer or 9861 Typewriter

OPERATION:

1. Type SCRATCH A, press EXECUTE.
2. Type LOAD 2, press EXECUTE.
3. Press RUN, EXECUTE.
4. The display reads, "T = ?".
5. Enter t-value, press EXECUTE.
6. The display reads, "DF = ?".
7. Enter the degrees of freedom, press EXECUTE.
8. To run another case, go to step 3.

EXAMPLE

```
T=      2.9980,DF=        6
PROB T GREATER THAN      2.9980=   0.0120

T=      3.0550,DF=       12
PROB T GREATER THAN      3.0550=   0.0050

T=      0.6840,DF=       25
PROB T GREATER THAN      0.6840=   0.2501
```

```
10 FORMAT F12.4,F8.0
20 FORMAT F12.4,F9.4
30 DISP "T=";
40 INPUT F9
50 DISP "DF=";
60 INPUT A9
70 WRITE (15,10)"T="F9",DF="A9
80 B9=1
90 T9=F9
100 F9=F9↑2
110 A9=A9/2
120 B9=B9/2
130 C9=0
140 X9=A9/(A9+B9*F9)
150 IF X9<(1/2) THEN 200
160 C9=A9
170 A9=B9
180 B9=C9
190 X9=1-X9
200 Z9=X9
210 X9=X9/(1-X9)
220 E9=2*((A9>B9)*A9+(B9 >= A9)*B9)
230 E9=20+(E9<50)*E9+(E9 >= 50)*50
240 J9=E9
250 D9=1
260 FOR I9=1 TO J9-1
270 E8=E9/2
280 E7=INT(E8)
290 E6=(A9+E9-2)*(A9+E9-1)
300 IF E8=E7 THEN 330
310 Y9=E7*(A9+B9-1+E7)
320 GOTO 340
330 Y9=(A9+E7-1)*(E7-B9)
340 Y9=(Y9/E6)*X9
350 D9=1+Y9/D9
360 E9=E9-1
370 NEXT I9
380 D9=1/D9
390 A4=1
400 A5=(INT(A9)=A9)
410 B5=(INT(B9)=B9)
420 F5=(INT(A9+B9)=A9+B9)
430 IF (A5+B5)>0 THEN 450
440 A4=A4*PI
450 F9=A9+B9
460 A8=(2-SGNA5)*INTA9
470 B8=(2-SGNB5)*INTB9
480 F8=(2-SGNF5)*INTF9
490 A7=2-A5-(A9=0.5)
```

```
500 B7=2-B5-(B9=0.5)
510 F7=2-F5
520 A6=B6=F6=1
530 A4=A6*A4/A7
540 A6=A6+A7
550 IF A8>A6 THEN 570
560 A6=A7=A8=1
570 A4=B6*A4/B7
580 B6=B6+B7
590 IF B8>B6 THEN 610
600 B6=B7=B8=1
610 B4=0
620 A4=A4*F7/F6
630 F6=F6+F7
640 B4=B4+1
650 IF F8>F6 THEN 670
660 F6=F7=F8=1
670 IF ((F8=1)+(A8=1)+(B8=1))=3 THEN 710
680 IF ((A8=1)+(B8=1))>0 THEN 530
690 IF B4=2 THEN 530
700 GOTO 620
710 A4=A4*A9
720 A4=(EXP(A9*LOGZ9))/A4
730 A4=A4*EXP((B9-1)*LOG(1-Z9))
740 P=A4*D9
750 P=SGN(C9)*(1-P)+(1-SGNC9)*P
760 WRITE (15,20)"PROB T GREATER THAN"T9"="P/2
770 PRINT
780 DISP "DONE"
790 END
```

PROGRAM SUBMITTAL INSTRUCTIONS AND FORMS

Program Submittal Instructions

Hewlett-Packard maintains a library of calculator programs available to HP users. New contributed programs are solicited to increase the number of programs available to you and other users.

Each program you submit will be evaluated for possible publication in the HP Keyboard or a program library, or inclusion in the HP Calculator Program Catalog.

Entries in the Calculator Program Catalog are of two types — supported programs from Hewlett-Packard and programs contributed by users. HP compiles but does not test or maintain contributed programs. Maintenance of these programs is the responsibility of the person submitting the program, since he is the most knowledgeable about his entry. Each program will bear either an original date or a revised date indicating a revision or correction.

Contributed programs should be typewritten and completely documented so that other users are able to easily understand and operate them. Most user questions can be obviated by having a person unfamiliar with your program read it and try the numerical example before submitting it. Completion of the Program Submittal Form and inclusion of the listed material and recorded mag cards or cassette will help insure adequately documented, publishable programs. The magnetic cards or cassette can be returned on request. Submittal and user instruction forms are found on the next few pages. Contact the HP sales office in your area if you need additional submittal forms.

Programs may be withdrawn from the Calculator Program Catalog by writing to Hewlett-Packard, and stating the reason for withdrawal, such as when the program is replaced with a redesigned version. Address all correspondence to:

Hewlett-Packard Company
Calculator Products Division
P. O. Box 301
Loveland, Colorado 80537

Attention: Applications Services

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Hewlett-Packard Company
Calculator Products Division

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3. Program Title: _____

4. Program Description and Application: _____

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9. Check (✓) to be sure each item below is included.

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☐ Numeric input/output example, including sample plot or printer tape if applicable.
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