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Fortran Programs for the Calculation of Most of the Commonly Used Experimental Design Models

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FORTRAN PROGRAMS FOR THE CALCULATION OF MOST OF THE COMMONLY USED EXPERIMENTAL DESIGN MODELS

by

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ABSTRACT

FORTRAN Programs for the Calculation of Most of the Commonly Used Experimental Design Models

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Two computer programs were developed using a CDC 3100. They were written in FORTRAN IV.

One program uses four tape drives, one card reader, and one printer. It will calculate factorial analysis of variance with or without covariance and/or multivariate analysis for one to eight factors and up to twenty-five variables.

The other program is used for completely randomized designs, randomized block designs, and latin square designs. It will handle twenty-five treatments, rows (blocks), and columns. The program can handle fifteen variables using any number of these variables for covariates.

(128 pages)

TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	3
FACTORIAL DESIGNS	5
Description	5
Methodology	6
Input	8
Output	18
BASIC DESIGNS	21
Description	21
Methodology	21
Input	22
Output	26
LITERATURE CITED	28
APPENDIXES	29
Appendix A. Factorial Designs Program	30
Appendix B. Factorial Program Sample Problems	51
Appendix C. Basic Designs Program	88
Appendix D. Basic Program Sample Problems	100
Appendix E. Modified Factorial Program	116
VITA	125

INTRODUCTION

During the past few years there has been an increasing interest in using computers to calculate analysis of variance, analysis of covariance and multivariate analysis. Many different methods and programs have been written to perform the necessary calculations. Most of these programs fall into three main categories: (i) those that will handle only small sets of data, (ii) those that require large amounts of core storage, and (iii) those that are written in a machine dependent language.

This thesis contains program writeups and listings for two computer programs, one for basic designs (completely randomized, randomized block, and latin square designs) and another for factorial designs. The program for basic designs is fairly restrictive on the size of problems it will handle, but is presented here because of its use as a teaching tool. The factorial program will handle up to eight factors with the only restriction on the number of levels per factor being that the number of subtotals needed for any uncorrected sum of squares must be less than 2500. Both programs will calculate analysis of variance and covariance and the factorial program will also calculate multivariate analysis. Appendix E contains the listing of a modified factorial program which will run faster but handle only analysis of variance. These programs will all run on

a 16k word Control Data Corporation 3100 with 3100 FORTRAN (a restricted FORTRAN IV), four tape drives, a card reader and a printer.

REVIEW OF LITERATURE

A few of the existing programs are those by Bone (1), Hurst (6), Dixon (4) and The Statistical Service Unit, University of Illinois (9). All of these programs will handle between seven and nine factors.

The programs by the Statistical Service Unit University of Illinois (9) are commonly known by the mnemonic name of SSUPAC. The SSUPAC series is written for an IBM 7094 with five tape drives, one 1301 disk storage file, a card reader and a printer. The analysis of variance program will handle one to seven factors plus replications.

Dixon (4) is the editor of a series of programs written at the University of California at Los Angeles, widely known as the BMD series. This series is also written for an IBM 7094, part of it in FORTRAN and part of it in FAP. The factorial analysis of variance will handle eight factors plus replications for only one variable. If covariance is desired another program is used which will handle six factors plus replications.

Bone (1) from Brigham Young University, at Provo Utah has written a program for an IBM 7040/44 in MAP. This program will handle up to ten factors. This program will also handle covariance.

Most of the ideas for the programs in this thesis were taken from the program series by Hurst (6). The first

program in this series is all that is required for analysis of variance. This program is written in SPS for an IBM 1620 with card input and output. If covariance or multivariate analysis is desired the output from the first program is then run on three other programs, one in SPS and two in FORTRAN. The covariance and multivariate routines used in this thesis are direct modifications of those by Hurst.

FACTORIAL DESIGNS

Description

This program is used to calculate the analysis of variance with or without covariance and/or multivariate analysis for equal subclass factorial designs with up to eight factors, replications counted as a factor. The program can also be used on some types of fractional replication designs and some designs using totals or averages.

The program is divided into four main parts. The first part is the mainline program, FACOV; this is the primary input section. The second part is the SUBROUTINE GAOV; this subroutine calculates the necessary totals and sums of squares for the AOV for each variable. The totals are written on tape to be used by later subroutines. SUBROUTINE FACT is the third part. It sorts the totals and calculates error and treatment plus error sums of squares and sums of products matrices which are also written on tape. The fourth part consists of three subprograms, SUBROUTINE MULVA, FUNCTION DET, and SUBROUTINE INVERT. This part calculates the covariance and/or multivariate analysis.

This program is written in FORTRAN IV. It requires one input unit (logical unit 5), one output unit (logical unit 6), and three intermediate work tapes (logical units 1, 2, 3). The program can also use one secondary input unit (logical unit 4).

Methodology

This program uses standard analysis of variance and covariance techniques as described in Snedecor (8) or any other good book on elementary statistical methods. The multivariate techniques are those described by Rao (7).

Program FACOV is the primary input section. This section reads the control cards and observations. The observations are then rewritten on logical unit 2, followed by the raw sum of squares trail cards, and the corrected sum of squares trail cards.

The first thing SUBROUTINE GAOV does is to read logical unit 2 and calculate the total sums of squares and sums of products matrix and write on logical unit 3. Logical unit 2 is then rewound. Next it reads the observations from logical unit 2 and writes only one variable on logical unit 1. It also calculates the total and total sums of squares. Next logical unit 1 is rewound. It then reads a raw sum of squares trail card from logical unit 2 and while reading the data from logical unit 1 calculates and writes on logical unit 3 the subtotals and, if requested, writes the averages on logical unit 6. The sum of squares is then calculated and stored internally. Logical unit 1 is then rewound and the next raw sum of squares trail card is used. It repeats this until all raw sum of squares trail cards are used. Then, the program reads the corrected sum of squares trail cards to calculate the analysis of variance, which is

written on logical unit 6. At this point logical units 1 and 2 are rewound, and the procedure is completed for the next variable. When all variables are completed, the program branches to SUBROUTINE FACT.

At this point logical unit 3 contains the total sums of squares and sums of products matrix, followed by the total for that variable and by the totals for each raw sum of squares trail card, sorted total within variable. SUBROUTINE FACT sorts the totals, using logical units 1, 2, 3, so that they are sorted variable within total. The sorted totals are then read and an uncorrected sums of squares and products matrix is calculated for each raw sum of squares trail card plus a total sums of squares and products matrix and a correction term matrix. The matrices are written on logical unit 6 and on either logical unit 1 or 2, (the sorted totals are on the other). The program then reads the linear combinations for the error and treatment plus error matrices, from logical unit 5, and performs the combinations, and writes the matrices on logical units 3 and 6.

The final part of the program is the SUBROUTINE MULVA, used with SUBROUTINE INVERT and FUNCTION DET. The first card read determines the number of models desired, and for each model, a control card is read to determine whether covariance or multivariate analysis or both is desired. Then a variable selection card is read to determine which

variables are to be used in the analysis. Logical unit 3 is rewound and a matrix is read. The first matrix must be an error matrix. The treatment plus error matrices, using this error matrix, should follow immediately. This may be followed by more error and treatment plus error matrices. The method distinguishing between error and treatment plus error matrices will be explained in the input section. This part of the program uses two main matrix areas. Matrix A is the general input matrix and is also used for matrix inversion and covariance analysis. Matrix B is used to store intermediate results and for the calculation of the determinates needed for multivariate analysis.

Input

An input deck consists of the following: control card, format card, a card of approximate means, the data cards, raw sum of squares trail cards (these cards are required; all others are optional), corrected sum of squares trail cards, corrected sums of squares and sums of products matrices trail cards, a card specifying the number of models on which covariance and/or multivariate analysis is wanted, and for each model a control card and a variable selection card is needed.

Control card

(10I3, I5, 3I4, F5.0, 3I2)

Column	Description
1-3	Number of variables $\leq$ 50
4-6	0 = Covariance or multivariate analysis is not desired 1 = Covariance or multivariate analysis is desired
7-9	Number of levels of factor A $\geq$ 1
10-12	Number of levels of factor B $\geq$ 1
⋮	⋮
27-30	Number of levels of factor H $\geq$ 1
31-35	Total number of observations
36-39	Number of raw SS trail cards
40-43	Number of corrected SS trail cards
44-47	Number of corrected matrices wanted
48-52	Special divisor to be used with correction term (See example on fractional replication sample)
53-54	0 = don't use special divisor 1 = use special divisor
55-56	0 = full replication 1 = fractional replication
57-58	0 = data on logical unit 5 1 = data on logical unit 4

The sum of columns (36-39) and (40-43) must be less than or equal to 126.

Format card

(20A4)

Column	Description
1	
2-80	A combination of X, F, and E format specifications with one F or E specification for each variable specified in columns 1 - 3 of the control card; also one F specification for a control field to be used if this is a fractional replication.

Approximate means card

(5E15.7)

There should be one mean for each variable. These means are used to help improve accuracy. These are not actual means and should not contain any more digits than the original variables. If this option is not desired, use means of 0.0.

Data cards

The data cards must be compatible with a FØRTRAN READ statement. The observations of each experimental unit should be recorded on a separate card. Different variables

measured on the same experimental unit may be recorded on separate fields of the same card. Negative signs are recorded as an eleven punch preceding the first significant digit of a field.

The data must be sorted by levels of H within levels of G . . . . within levels of B within levels of A. The program does not interrogate treatment levels. Therefore, it is the user's responsibility to see that the data cards are in sequence and that there are no missing observations. However, if the design is a fractional replication, by definition there are missing observations. These missing observations must be inserted into the data deck with the data fields blank and an additional control field of 9999.0.

Raw sum of squares trail cards

(9X, 8I1, I3, I2, F5.0, I2)

Column	Description
1-9	Not used
10-17	Binary definition of sum of squares wanted. A "0" is used for each subscript which is dotted. A "1" is used for each subscript which is to be summed on.
18-20	Line number $\geq$ 3. Used to identify sum of squares. Numbers assigned consecutively.

Column	Description
21-22	0, don't punch means 1, punch means
23-27	Special divisor to be used with this line number; see fractional replication sample
28-29	0, don't use special divisor 1, use special divisor

Line number 01 is reserved for the total sum of squares ($\sum_{ijk'} Y^2_{ijk'}$) which is automatically produced. Line number 02 is reserved for the correction term ($Y^2_{....}/abcd$), which is also automatically produced.

The preceding cards are required, all other cards are needed only if requested in the control card.

Corrected sum of squares trail cards

(3A4, 17I4/(20X, 15I4))

Column	Description
1-12	Descriptive information
13-16	Line number. Begins where the raw sums of squares line numbers leave off. Line numbers are assigned consecutively and must be less than 128.
17-20	Number of terms in the linear combination for this line.

Column	Description
21-24	Line number of raw or previously calculated corrected sum of squares to be used to calculate this corrected line. If it is to be subtracted it is written as a negative number.
25-28	Next term of this linear combination
⋮	⋮
77-80	15th term in this linear combination. If this is the last term it must be followed by a blank card. If more terms are needed begin another card in columns 21-24.

Corrected matrices trail cards

(3A4, 2I4, 10(F3.0,I3)/(20X, 10(F3.0, I3)))

Column	Description
1-12	Descriptive information
13-16	Line Number. A negative line number identifies an error sums of squares and products matrix. Positive line numbers are for treatment plus error matrices.

Column	Description
17-20	Number of terms in this linear combination.
21-23 24-26	Each term in the linear combination consists of two fields. The first is a weighting factor. The second is a line number which corresponds to one of the raw sum of squares trail cards. The weighting factor is multiplied times each element of the matrix.
27-29 30-32	The next term in the linear combination.
⋮	⋮
75-77 78-80	The 10th term in this linear combination. If this is the last term this card must be followed by a blank card. If more terms are needed, begin another card in columns 21-23, 24-26.

Number of models card

(I3)

Column	Description
1-3	Number of covariance and/or multivariate analysis models wanted.

For each model the next two cards are required.

Covariance and/or multivariate analysis control card

(2I3, 3I2)

Column	Description
1-3	Number of independent variables; X's
4-6	Number of dependent variables; Y's
7-8	0, don't write inverse of error matrix
	1, write inverse of error matrix
9-10	0, don't write error regression coefficients.
	1, write error regression coefficients
11-12	0, No multivariate analysis
	1, Multivariate analysis

The sum of columns (1-3) and (4-6) must be less than or equal to 25.

Variable selection card

(20I4)

Column	Description
1-4	The position, in the original read list, of variable 1.
5-8	The position, in the original read list, of variable 2.
⋮	⋮
77-80	The position, in the original read list, of variable 20.

If more than 20 variables are needed, begin in columns (1-4) of a second card with variable 21. The X variables come first, followed by the Y variables.

The following example is used to illustrate the preparation of the input.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + (\beta\gamma)_{ik} + \varepsilon_{ijk} \qquad \begin{matrix} i = 1, \ldots, a \\ j = 1, \ldots, b \\ k = 1, \ldots, c \end{matrix}$$

TOT	abc - 1	$\sum_{ijk}\sum\sum Y^2_{ijk} - Y^2_{...}/abc$
A	a - 1	$\sum_{i} Y^2_{i..}/bc - Y^2_{...}/abc$
B	b - 1	$\sum_{j} Y^2_{.j.}/ac - Y^2_{...}/abc$
C	c - 1	$\sum_{k} Y^2_{..k}/ab - Y^2_{...}/abc$
B x C	(b-1)(c-1)	$\sum_{jk}\sum Y^2_{.jk}/a - \sum_{j} Y^2_{.j.}/ac - \sum_{k} Y^2_{..k}/ab + Y^2_{...}/abc$
Error	abc-bc-a+1	$\sum_{ijk}\sum\sum Y^2_{ijk} - \sum_{jk}\sum Y^2_{.jk}/a - \sum_{i} Y^2_{i..}/bc + Y^2_{...}/abc$

For this example we will use only one variable, a = 16, b = 3, and c = 2. From the analysis of variance we see that we need 6 raw sums of squares, as follows.

(1) $\sum_{ijk}\sum\sum Y^2_{ijk}$

(2) $Y^2_{...}/abc$

(3) $\sum_{i} Y_{i..}/bc$

(4) $\sum_{j} Y^2_{.j.}/ac$

(5) $\sum_{i} Y^2_{..k}/ab$

(6) $\sum_{jk}\sum Y^2_{.jk}/a$

(1) and (2) are automatic; therefore, four raw sum of squares trail cards and six corrected sum of squares trail cards are needed.

If we assume the data to have the following format: factor A coded in column 1-2, factor B coded in column 3, factor C coded in column 4, Y recorded in columns 8-10 with 2 positions to the right of the decimal, and an approximate mean of 4.0. The data and control cards will be as follows:

<u>Control card</u>

Column: ↓3 ↓10 ↓43

bb1bb0b16bb3bb2bb1bb1bb1bb1bb1bbb96bbb4bbb6

<u>Format card</u>

Column: ↓1

(7X,F3.2)

<u>Approximate mean</u>

Column: ↓1 ↓15

4.0

Data cards

The data cards are sorted first on column 4, then 3, and then 2 and 1.

Raw SS trail cards

Column

```
↓10        ↓22
10000000bb3bl
01000000bb4bl
00100000bb5bl
01100000bb6bl
```

Corrected SS trail cards

Column

```
↓1              ↓16
TØTbbbbbbbbbbbb7bbb2bbblbb-2
```

Column

```
↓1      ↓16
A        8bbb2bbb3bb-2
B        9bbb2bbb4bb-2
C       10bbb2bbb5bb-2
BC      11bbb4bbb6bb-4bb-5bbb2
ERRØR   12bbb4bbblbb-6bb-3bbb2
```

Output

Most of the output is self-explanatory; however, the following information will be helpful. The first three lines are the control cards written so that they may be checked. Following the control cards are the raw sum of squares lines, with their corresponding treatment identifications and means, the corrected sum of squares trail cards, and the analysis of variance for each variable. If corrected matrices are requested, following the last variable

are the uncorrected sums of squares and products matrices, and the corrected matrices. Each corrected matrix is preceded by its corresponding trail card. Both uncorrected and corrected matrices are written in the following manner.

ROW				
1	$a_{1,1}$	$a_{1,2}$	$\cdots\cdots\cdots$	$a_{1,n}$
2	$a_{2,2}$	$a_{2,3}$	$\cdots\cdots$	$a_{2,n}$
⋮				
n	$a_{n,n}$			

Next comes the output for covariance and/or multivariate analysis. This output may be best explained by defining the following abbreviations.

REG CØEF	= Regression coefficients
DUE TØ REG	= Due to regression
DF	= Degrees of freedom
SS AND SP	= Sum of squares and sum of products
MS AND MP	= Mean square and mean products
DEV FR REG	= Deviation from regression
TRT ADJ	= Treatment adjusted
ERR MATRIX	= Error matrix
TRT MATRIX	= Treatment matrix
ERRØR DET	= Determinate of error matrix

TRT + ERR DET = Determinate of treatment plus error matrix

MUL F = Multivariate F value

The numbers under the headings RØW, CØL, X, and Y are variable numbers corresponding to the variables in the original input list.

BASIC DESIGNS

Description

This program is used to calculate analysis of variance and covariance for completely randomized designs with unequal sample size, or randomized block designs, or latin square designs without replications or subsampling. With covariance on a completely randomized design it will, on control, give you a linear regression analysis within each treatment.

Automatically, the program will give you an analysis of variance and treatment means for each variable, and if you wish, covariance, the error correlation matrix, inverse matrix, solution matrix, adjusted analysis of variance, and adjusted means.

The program is written in FORTRAN IV. It requires one input unit (logical unit 5) and one output unit (logical unit 6). The DIMENSION statement is set up for 25 treatments, 25 blocks, 25 columns, and 15 variables.

Methodology

A control card is read to determine the model, number of treatments, number of blocks, number of independent variables (X's), number of dependent variables (Y's), and whether you want regression analysis on a completely

randomized design with covariance. If the model is a completely randomized design, a card containing number of observations per treatment is read next. Then, for all models in order, a format specification card, a rearrangement vector card, and a card containing approximate means are read. These are then followed by the data cards.

As the data cards are read the total sums of squares and products matrix, treatment totals, row (block) totals, column totals, and variable totals are produced. Also, if you wish regression analysis within treatments, the analysis is given at the end of each treatment. After the data has been read, the analysis of variance for each variable and treatment means are calculated and outputted. If you wish covariance (number of X's is greater than zero) the error and treatment plus error matrices are calculated and the program branches to SUBROUTINE COVAR.

SUBROUTINE COVAR outputs the error correlation matrix and with the help of SUBROUTINE INVERT calculates and outputs the inverse of the error matrix and the solution matrix. It then gives you the adjusted analysis and adjusted treatment means.

Input

The first card of the input is a number of jobs card. The input for each problem consists of: a control card, a number of observations card (if model is a completely

randomized design), a format specification card, a rearrangement vector card, a card with approximate means, and the data cards. All fields on the control cards, except description, format, and approximate means, must be right justified. The approximate means must have a decimal point punched.

Number of jobs card

(I4)

Column	Description
1-4	Number of separate jobs (models) to be run.

The following cards are repeated for as many times as specified in the previous card.

Control card

(5I4, 2I2, 16X, 10A4)

Column	Description
1-4	Model identification 1 = Completely randomized design 2 = Randomized block design 3 = Latin square design
5-8	Number of treatments
9-12	≤ 25
9-12	Number of blocks
	≤ 25
13-16	Number of X's
	Sum must be less than 15
17-20	Number of Y's

Column	Description
21-22	1 = output regression within treatment for completely randomized design
	0 = do not output regression
23-24	0 = data on logical unit 5
	1 = data on logical unit 4
41-80	Descriptive information

Number of observations per treatment card
(used for completely randomized designs only)

(20I4)

Column	Description
1-4	Number of observations for treatment 1.
5-8	Number of observations for treatment 2.
⋮	⋮
77-80	Number of observations for treatment 20.

If you have more than 20 treatments follow with card beginning with treatment 21 in columns 1-4.

Format specification card

(20A4)

It must begin with a left parenthesis in column 1, followed by a combination of F, E,/, and X format specifications followed by a right parenthesis. You must have one F or E format specification for each variable. If your model is a latin square design you must also have a Fw.o specification to read column identification.

Rearrangement vector

(20I4)

Column	Description
1-4	The position in read list of variable 1.
5-8	The position in read list of variable 2.
⋮	⋮
57-60	The position in read list of variable 15.

The X variables come first, followed by the Y variables. If your model is a latin square design, follow your last variable with the position, in read list, of column identification.

Approximate means card

(5E15.8)

Column	Description
1-15	The approximate mean of variable 1.
16-30	The approximate mean of variable 2.
⋮	⋮
61-75	The approximate mean of variable 5.

If you have more than 5 variables follow with additional cards. These constants are subtracted from the variables to improve the accuracy of the sums and sums of squares and products of the variables. The approximate means should contain no more digits than the original data.

An exact eight digit mean when used with a three digit field will produce more error than an approximate mean of only three digits. A zero is a legitimate constant and may be used to ignore this feature.

Data cards

The data cards must be compatible with a FORTRAN READ statement. An extra column must be provided for sign control in fields that may go negative. A negative punch (an eleven punch) is recorded to the left of the most significant digit. Recorded decimals will override format specifications. Normally it is a waste of card columns to record decimals. The data cards must be sorted; observation within treatment for a completely randomized design, block within treatment for a randomized block design, and row within treatment for a latin square design. For a latin square design the column identification must be integers running sequentially from 1 to the number of treatments.

Output

Most of the output is self-explanatory. However, the following information will be helpful. The first four or five cards are the control cards, printed out so that you can check them. All matrices are printed in the following manner:

$$
\begin{array}{ll}
1 & a_{1,1}\ a_{1,2} \cdots \cdots \cdots \cdots a_{1,n} \\
2 & a_{2,2}\ a_{2,3} \cdots \cdots \cdots \cdots a_{2,n} \\
\vdots & \\
n & a_{n,n}
\end{array}
$$

The regression coefficients are printed

$$i \quad j \qquad b_{i,j}$$

where $b_{i,j}$ is the partial regression coefficient of variable i on variable j.

The following abbreviations are used:

DF = degrees of freedom

SS = sum of squares

MS = mean square

SE = standard error of a mean

EXP MEAN = overall mean of that variable

C.V. = coefficient of variation

CØEF ØF DET = coefficient of determination (R^2)

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APPENDIXES

Appendix A

Factorial Designs Program

Table 1 shows the dependencies that must be maintained if the DIMENSION statements are to be changed. Capital letters are used for variable names within the programs and lower case letters for all other variables. Subroutine GAOV is the program which contains most of the limitations. Following Table 1 is a listing of the factorial program as it ran on a CDC 3100.

Table 1. Dependencies in EQUIVALENCE and DIMENSION statements

Program	Dimension	Equivalence
FACOV		
	CONST (NV)	(A(20),X(1))
	FMT (20)	(IX(1),NIN(1))
	X (NV+1)	
	NIN (8)	
	DES (3)	
	IX (b)	
	A (n,n)	
GAOV		
	A (n,n)	(A(1),TOT(1))
	TOT (m)	(IX(1),NIN(1))
	NDF (f)	(IX(9),NOUT(1))
	SS (f)	
	NL (8)	
	NX (8)	
	NOUT (8)	
	NIN (8)	
	IX (b)	
	DES (3)	
	DIVMN (f)	
	NLEV (f)	
	CONST (NV)	

Table 1. Continued

Program	Dimension	Equivalence
FACT		
	DIV (f)	(A(m/2+1),AX(1))
	NL (f)	(A(m/2+b+1),ST(1))
	ST (NV)	
	A (n,n)	
	CONST (NV)	
	AX (b)	
	IX (b)	
	DES (3)	
MULVA		
	A (n,n)	(A(m/2+1),B(1))
	B (n,n/2)	(A(n/2+1),X(1))
	ID (b)	
	X (n/2)	
DET		
	A(n,n)	(A(m/2+1),B(1))
	B (n,n/2)	(A(n/2+1),F(1))
	F (n/2)	
INVERT		
	A (n,n)	

NV = Number of variables
LC = Number of corrected SS trail cards
LI = Number of raw SS trail cards
LZZ = Number of terms in any linear combination
$f \geq LI+LC+2$
$b \geq LZZ$
$b \geq NV$
$n/2 > NV$
$m = \overline{n^2} \geq$ Largest number of subtotals needed in any sum of squares.

```
C       PROGRAM FACOV                                                          FA000010
C       THIS IS THE PRIMARY INPUT SECTION                                      FA000020
        DIMENSION CONST(25),FMT(20),X(26),NIN(8),DES(3),IX(75),A(50,50)        FA000030
        COMMONA,NV,MC,IX,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,ISPD,SPD,CONSTFA000040
       1 ,DES,KON                                                              FA000050
        EQUIVALENCE (A(20),X(1)),(IX(1),NIN(1))                                FA000060
        REWIND 02                                                              FA000070
        READ  (5,100)NV,KON,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,MC,SPD,ISPDFA000080
       1,IFR,IO                                                                FA000090
        WRITE (6,300)NV,KON,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,MC,SPD,ISPDFA000100
       1,IFR,IO                                                                FA000110
  300 FORMAT (1H110I3,I5,3I4,F5.0,3I2)                                         FA000120
  100 FORMAT (   10I3,I5,3I4,F5.0,3I2)                                        FA000130
        IN=5-IO                                                                FA000140
        READ  (5,101) (FMT(K),K=1,20)                                          FA000150
  101 FORMAT(20A4)                                                             FA000160
        WRITE (6,111) (FMT(K),K=1,20)                                          FA000170
  111 FORMAT(1H ,20A4)                                                         FA000180
        X(NV+1)=0.0                                                            FA000190
        INC=NV+IFR                                                             FA000200
        READ (5,102) (CONST(I),I=1,NV)                                         FA000210
  302 FORMAT (1H 5E15.7)                                                       FA000220
  102 FORMAT    ( 5E15.7)                                                      FA000230
        WRITE (6,302) (CONST(I),I=1,NV)                                        FA000240
        KK=NV+1                                                                FA000250
        IF (IO) 52,52,51                                                       FA000260
   51 REWIND 4                                                                 FA000270
   52 DO 10 J=1,NOBS                                                           FA000280
        READ (IN,FMT) (X(I),I=1,INC)                                           FA000290
        IF (X(KK)-9999.0)5,10,5                                                FA000300
    5 DO 6 I=1,NV                                                              FA000310
    6 X(I)=X(I)-CONST(I)                                                       FA000320
   10 WRITE (2) (X(IL),IL=1,NV)                                                FA000330
        IF (IO)2,2,1                                                           FA000340
    1 REWIND 4                                                                 FA000350
```

```
      PAUSE                                                                  FA000360
    2 DO 15 LN=1,LI                                                          FA000370
      READ  (5,1001) (NIN(I),I=1,8),ILINE,Ip,pD,IpD                          FA000380
   15 WRITE (02)     (NIN(I),I=1,8),ILINE,IP,PD,IPD                        FA000390
 1001 FORMAT(9X,8I1,I3,I2,F5.0,I2)                                          FA000400
      IF (LC)18,18,13                                                        FA000410
   13 DO 14 LN=1,LC                                                         FA000420
      READ  (5,1003) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)             FA000430
   14 WRITE (02) (DES(Iyy),Iyy=1,3),LCN,LZZ,(IX(K),K=1,LZZ)                 FA000440
 1003 FORMAT(3A4,17I4,/(20X,15I4))                                          FA000450
   18 REWIND 02                                                             FA000460
      CALL GAOV                                                             FA000470
      STOP                                                                  FA000480
      END                                                                   FA000490
```

```
      SUBROUTINE GAOV                                                    FA000500
C     THIS IS THE FACTORIAL ANALYSIS OF VARIANCE PORTION                 FA000510
      DIMENSIONA(50,50),TOT(2500),NDF(128),SS(128),NL(8),NX(8),NOUT(8)   FA000520
     1 ,NIN(8),IX(75),DES(3),DIVM(128),NLEV(128),CONST(25)               FA000530
      COMMONA,NV,MC,IX,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,ISPD,SPD,CONSTFA000540
     1 ,DES,KON,DIVM,NLEV                                               FA000550
      EQUIVALENCE (A(1),TOT(1)),(IX(1),NIN(1)),(IX(9),NOUT(1))           FA000560
      REWIND 3                                                           FA000570
      IF (MC) 650,650,600                                                FA000580
  600 DO 300 K=1,NV                                                      FA000590
      DO 300 J=K,NV                                                      FA000600
  300 A(K,J)=0.0                                                         FA000610
C     CALCULATE TOTAL SS AND SP MATRIX                                   FA000620
      DO 500 M=1,NOBS                                                    FA000630
      READ (2) (SS(J),J=1,NV)                                            FA000640
      DO 500 K=1,NV                                                      FA000650
      DO 500 J=K,NV                                                      FA000660
  500 A(K,J)=A(K,J)+SS(J)*SS(K)                                          FA000670
      REWIND 2                                                           FA000680
      NONE=1                                                             FA000690
      WRITE (3) NONE                                                     FA000700
      DO 400 K=1,NV                                                      FA000710
      DO 400 J=K,NV                                                      FA000720
  400 WRITE (3) A(K,J)                                                   FA000730
  650 DO 17 IXX=1,NV                                                     FA000740
      REWIND 1                                                           FA000750
      WRITE (6,413)IXX                                                   FA000760
  413 FORMAT (9H1VARIABLE ,I3)                                           FA000770
      WRITE (6,333)                                                      FA000780
  333 FORMAT(//2X6HBINARY,3X4HLINE,9X11HTREAT IDENT,                     FA000790
     1  7X6HNO OBS,3X7HAVERAGE/)                                        FA000800
      SS(1)=0.0                                                          FA000810
      SUM=0.0                                                            FA000820
      OBS=NOBS                                                           FA000830
      NL(1)=NA                                                           FA000840
```

```
      NL(2)=NB                                                          FA000850
      NL(3)=NC                                                          FA000860
      NL(4)=ND                                                          FA000870
      NL(5)=NE                                                          FA000880
      NL(6)=NF                                                          FA000890
      NL(7)=NG                                                          FA000900
      NL(8)=NH                                                          FA000910
C     READ DATA                                                         FA000920
C     COMPUTE GRAND TOTAL AND TOTAL SUM OF SQUARES                      FA000930
      DO 40 L=1,NOBS                                                    FA000940
      READ (2) (TOT(J),J=1,NV)                                          FA000950
      Y=TOT(IXX)                                                        FA000960
      SS(1)=SS(1)+Y*Y                                                   FA000970
      SUM=SUM+Y                                                         FA000980
   40 WRITE (01)Y                                                       FA000990
      REWIND 1                                                          FA001000
   41 IF(ISPD)20,21,20                                                  FA001010
   20 NDF(1)=SPD                                                        FA001020
      GO TO 22                                                          FA001030
   21 NDF(1)=NOBS                                                       FA001040
C     COMPUTE AND WRITE THE CORRECTION TERM                             FA001050
      IW=0                                                              FA001060
   22 IF(ISPD)23,24,23                                                  FA001070
   23 SS(2)=SUM*SUM/SPD                                                 FA001080
      DIV=SPD                                                           FA001090
      GO TO 25                                                          FA001100
   24 SS(2)=SUM*SUM/OBS                                                 FA001110
      DIV=OBS                                                           FA001120
   25 NDF(2)=1                                                          FA001130
      LEN=2                                                             FA001140
      AV=SUM/DIV+CONST(IXX)                                             FA001150
      WRITE (6,102) IW,IW,IW,IW,IW,WI,IW,IW,LEN,IW,IW,IW,IW,IW,IW,IW,IW,FA001160
     1DIV,AV                                                            FA001170
C     REPEAT DOWN TO 5 FOR EACH RAW SS WANTED                           FA001180
      DIVM(1)=1.0                                                       FA001190
```

```
      NLEV(1)=DIV                                                       FA001200
      DIVM(2)=NDF(1)                                                    FA001210
      NLEV(2)=1                                                         FA001220
      WRITE (3) SUM                                                     FA001230
      DO 5 LN=1,LI                                                      FA001240
C     COMPUTE OPERATIONAL CONSTANTS                                     FA001250
      READ (2)   (NIN(I),I=1,8),ILINE,IP,RPD,IRPD                      FA001260
      LEN=1                                                             FA001270
      DO 50 I=1,8                                                       FA001280
      IF(NIN(I)) 52,51,52                                               FA001290
   51 NX(I)=0                                                           FA001300
      NOUT(I)=1                                                         FA001310
      GO TO 50                                                          FA001320
   52 K=I+1                                                             FA001330
      NOUT(I)=NL(I)                                                     FA001340
      NZ=1                                                              FA001350
   55 IF (K-8)56,56,58                                                  FA001360
   56 IF (NIN(K))54,57,54                                               FA001370
   54 NZ=NZ*NL(K)                                                       FA001380
   57 K=K+1                                                             FA001390
      GO TO 55                                                          FA001400
   58 NX(I)=NZ                                                          FA001410
      LEN=LEN*NL(I)                                                     FA001420
   50 CONTINUE                                                          FA001430
C     ZERO THE TOTALS REQUIRED FOR THIS SET                             FA001440
      DO 6 I=1,LEN                                                      FA001450
    6 TOT(I)=0.0                                                        FA001460
C     ACCUMLATE A SET OF TOTALS                                         FA001470
C     OPERATE ON ALL OBSERVATIONS                                       FA001480
      DO 7 I=1,NA                                                       FA001490
      DO 7 J=1,NB                                                       FA001500
      DO 7 K=1,NC                                                       FA001510
      DO 7 L=1,ND                                                       FA001520
      DO 7 M=1,NE                                                       FA001530
      DO 7 N=1,NF                                                       FA001540
```

```
      DO 7 IZA=1,NG                                                          FA001550
      DO 7 IZB=1,NH                                                          FA001560
      READ  (1) Y                                                            FA001570
C     FIND IDENTIFICATION OF TOTAL                                           FA001580
      IA=(I-1)*NX(1)+(J-1)*NX(2)+(K-1)*NX(3)+(L-1)*NX(4)+(M-1)*NX(5)+1       FA001590
      IA=IA+(N-1)*NX(6)+(IZA-1)*NX(7)+(IZB-1)*NX(8)                          FA001600
C     INCREMENT THE SPECIFIED TOTAL                                          FA001610
    7 TOT(IA)=TOT(IA)+Y                                                      FA001620
      REWIND 1                                                               FA001630
      SS(ILINE)=0.0                                                          FA001640
      NDF(ILINE)=LEN                                                         FA001650
      IF(IRPD)26,27,26                                                       FA001660
   26 DIV=RPD                                                                FA001670
      GO TO 28                                                               FA001680
   27 DIV=NOBS/LEN                                                           FA001690
C     EACH OF THE FOLLOWING SHOULD BE EITHER ONE OR THE NUMBER OF LEVELS     FA001700
   28 NAA=NOUT(1)                                                            FA001710
      NBB=NOUT(2)                                                            FA001720
      NCC=NOUT(3)                                                            FA001730
      NDD=NOUT(4)                                                            FA001740
      NEE=NOUT(5)                                                            FA001750
      NFF=NOUT(6)                                                            FA001760
      NGG=NOUT(7)                                                            FA001770
      NHH=NOUT(8)                                                            FA001780
      LL=1                                                                   FA001790
      DO 8 I=1,NAA                                                           FA001800
      II=I*NIN(1)                                                            FA001810
      DO 8 J=1,NBB                                                           FA001820
      IJ=J*NIN(2)                                                            FA001830
      DO 8 K=1,NCC                                                           FA001840
      IK=K*NIN(3)                                                            FA001850
      DO 8 L=1,NDD                                                           FA001860
      IL=L*NIN(4)                                                            FA001870
      DO 8 M=1,NEE                                                           FA001880
      IM=M*NIN(5)                                                            FA001890
```

```
      DO 8 N=1,NFF                                                        FA001900
      IN=N*NIN(6)                                                         FA001910
      DO 8 IZA=1,NGG                                                      FA001920
      IIZA=IZA*NIN(7)                                                     FA001930
      DO 8 IZB=1,NHH                                                      FA001940
      IIZB=IZB*NIN(8)                                                     FA001950
      IF(IP) 9,18,9                                                       FA001960
C     WRITE MEANS IF REQUESTED                                            FA001970
    9 AVE=TOT(LL)/DIV+CONST(IXX)                                          FA001980
      WRITE (6,102) (NIN(IIM),IIM=1,8),ILINE,II,IJ,IK,IL,IM,IN,IIZA,IIZBFA001990
     1,DIV,AVE                                                            FA002000
  102 FORMAT(1H 8I1,2I5,7I3,F6.0,2X,E14.7)                                FA002010
   18 SS(ILINE)=SS(ILINE)+TOT(LL)*TOT(LL)                                 FA002020
      WRITE (03) TOT(LL)                                                  FA002030
    8 LL=LL+1                                                             FA002040
      DIVM(LN+2)=DIV                                                      FA002050
      NLEV(LN+2)=LEN                                                      FA002060
    5 SS(ILINE)=SS(ILINE)/DIV                                             FA002070
      IF (LC) 10,17,10                                                    FA002080
C     FORM CORRECTED SUMS OF SQUARES                                      FA002090
   10 WRITE  (6,1103)                                                     FA002100
 1103 FORMAT(/ 13X21HLINEAR FUNCTION CARDS/)                              FA002110
      DO 15 I=1,LC                                                        FA002120
      NDOF=0                                                              FA002130
      SQS=0.0                                                             FA002140
      READ  (02) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)               FA002150
      WRITE (6,1004) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)           FA002160
 1004 FORMAT(1H ,3A4,17I4,/(21X,15I4))                                    FA002170
      DO 14 K=1,LZZ                                                       FA002180
      IF(IX(K)) 11,12,13                                                  FA002190
   11 IZ=-IX(K)                                                           FA002200
      SQS=SQS-SS(IZ)                                                      FA002210
      NDOF=NDOF-NDF(IZ)                                                   FA002220
      GO TO 14                                                            FA002230
   13 IZ=IX(K)                                                            FA002240
```

```
      SQS=SQS+SS(IZ)                                                    FA002250
      NDOF=NDOF+NDF(IZ)                                                 FA002260
   14 CONTINUE                                                          FA002270
   12 DOF=NDOF                                                          FA002280
      AMS=SQS/DOF                                                       FA002290
      SS(LCN)=SQS                                                       FA002300
      NDF(LCN)=NDOF                                                     FA002310
   15 WRITE (1) (DES(IYY),IYY=1,3),LCN,NDOF,SQS,AMS                     FA002320
      REWIND 2                                                          FA002330
      REWIND 1                                                          FA002340
      WRITE (6,84) IXX                                                  FA002350
   84 FORMAT (36H1     ANALYSIS OF VARIANCE, VARIABLE,I3//              FA002360
     17H SOURCE, 9X2HDF,8X2HSS,14X2HMS )                                FA002370
      DO 30 I=1,LC                                                      FA002380
      READ  (1) (DES(IYY),IYY=1,3),LCN,NDOF,SQS,AMS                     FA002390
   30 WRITE  (6,103) (DES(IYY),IYY=1,3), NDOF,SQS,AMS                   FA002400
  103 FORMAT(1H 3A4,I5,2X,E14.7,2X,E14.7)                               FA002410
   17 CONTINUE                                                          FA002420
      IF (MC) 202,202,201                                               FA002430
  201 CALL FACT                                                         FA002440
  202 STOP                                                              FA002450
      END                                                               FA002460
```

```
      SUBROUTINE FACT                                                    FA002470
C     SUBROUTINE TO CALCULATE SS AND SP MATRICES                         FA002480
      DIMENSION DIV(128),NL(128),ST(25),A(50,50),CONST(25),AX(75),IX(75)FA002490
     1 ,DES(3)                                                           FA002500
      COMMON A,NV,MC,IX,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,ISPD,SPD,CONSTFA002510
     1 ,DES,KON,DIV,NL                                                   FA002520
      EQUIVALENCE (A(1251),AX(1)) ,(A(1326),ST(1))                       FA002530
      REWIND 1                                                           FA002540
      REWIND 2                                                           FA002550
      REWIND 3                                                           FA002560
      READ (3) K                                                         FA002570
      DO 3 I=1,NV                                                        FA002580
      DO 3 J=I,NV                                                        FA002590
      READ (03) Z                                                        FA002600
    3 A(I,J)=0.0                                                         FA002610
      LK=LI+1                                                            FA002620
      NTOT=0                                                             FA002630
C     DETERMINE NUMBER OF RECORDS ON TAPE                                FA002640
      DO 5 I=1,LK                                                        FA002650
    5 NTOT=NTOT+NL(I+1)                                                  FA002660
      NOL=LK+1                                                           FA002670
      K1=1                                                               FA002680
      K2=2                                                               FA002690
C     SORT TAPE                                                          FA002700
      DO 20 K=1,NV                                                       FA002710
      K3=K1                                                              FA002720
      K1=K2                                                              FA002730
      K2=K3                                                              FA002740
      DO 15 I=1,NTOT                                                     FA002750
      IF (K-1) 10,12,10                                                  FA002760
   10 NPV= K-1                                                           FA002770
      DO 11 J=1,NPV                                                      FA002780
      READ  (K1) TOT                                                     FA002790
   11 WRITE (K2) TOT                                                     FA002800
   12 READ   (3) TOT                                                     FA002810
```

```
   15 WRITE (K2) TOT                                                        FA002820
      REWIND K1                                                             FA002830
      REWIND K2                                                             FA002840
   20 CONTINUE                                                              FA002850
C     THE SORTED TAPE IS K2                                                 FA002860
      REWIND 03                                                             FA002870
      READ (3) ID                                                           FA002880
      WRITE (K1) ID                                                         FA002890
C     READ TOTAL SS AND SP MATRIX OFF OF TAPE 3 AND WRITE IT ON TAPE K1     FA002900
      DO 7 I=1,NV                                                           FA002910
      DO 7 J=I,NV                                                           FA002920
      READ (03)Z                                                            FA002930
    7 WRITE (K1) Z                                                          FA002940
C     COMPUTE A SS AND SP MATRIX FOR THE CORRECTION TERM                    FA002950
C     AND EACH RAW SS TRAIL CARD                                            FA002960
      DO 40 I=2,NOL                                                         FA002970
      WRITE (K1) I                                                          FA002980
      NK=NL(I)                                                              FA002990
      DO 30 M=1,NK                                                          FA003000
      DO 35 J=1,NV                                                          FA003010
   35 READ  (K2) ST(J)                                                      FA003020
      DO 30 K=1,NV                                                          FA003030
      DO 30 J=K,NV                                                          FA003040
   30 A(K,J)=A(K,J)+ST(J)*ST(K)                                             FA003050
      DO 40 K=1,NV                                                          FA003060
      DO 40 J=K,NV                                                          FA003070
      Z=A(K,J)/DIV(I)                                                       FA003080
      WRITE (K1) Z                                                          FA003090
   40 A(K,J)=0.0                                                            FA003100
      WRITE (6,303)                                                         FA003110
  303 FORMAT (21H1UNCORRECTED MATRICES  )                                   FA003120
      REWIND K1                                                             FA003130
      DO 50 I=1,NOL                                                         FA003140
      READ (K1) KK                                                          FA003150
      WRITE (6,304)                                                         FA003160
```

```
  304 FORMAT (18HOLINE  NO OBS  ROW  )                                          FA003170
      DO 50 K=1,NV                                                              FA003180
      DO 55 J=K,NV                                                              FA003190
   55 READ (K1) ST(J)                                                           FA003200
   50 WRITE (6,250) KK,NL(I),K,(ST(J),J=K,NV)                                   FA003210
  250 FORMAT (1H I4,I6,I5,4(2X,E14.7)/(16X,4(2X,E14.7)))                        FA003220
      WRITE (6,300)                                                             FA003230
  300 FORMAT (19H1CORRECTED MATRICES  )                                         FA003240
      REWIND 03                                                                 FA003250
C     COMPUTE CORRECTED MATRICES                                                FA003260
      DO 13 IXX=1,MC                                                            FA003270
      READ  (5,101) (DES(J),J=1,3),LCN,LZZ,(AX(I),IX(I),I=1,LZZ)                FA003280
      WRITE (6,301) (DES(J),J=1,3),LCN,LZZ,(AX(I),IX(I),I=1,LZZ)                FA003290
  301 FORMAT (1H0,3A4,2I4,10(F3.0,I3)/(21X,10(F3.0,I3)))                        FA003300
  101 FORMAT (    3A4,2I4,10(F3.0,I3)/(20X,10(F3.0,I3)))                        FA003310
      REWIND K1                                                                 FA003320
      DF=0.0                                                                    FA003330
      DO 16 I=1,LZZ                                                             FA003340
   14 READ (K1)ID                                                               FA003350
      DO 60 K=1,NV                                                              FA003360
      DO 60 J=K,NV                                                              FA003370
      READ (K1) Z                                                               FA003380
      IF (ID-IX(I))60,61,62                                                     FA003390
   61 A(K,J)=A(K,J)+AX(I)*Z                                                     FA003400
   60 CONTINUE                                                                  FA003410
      IF (ID-IX(I))14,17,62                                                     FA003420
   62 REWIND K1                                                                 FA003430
      GO TO 14                                                                  FA003440
   17 DI=NL(ID)                                                                 FA003450
      DF=DF+AX(I)*DI                                                            FA003460
      IF (ID-LI) 16,18,18                                                       FA003470
   18 REWIND K1                                                                 FA003480
   16 CONTINUE                                                                  FA003490
      WRITE (6,302)                                                             FA003500
  302 FORMAT (17H0 LINE   DF   ROW  )                                           FA003510
```

```
      WRITE (3) LCN,DF                                                  FA003520
      DO 13 K=1,NV                                                      FA003530
      IDF=DF                                                            FA003540
C     WRITE CORRECTED MATRICES                                          FA003550
      WRITE (6,250) LCN,IDF,K,(A(K,J),J=K,NV)                           FA003560
      DO 13 J=K,NV                                                      FA003570
      WRITE (3) A(K,J)                                                  FA003580
   13 A(K,J)=0.0                                                        FA003590
      IF (KON) 202,202,201                                              FA003600
  201 CALL MULVA                                                        FA003610
  202 STOP                                                              FA003620
      END                                                               FA003630
```

```
      SUBROUTINE MULVA                                                  FA003640
C     SUBROUTINE FOR COVARIANCE AND MULTIVARIATE ANALYSIS               FA003650
C     MODIFICATION OF A PROGRAM WRITTEN BY DR. REX L. HURST             FA003660
C     UTAH STATE UNIVERSITY  LOGAN, UTAH                                FA003670
      DIMENSION A(50,50),B(50,25),ID(75),X(25)                          FA003680
      COMMON A,NOV,NOC,ID                                               FA003690
      EQUIVALENCE (A(1251),B(1)),(A(26),X(1))                           FA003700
      READ (5,100) NJB                                                  FA003710
      DO 5 IXZY=1,NJB                                                   FA003720
      REWIND 03                                                         FA003730
      READ (5,100)  NX,NY,IX,IY,IZ                                      FA003740
      WRITE (6,300) NX,NY,IX,IY,IZ                                      FA003750
  300 FORMAT (1H12I3,3I2)                                               FA003760
  100 FORMAT (   2I3,3I2)                                               FA003770
      NV=NX+NY                                                          FA003780
C     READ AND WRITE THE SELECTION VECTOR                               FA003790
      READ  (5,102) (ID(I),I=1,NV)                                      FA003800
      WRITE (6,302) (ID(I),I=1,NV)                                      FA003810
  302 FORMAT (1H 20I4)                                                  FA003820
  102 FORMAT (   20I4)                                                  FA003830
      NXPO=NX+1                                                         FA003840
      NYPO=NY+1                                                         FA003850
      ANX=NX                                                            FA003860
      WRITE (6,110)                                                     FA003870
  110 FORMAT (1H0,11X,4HLINE/11X,6HNUMBER)                              FA003880
      ANY=NY                                                            FA003890
      DO 5 MM=1,NOC                                                     FA003900
C     READ AND SELECT A MATRIX                                          FA003910
      READ (3) LINE,DF                                                  FA003920
      DO 50 I=1,NOV                                                     FA003930
      DO 500 J=I,NOV                                                    FA003940
  500 READ (3) X(J)                                                     FA003950
      DO 51 K=1,NV                                                      FA003960
      IF(I-ID(K)) 51,52,51                                              FA003970
   51 CONTINUE                                                          FA003980
```

```
      GO TO 50                                                          FA003990
   52 DO 53 J=1,NV                                                      FA004000
      L=ID(J)                                                           FA004010
      IF (L-I)53,54,54                                                  FA004020
   54 A(K,J)=X(L)                                                       FA004030
      A(J,K)=X(L)                                                       FA004040
   53 CONTINUE                                                          FA004050
   50 CONTINUE                                                          FA004060
      IF(NX) 21,21,205                                                  FA004070
   21 DO 22 I=1,NY                                                      FA004080
      DO 22 J=I,NY                                                      FA004090
   22 B(I,J)=A(I,J)                                                     FA004100
      IF(LINE) 23,24,24                                                 FA004110
   23 WRITE (6,114)                                                     FA004120
  114 FORMAT(11HOERR MATRIX9X25H DF  ROW COL    SS AND SP6X9HMS AND MP) FA004130
      EDF=DF                                                            FA004140
      DO 28 I=1,NY                                                      FA004150
      DO 28 J=I,NY                                                      FA004160
      ELEM=B(I,J)/EDF                                                   FA004170
   28 WRITE(6,111)  LINE,EDF,ID(I),ID(J),B(I,J),ELEM                    FA004180
      GO TO 29                                                          FA004190
   24 WRITE (6,115)                                                     FA004200
  115 FORMAT (11HOTRT MATRIX)                                           FA004210
      TDF=DF-EDF                                                        FA004220
      DO 30 I=1,NY                                                      FA004230
      DO 30 J=I,NY                                                      FA004240
      ELEM=B(I,J)-B(J+1,I)                                              FA004250
      AMS=ELEM/TDF                                                      FA004260
   30 WRITE (6,111) LINE,TDF,ID(I),ID(J),ELEM,AMS                       FA004270
      GO TO 31                                                          FA004280
  205 N1=1                                                              FA004290
      CALL INVERT (A,N1,NX,NXPO,NV)                                     FA004300
C     TEST FOR TYPE OF MATRIX ERROR IF NEGATIVE, TRT+ERR IF POSITIVE    FA004310
      IF(LINE) 6,7,7                                                    FA004320
C     CALCULATIONS ON ERROR MATRIX                                      FA004330
```

```
C       COMPUTE SS AND SP DUE TO REGRESSION, STORE IN B                    FA004340
      6 DO 8 I=1,NY                                                        FA004350
        L=I+NX                                                             FA004360
        DO 8 J=1,I                                                         FA004370
        M=J+NX                                                             FA004380
        B(I+1,J)=0.0                                                       FA004390
        DO 8 K=1,NX                                                        FA004400
      8 B(I+1,J)=B(I+1,J)+A(L,K)*A(K,M)                                    FA004410
        EDF=DF-ANX                                                         FA004420
        IF(IX) 11,12,11                                                    FA004430
C       WRITE OUT INVERSE                                                  FA004440
     11 WRITE (6,105)                                                      FA004450
    105 FORMAT( 37H0INVERSE          ROW COL      ELEMENT)                 FA004460
        DO 13 I=1,NX                                                       FA004470
        DO 13 J=I,NX                                                       FA004480
        ELEM=-A(I,J)                                                       FA004490
     13 WRITE (6,104) LINE,ID(I),ID(J),ELEM                                FA004500
    104 FORMAT(11X,I4,I5,I4,E16.7)                                         FA004510
     12 IF(IY) 14,15,14                                                    FA004520
C       WRITE OUT SOLUTINE MATRIX                                          FA004530
     14 WRITE (6,106)                                                      FA004540
    106 FORMAT( 39H0REG COEF          X    Y     COEFFICIENT)             FA004550
        DO 16 J=NXPO,NV                                                    FA004560
        DO 16 I=1,NX                                                       FA004570
     16 WRITE (6,104) LINE,ID(I),ID(J),A(I,J)                              FA004580
C       WRITE OUT SS AND SP DUE TO REGRESSION                              FA004590
     15 WRITE (6,107)                                                      FA004600
    107 FORMAT(12H0DUE TO REG 8X25H DF  ROW COL     SS AND SP6X9HMS AND MP)FA004610
        DO 17 I=1,NY                                                       FA004620
        K=I+1                                                              FA004630
        M=I+NX                                                             FA004640
        DO 17 J=K,NYPO                                                     FA004650
        L=J-1+NX                                                           FA004660
        AMS=B(J,I)/ANX                                                     FA004670
     17 WRITE (6,111) LINE,ANX,ID(M),ID(L),B(J,I),AMS                      FA004680
```

```
  111 FORMAT(11X,I4,F8.0,I4,I4,E15.7,E15.7)                          FA004690
C     WRITE OUT SS AND Sp DEVIATIONS FROM REGRESSION                 FA004700
      WRITE (6,108)                                                  FA004710
  108 FORMAT( 11HODEV FR REG)                                        FA004720
      DO 18 I=1,NY                                                   FA004730
      L=I+NX                                                         FA004740
      DO 18 J=I,NY                                                   FA004750
      M=J+NX                                                         FA004760
      B(J+1,I)=A(L,M)-B(J+1,I)                                       FA004770
      B(I,J)=B(J+1,I)                                                FA004780
      AMS=B(J+1,I)/EDF                                               FA004790
   18 WRITE (6,111) LINE,EDF,ID(L),ID(M),B(J+1,I),AMS                FA004800
   29 IF(IZ) 5,5,25                                                  FA004810
   25 DO 26 I=1,NY                                                   FA004820
      DO 26 J=I,NY                                                   FA004830
   26  B(J+1,I)=B(I,J)                                               FA004840
      EDET=DET(NY)                                                   FA004850
      WRITE (6,101) EDET                                             FA004860
  101 FORMAT (35X,11HERROR DET =,E15.7)                              FA004870
      GO TO 5                                                        FA004880
C     CALCULATIONS ON TRT+ERROR MATRIX                               FA004890
    7 TDF=DF-ANX-EDF                                                 FA004900
C     WRITE OUT ADJUSTED TREATMENT SS AND Sp                         FA004910
      WRITE (6,109)                                                  FA004920
  109 FORMAT (8HOTRT ADJ)                                            FA004930
      DO 10 I=1,NY                                                   FA004940
      L=I+NX                                                         FA004950
      DO 10 J=I,NY                                                   FA004960
      M=J+NX                                                         FA004970
      B(I,J)=0.0                                                     FA004980
      DO 20 K=1,NX                                                   FA004990
   20 B(I,J)=B(I,J)+A(L,K)*A(K,M)                                    FA005000
      B(I,J)=A(L,M)-B(I,J)                                           FA005010
      ELEM=B(I,J)-B(J+1,I)                                           FA005020
      AMS=ELEM/TDF                                                   FA005030
```

```
   10 WRITE (6,111) LINE,TDF,ID(L),ID(M),ELEM,AMS                    FA005040
   31 IF(IZ) 5,5,27                                                  FA005050
   27 TEDET=DET(NY)                                                  FA005060
      DEL=EDET/TEDET                                                 FA005070
      WRITE (6,116) TEDET                                            FA005080
  116 FORMAT (33X,13HTRT+ERR DET =,E15.7)                            FA005090
C     COMPUTE MULTIVARIATE F AND DF                                  FA005100
      P=ANY                                                          FA005110
      T=TDF+EDF                                                      FA005120
      Q=TDF                                                          FA005130
      IF (P-2.0)40,42,41                                             FA005140
   40 DF1=Q                                                          FA005150
      DF2=T-Q                                                        FA005160
      GO TO 48                                                       FA005170
   41 IF (Q-2.0)43,44,47                                             FA005180
   42 DF1=2.*Q                                                       FA005190
      DF2=2.*(T-Q-1.)                                                FA005200
      DEL=SQRT(DEL)                                                  FA005210
      GO TO 48                                                       FA005220
   44 Q=P                                                            FA005230
      GO TO 42                                                       FA005240
   43 Q=P                                                            FA005250
      GO TO 40                                                       FA005260
   47 DF1=P*Q                                                        FA005270
      AM=T-(P+Q+1.)/2.                                               FA005280
      S=SQRT((P*P*Q*Q-4.)/(P*P+Q*Q-5.))                              FA005290
      DEL=DEL**(1./S)                                                FA005300
      DF2=AM*S-(P*Q-2.)/2.                                           FA005310
   48 FH2=(1.-DEL)*DF2/(DEL*DF1)                                     FA005320
      WRITE (6,113) FH2,DF1,DF2                                      FA005330
  113 FORMAT (1H0,38X,7HMUL F =,E15.7/42X,4HDF =,F5.0,5H AND F5.0)   FA005340
    5 CONTINUE                                                       FA005350
      STOP                                                           FA005360
      END                                                            FA005370
```

```
      FUNCTION DET(NY)                                                  FA005380
C     SUBPROGRAM TO COMPUTE THE DETERMINATE OF THE UPPER TRIANGULAR     FA005390
C     PORTION OF MATRIX B USING CHIO'S METHOD.                          FA005400
      DIMENSION A(50,50),B(50,25),F(25)                                 FA005410
      EQUIVALENCE (A(1251),B(1)),(A(26),F(1))                           FA005420
      COMMON A                                                          FA005430
      NMI=NY-1                                                          FA005440
      DET=1.0                                                           FA005450
      IF(NY-1) 703,703,702                                              FA005460
  702 DO 701 M=1,NMI                                                    FA005470
      DET=DET*B(M,M)                                                    FA005480
      REC=1.0/B(M,M)                                                    FA005490
      MPL=M+1                                                           FA005500
      DO 701 I=MPL,NY                                                   FA005510
      F(I)=B(M,I)*REC                                                   FA005520
      DO 701 J=I,NY                                                     FA005530
  701 B(I,J)=B(I,J)-F(I)*B(M,J)                                         FA005540
  703 DET=DET*B(NY,NY)                                                  FA005550
      RETURN                                                            FA005560
      END                                                               FA005570
```

```
      SUBROUTINE INVERT(A,N1,N2,NPX,NK)                                 FA005580
C     MATRIX INVERSION ROUTINE INVERTS UPPER TRIANGULAR PORTION         FA005590
C     OF MATRIX BETWEEN ROW N1 AND ROW N2.  WITH SOLUTION FROM          FA005600
C     ROW NPX TO ROW NK.  THE INVERSE IS THE NEGATIVE OF THE INVERSE    FA005610
      DIMENSION A(50,50)                                                FA005620
      DO 501 L=N1,N2                                                    FA005630
      RECIP=1.0/A(L,L)                                                  FA005640
      DO 502 I=N1,N2                                                    FA005650
      IF(I-L) 503,504,505                                               FA005660
  503 R=A(I,L)*RECIP                                                    FA005670
      GO TO 506                                                         FA005680
  504 R=0.0                                                             FA005690
      GO TO 506                                                         FA005700
  505 R=A(L,I)*RECIP                                                    FA005710
  506 DO 507 J=I,N2                                                     FA005720
      IF(J-L) 508,507,509                                               FA005730
  508 A(I,J)=A(I,J)-R*A(J,L)                                            FA005740
      GO TO 507                                                         FA005750
  509 A(I,J)=A(I,J)-R*A(L,J)                                            FA005760
  507 CONTINUE                                                          FA005770
      DO 510 J=NPX,NK                                                   FA005780
  510 A(I,J)=A(I,J)-R*A(L,J)                                            FA005790
      IF(I-L) 511,512,513                                               FA005800
  511 A(I,L)=R                                                          FA005810
      GO TO 502                                                         FA005820
  512 A(L,L)=-RECIP                                                     FA005830
      GO TO 502                                                         FA005840
  513 A(L,I)=R                                                          FA005850
  502  CONTINUE                                                         FA005860
      DO 501 N=NPX,NK                                                   FA005870
  501 A(L,N)=A(L,N)*RECIP                                               FA005880
      RETURN                                                            FA005890
      END                                                               FA005900
```

Appendix B

Factorial Program Sample Problems

Three examples will be used to demonstrate the capabilities of this program--a split-plot design with covariance, a randomized block with multivariate analysis, and a fractional replication with covariance.

Split-plot

Due to the problem of finding a good split-plot design with covariance, the data for this example was generated on a computer. The format for this data is as follows:

Column	Description
1	Replication
2	Whole plot
3	Sub-plot
4-10	Independent Variable XXXX.XX
11-17	Dependent Variable XXXX.XX

Model

$$Y_{ijk} = \mu + \rho_i + \alpha_j + \delta_{ij} + \beta_k + (\alpha\beta)_{jk} + \eta_{ij} + \varepsilon_{ijk}$$

$$+ B(X_{ijk} - \overline{X}_{...})$$

$i = 1 \ldots r \qquad r = 6$

$j = 1 \ldots a \qquad a = 5$

$k = 1 \ldots b \qquad b = 5$

Source		d.f.	SS
ρ_i	Reps	r-1	$\sum_i \frac{Y_{i..}^2}{ab} - \frac{Y_{...}^2}{rab}$
α_j	Whole plot	a-1	$\sum_j \frac{Y_{.j.}^2}{rb} - \frac{Y_{...}^2}{rab}$
δ_{ij}	Err(a)	ar-a-r+1	$\sum_{ij} \frac{Y_{ij.}^2}{b} - \sum_i \frac{Y_{i..}^2}{ab} - \sum_j \frac{Y_{.j.}^2}{rb} + \frac{Y_{...}^2}{rab}$
β_k	Sub-plot	b-1	$\sum_k \frac{Y_{..k}^2}{ra} - \frac{Y_{...}^2}{rab}$
$(\alpha\beta)_{jk}$	W x S	ab-a-b+1	$\sum_{jk} \frac{Y_{.jk}^2}{r} - \sum_j \frac{Y_{.j.}^2}{rb} - \sum_k \frac{Y_{..k}^2}{ra} + \frac{Y_{...}^2}{rab}$
$\eta_{ik} + \varepsilon_{ijk}$	Err(b)	abr-ab-ar+a	$\sum_{ijk} Y_{ijk}^2 - \sum_{jk} \frac{Y_{.jk}^2}{r} - \sum_{ij} \frac{Y_{ij.}^2}{b} + \sum_j \frac{Y_{.j.}^2}{rb}$
TOTAL		abr-1	$\sum_{ijk} Y_{ijk}^2 - \frac{Y_{...}^2}{rab}$

SAMPLE INPUT

```
  2  1  6  5  5  1  1  1  1  1  150   5   7   5    0 0 0
(3X,2F7.2)
   12.0          110.0
111    8.47 113.37
112   14.18 168.46
113   11.54 126.84
114   14.73 172.07
115   13.90 154.73
121   12.85 142.02
122    7.68  98.15
123   21.05 225.42
124   13.12 141.68
125    7.05  85.31
131   17.05 198.31
132   10.84 127.12
133   11.05 129.60
134    7.85  92.51
135    9.38 106.13
141   18.18 195.16
142   14.77 167.16
143   14.67 182.56
144    8.03 103.25
145   15.01 172.57
151   13.37 150.96
152   10.61 118.57
153   14.03 166.52
154    7.79  78.60
155   15.05 168.55
211   12.33 156.02
212   17.51 201.15
213   13.15 143.76
214   13.41 160.44
215   14.45 157.74
221   16.21 185.59
```

222	6.91	87.96
223	11.95	129.67
224	12.49	141.57
225	7.70	91.04
231	15.10	176.80
232	13.16	152.05
233	13.45	157.16
234	9.12	106.92
235	17.32	190.58
241	12.13	129.57
242	9.40	102.21
243	20.76	248.45
244	9.40	115.17
245	16.45	182.74
251	16.42	184.29
252	10.73	119.74
253	10.02	122.73
254	16.45	177.04
255	14.19	156.44
311	12.36	154.04
312	17.00	196.21
313	7.91	85.06
314	11.25	130.17
315	14.16	160.12
321	9.73	109.52
322	11.30	138.14
323	14.01	148.29
324	11.03	121.83
325	13.51	159.14
331	12.32	144.66
332	14.65	166.35
333	12.01	138.10
334	12.55	139.69
335	9.43	107.39
341	17.24	186.35

342	9.18	103.63
343	11.02	140.71
344	12.92	152.47
345	14.05	164.28
351	9.62	107.99
352	13.01	146.28
353	8.17	99.31
354	18.27	190.86
355	15.48	176.70
411	11.54	144.02
412	12.66	143.23
413	10.84	111.32
414	11.25	133.87
415	16.03	178.45
421	14.40	160.42
422	8.85	106.28
423	15.23	157.86
424	11.72	128.05
425	12.47	149.20
431	11.69	135.48
432	15.30	171.61
433	12.72	143.00
434	12.14	137.43
435	9.69	111.17
441	9.51	98.09
442	11.12	118.00
443	9.43	119.93
444	6.61	83.73
445	16.80	191.78
451	13.99	155.65
452	11.44	125.78
453	11.48	134.85
454	13.26	136.64
455	3.94	48.92
511	6.88	93.18

512	7.47	92.42
513	12.93	138.76
514	7.40	91.75
515	14.06	155.97
521	9.24	102.50
522	14.56	170.60
523	6.62	68.62
524	8.58	94.45
525	10.60	125.44
531	13.22	153.48
532	12.10	138.04
533	6.60	80.08
534	13.89	160.35
535	12.11	135.13
541	12.94	136.01
542	9.22	100.56
543	13.01	162.33
544	8.45	106.17
545	12.72	142.46
551	14.52	159.49
552	15.04	167.45
553	10.95	130.57
554	13.40	140.60
555	15.55	173.32
611	10.38	128.27
612	13.45	153.56
613	14.17	151.14
614	14.72	170.57
615	14.25	157.43
621	12.24	129.52
622	13.43	156.86
623	9.16	91.32
624	13.59	149.78
625	13.88	163.61
631	10.92	122.42

```
632  17.07 191.42
633  11.64 135.10
634  14.80 172.21
635  13.69 152.03
641   9.53  92.87
642   9.49 104.06
643  12.74 157.67
644   9.46 117.55
645  13.80 159.08
651  14.20 152.27
652  11.80 128.07
653  12.58 145.23
654  12.70 131.50
655  11.32 128.66
          10000000   3 1     0 0
          01000000   4 1     0 0
          00100000   5 1     0 0
          11000000   6 1     0 0
          01100000   7 1     0 0
REP                8    2    3   -2
WHOLE PLOT         9    2    4   -2
ERROR (A)         10    4    6   -3   -4    2
SUB PLOT          11    2    5   -2
SUB X WHOLE       12    4    7   -4   -5    2
ERROR (B)         13    4    1   -6   -7    4
TOTAL             14    2    1   -2
ERROR (A)         -1    4   1   2 -1   3 -1   4   1   6
W + ERR (A)        1    2 -1   3   1   6
ERROR (B)         -2    4   1   1   1   4 -1   6 -1   7
S+ERR(B)           2    6   1   1 -1   2   1   4   1   5 -1   6 -1   7
S X W +ERR(B       2    4   1   1   1   2 -1   5 -1   6
  1
  1   1 1 1 0
    1    2
```

SAMPLE OUTPUT

```
  2  1  6  5  5  1  1  1  1  1  150   5   7   5   0.000
(3X,2F7.2)
   .1200000E+02   .1100000E+03
```

VARIABLE 1

BINARY	LINE	TREAT							IDENT	NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	150.	.1230547E+02
10000000	3	1	0	0	0	0	0	0	0	25.	.1249000E+02
10000000	3	2	0	0	0	0	0	0	0	25.	.1320840E+02
10000000	3	3	0	0	0	0	0	0	0	25.	.1248720E+02
10000000	3	4	0	0	0	0	0	0	0	25.	.1176440E+02
10000000	3	5	0	0	0	0	0	0	0	25.	.1128240E+02
10000000	3	6	0	0	0	0	0	0	0	25.	.1260040E+02
01000000	4	0	1	0	0	0	0	0	0	30.	.1247933E+02
01000000	4	0	2	0	0	0	0	0	0	30.	.1170533E+02
01000000	4	0	3	0	0	0	0	0	0	30.	.1242867E+02
01000000	4	0	4	0	0	0	0	0	0	30.	.1226800E+02
01000000	4	0	5	0	0	0	0	0	0	30.	.1264600E+02
00100000	5	0	0	1	0	0	0	0	0	30.	.1261933E+02
00100000	5	0	0	2	0	0	0	0	0	30.	.1213100E+02
00100000	5	0	0	3	0	0	0	0	0	30.	.1216300E+02
00100000	5	0	0	4	0	0	0	0	0	30.	.1167933E+02
00100000	5	0	0	5	0	0	0	0	0	30.	.1293467E+02
11000000	6	1	1	0	0	0	0	0	0	5.	.1256400E+02
11000000	6	1	2	0	0	0	0	0	0	5.	.1235000E+02
11000000	6	1	3	0	0	0	0	0	0	5.	.1123400E+02
11000000	6	1	4	0	0	0	0	0	0	5.	.1413200E+02
11000000	6	1	5	0	0	0	0	0	0	5.	.1217000E+02
11000000	6	2	1	0	0	0	0	0	0	5.	.1417000E+02
11000000	6	2	2	0	0	0	0	0	0	5.	.1105200E+02

11000000	6	2	3	0	0	0	0	0	0	5.	.1363000E+02
11000000	6	2	4	0	0	0	0	0	0	5.	.1362800E+02
11000000	6	2	5	0	0	0	0	0	0	5.	.1356200E+02
11000000	6	3	1	0	0	0	0	0	0	5.	.1253600E+02
11000000	6	3	2	0	0	0	0	0	0	5.	.1191600E+02
11000000	6	3	3	0	0	0	0	0	0	5.	.1219200E+02
11000000	6	3	4	0	0	0	0	0	0	5.	.1288200E+02
11000000	6	3	5	0	0	0	0	0	0	5.	.1291000E+02
11000000	6	4	1	0	0	0	0	0	0	5.	.1246400E+02
11000000	6	4	2	0	0	0	0	0	0	5.	.1253400E+02
11000000	6	4	3	0	0	0	0	0	0	5.	.1230800E+02
11000000	6	4	4	0	0	0	0	0	0	5.	.1069400E+02
11000000	6	4	5	0	0	0	0	0	0	5.	.1082200E+02
11000000	6	5	1	0	0	0	0	0	0	5.	.9748000E+01
11000000	6	5	2	0	0	0	0	0	0	5.	.9920000E+01
11000000	6	5	3	0	0	0	0	0	0	5.	.1158400E+02
11000000	6	5	4	0	0	0	0	0	0	5.	.1126800E+02
11000000	6	5	5	0	0	0	0	0	0	5.	.1389200E+02
11000000	6	6	1	0	0	0	0	0	0	5.	.1339400E+02
11000000	6	6	2	0	0	0	0	0	0	5.	.1246000E+02
11000000	6	6	3	0	0	0	0	0	0	5.	.1362400E+02
11000000	6	6	4	0	0	0	0	0	0	5.	.1100400E+02
11000000	6	6	5	0	0	0	0	0	0	5.	.1252000E+02
01100000	7	0	1	1	0	0	0	0	0	6.	.1032667E+02
01100000	7	0	1	2	0	0	0	0	0	6.	.1371167E+02
01100000	7	0	1	3	0	0	0	0	0	6.	.1175667E+02
01100000	7	0	1	4	0	0	0	0	0	6.	.1212667E+02
01100000	7	0	1	5	0	0	0	0	0	6.	.1447500E+02
01100000	7	0	2	1	0	0	0	0	0	6.	.1244500E+02
01100000	7	0	2	2	0	0	0	0	0	6.	.1045500E+02
01100000	7	0	2	3	0	0	0	0	0	6.	.1300333E+02
01100000	7	0	2	4	0	0	0	0	0	6.	.1175500E+02
01100000	7	0	2	5	0	0	0	0	0	6.	.1086833E+02
01100000	7	0	3	1	0	0	0	0	0	6.	.1338333E+02
01100000	7	0	3	2	0	0	0	0	0	6.	.1385333E+02

01100000	7	0	3	3	0	0	0	0	0	6.	.1124500E+02
01100000	7	0	3	4	0	0	0	0	0	6.	.1172500E+02
01100000	7	0	3	5	0	0	0	0	0	6.	.1193667E+02
01100000	7	0	4	1	0	0	0	0	0	6.	.1325500E+02
01100000	7	0	4	2	0	0	0	0	0	6.	.1053000E+02
01100000	7	0	4	3	0	0	0	0	0	6.	.1360500E+02
01100000	7	0	4	4	0	0	0	0	0	6.	.9145000E+01
01100000	7	0	4	5	0	0	0	0	0	6.	.1480500E+02
01100000	7	0	5	1	0	0	0	0	0	6.	.1368667E+02
01100000	7	0	5	2	0	0	0	0	0	6.	.1210500E+02
01100000	7	0	5	3	0	0	0	0	0	6.	.1120500E+02
01100000	7	0	5	4	0	0	0	0	0	6.	.1364500E+02
01100000	7	0	5	5	0	0	0	0	0	6.	.1258833E+02

LINEAR FUNCTION CARDS

REP	8	2	3	-2		
WHOLE PLOT	9	2	4	-2		
ERROR (A)	10	4	6	-3	-4	2
SUB PLOT	11	2	5	-2		
SUB X WHOLE	12	4	7	-4	-5	2
ERROR (B)	13	4	1	-6	-7	4
TOTAL	14	2	1	-2		

ANALYSIS OF VARIANCE, VARIABLE 1

SOURCE	DF	SS	MS
REP	5	.5771931E+02	.1154386E+02
WHOLE PLOT	4	.1568804E+02	.3922010E+01
ERROR (A)	20	.1342130E+03	.6710649E+01
SUB PLOT	4	.2811550E+02	.7028875E+01
SUB X WHOLE	16	.2525939E+03	.1578712E+02
ERROR (B)	100	.8390800E+03	.8390800E+01
TOTAL	149	.1327410E+04	.8908791E+01

VARIABLE 2

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	150.	.1401095E+03
10000000	3	1	0	0	0	0	0	0	0	25.	.1434248E+03
10000000	3	2	0	0	0	0	0	0	0	25.	.1510732E+03
10000000	3	3	0	0	0	0	0	0	0	25.	.1426916E+03
10000000	3	4	0	0	0	0	0	0	0	25.	.1329904E+03
10000000	3	5	0	0	0	0	0	0	0	25.	.1287892E+03
10000000	3	6	0	0	0	0	0	0	0	25.	.1416880E+03
01000000	4	0	1	0	0	0	0	0	0	30.	.1441373E+03
01000000	4	0	2	0	0	0	0	0	0	30.	.1319947E+03
01000000	4	0	3	0	0	0	0	0	0	30.	.1424107E+03
01000000	4	0	4	0	0	0	0	0	0	30.	.1412190E+03
01000000	4	0	5	0	0	0	0	0	0	30.	.1407860E+03
00100000	5	0	0	1	0	0	0	0	0	30.	.1432773E+03
00100000	5	0	0	2	0	0	0	0	0	30.	.1387040E+03
00100000	5	0	0	3	0	0	0	0	0	30.	.1390653E+03
00100000	5	0	0	4	0	0	0	0	0	30.	.1326307E+03
00100000	5	0	0	5	0	0	0	0	0	30.	.1468703E+03
11000000	6	1	1	0	0	0	0	0	0	5.	.1470940E+03
11000000	6	1	2	0	0	0	0	0	0	5.	.1385160E+03
11000000	6	1	3	0	0	0	0	0	0	5.	.1307340E+03
11000000	6	1	4	0	0	0	0	0	0	5.	.1641400E+03
11000000	6	1	5	0	0	0	0	0	0	5.	.1366400E+03
11000000	6	2	1	0	0	0	0	0	0	5.	.1638220E+03
11000000	6	2	2	0	0	0	0	0	0	5.	.1271660E+03
11000000	6	2	3	0	0	0	0	0	0	5.	.1567020E+03
11000000	6	2	4	0	0	0	0	0	0	5.	.1556280E+03
11000000	6	2	5	0	0	0	0	0	0	5.	.1520480E+03
11000000	6	3	1	0	0	0	0	0	0	5.	.1451200E+03
11000000	6	3	2	0	0	0	0	0	0	5.	.1353840E+03
11000000	6	3	3	0	0	0	0	0	0	5.	.1392380E+03

11000000	6	3	4	0	0	0	0	0	0	5.	.1494880E+03
11000000	6	3	5	0	0	0	0	0	0	5.	.1442280E+03
11000000	6	4	1	0	0	0	0	0	0	5.	.1421780E+03
11000000	6	4	2	0	0	0	0	0	0	5.	.1403620E+03
11000000	6	4	3	0	0	0	0	0	0	5.	.1397380E+03
11000000	6	4	4	0	0	0	0	0	0	5.	.1223060E+03
11000000	6	4	5	0	0	0	0	0	0	5.	.1203680E+03
11000000	6	5	1	0	0	0	0	0	0	5.	.1144160E+03
11000000	6	5	2	0	0	0	0	0	0	5.	.1123220E+03
11000000	6	5	3	0	0	0	0	0	0	5.	.1334160E+03
11000000	6	5	4	0	0	0	0	0	0	5.	.1295060E+03
11000000	6	5	5	0	0	0	0	0	0	5.	.1542860E+03
11000000	6	6	1	0	0	0	0	0	0	5.	.1521940E+03
11000000	6	6	2	0	0	0	0	0	0	5.	.1382180E+03
11000000	6	6	3	0	0	0	0	0	0	5.	.1546360E+03
11000000	6	6	4	0	0	0	0	0	0	5.	.1262460E+03
11000000	6	6	5	0	0	0	0	0	0	5.	.1371460E+03
01100000	7	0	1	1	0	0	0	0	0	6.	.1314833E+03
01100000	7	0	1	2	0	0	0	0	0	6.	.1591717E+03
01100000	7	0	1	3	0	0	0	0	0	6.	.1261467E+03
01100000	7	0	1	4	0	0	0	0	0	6.	.1431450E+03
01100000	7	0	1	5	0	0	0	0	0	6.	.1607400E+03
01100000	7	0	2	1	0	0	0	0	0	6.	.1382617E+03
01100000	7	0	2	2	0	0	0	0	0	6.	.1263317E+03
01100000	7	0	2	3	0	0	0	0	0	6.	.1368633E+03
01100000	7	0	2	4	0	0	0	0	0	6.	.1295600E+03
01100000	7	0	2	5	0	0	0	0	0	6.	.1289567E+03
01100000	7	0	3	1	0	0	0	0	0	6.	.1551917E+03
01100000	7	0	3	2	0	0	0	0	0	6.	.1577650E+03
01100000	7	0	3	3	0	0	0	0	0	6.	.1305067E+03
01100000	7	0	3	4	0	0	0	0	0	6.	.1348517E+03
01100000	7	0	3	5	0	0	0	0	0	6.	.1337383E+03
01100000	7	0	4	1	0	0	0	0	0	6.	.1396750E+03
01100000	7	0	4	2	0	0	0	0	0	6.	.1159367E+03
01100000	7	0	4	3	0	0	0	0	0	6.	.1686083E+03

```
01100000    7    0  4  4  0  0  0  0  0    6.    .1130567E+03
01100000    7    0  4  5  0  0  0  0  0    6.    .1688183E+03
01100000    7    0  5  1  0  0  0  0  0    6.    .1517750E+03
01100000    7    0  5  2  0  0  0  0  0    6.    .1343150E+03
01100000    7    0  5  3  0  0  0  0  0    6.    .1332017E+03
01100000    7    0  5  4  0  0  0  0  0    6.    .1425400E+03
01100000    7    0  5  5  0  0  0  0  0    6.    .1420983E+03
```

LINEAR FUNCTION CARDS

REP	8	2	3	-2		
WHOLE PLOT	9	2	4	-2		
ERROR (A)	10	4	6	-3	-4	2
SUB PLOT	11	2	5	-2		
SUB X WHOLE	12	4	7	-4	-5	2
ERROR (B)	13	4	1	-6	-7	4
TOTAL	14	2	1	-2		

ANALYSIS OF VARIANCE, VARIABLE 2

SOURCE	DF	SS	MS
REP	5	.7979580E+04	.1595916E+04
WHOLE PLOT	4	.2671740E+04	.6679350E+03
ERROR (A)	20	.1601672E+05	.8008360E+03
SUB PLOT	4	.3442280E+04	.8605700E+03
SUB X WHOLE	16	.2620592E+05	.1637870E+04
ERROR (B)	100	.1029859E+06	.1029859E+04
TOTAL	149	.1593021E+06	.1069142E+04

UNCORRECTED MATRICES

LINE	NO OBS	ROW		
1	150	1	.1341406E+04	.1557697E+05

```
   1   150     2     .2952897E+06

LINE  NO OBS  ROW
   2      1     1     .1399648E+02     .1379619E+04
   2      1     2     .1359876E+06

LINE  NO OBS  ROW
   3      6     1     .7171579E+02     .2051604E+04
   3      6     2     .1439672E+06

LINE  NO OBS  ROW
   4      5     1     .2968452E+02     .1560897E+04
   4      5     2     .1386593E+06

LINE  NO OBS  ROW
   5      5     1     .4211198E+02     .1689366E+04
   5      5     2     .1394299E+06

LINE  NO OBS  ROW
   6     30     1     .2216168E+03     .3695489E+04
   6     30     2     .1626556E+06

LINE  NO OBS  ROW
   7     25     1     .3103939E+03     .4170962E+04
   7     25     2     .1683075E+06


CORRECTED MATRICES

ERROR (A)      -1   4 1.  2-1.  3-1.  4 1.  6

 LINE   DF   ROW
  -1    20    1     .1342130E+03     .1462608E+04
  -1    20    2     .1601672E+05
```

```
W + ERR (A)      1    2-1.   3 1.   6

 LINE    DF    ROW
    1     24     1     .1499010E+03     .1643885E+04
    1     24     2     .1868846E+05

ERROR (B)       -2    4 1.   1 1.   4-1.   6-1.   7

 LINE    DF    ROW
   -2    100     1     .8390800E+03     .9271416E+04
   -2    100     2     .1029859E+06

S+ERR(B)         2    6 1.   1-1.   2 1.   4 1.   5-1.   6-1.   7

 LINE    DF    ROW
    2    104     1     .8671955E+03     .9581164E+04
    2    104     2     .1064282E+06

S X W +ERR(B     2    4 1.   1 1.   2-1.   5-1.   6

 LINE    DF    ROW
    2    116     1     .1091674E+04     .1157173E+05
    2    116     2     .1291918E+06


   1   1 1 1 0
    1    2

            LINE
           NUMBER

INVERSE                ROW COL      ELEMENT
                -1      1   1     .7450845E-02
```

REG COEF		X	Y	COEFFICIENT	
	-1	1	2	.1089766E+02	
DUE TO REG		DF	ROW	COL	SS AND SP	MS AND MP
	-1	1.	2	2	.1593900E+05	.1593900E+05
DEV FR REG						
	-1	19.	2	2	.7771600E+02	.4090316E+01
TRT ADJ						
	1	4.	2	2	.5831200E+03	.1457800E+03
INVERSE		ROW	COL	ELEMENT		
	-2	1	1	.1191781E-02		
REG COEF		X	Y	COEFFICIENT		
	-2	1	2	.1104950E+02		
DUE TO REG		DF	ROW	COL	SS AND SP	MS AND MP
	-2	1.	2	2	.1024445E+06	.1024445E+06
DEV FR REG						
	-2	99.	2	2	.5413700E+03	.5468384E+01
TRT ADJ						
	2	4.	2	2	.2982000E+02	.7455000E+01
TRT ADJ						
	2	16.	2	2	.5990170E+04	.3743856E+03

Randomized block

This data is a two way factorial arranged in a randomized block design, taken from Hurst (5, pp. 74-76). The format is as follows:

Columns	Description
1-2	Block number
3	Planting
4	Nitrogen level
5-7	Y_1 Total dry matter
8-10	Y_2 Total dry ears

Model

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + (\beta\gamma)_{jk} + (\alpha\beta)_{ij} + (\alpha\gamma)_{ij} + (\alpha\beta\gamma)_{ijk} + B(X_{ijk} - \bar{X}_{...})$$

$i = 1 \ldots a \qquad a = 16$

$j = 1 \ldots b \qquad b = 3$

$k = 1 \ldots c \qquad c = 2$

Source		d.f.	SS
TOTAL		abc-1	$\sum_{ijk} Y_{ijk}^2 - \frac{Y_{...}^2}{abc}$
Blocks	α_i	a-1	$\sum_{i} \frac{Y_{i..}^2}{bc} - \frac{Y_{...}^2}{abc}$
Date	β_j	b-1	$\sum_{j} \frac{Y_{.j.}^2}{ac} - \frac{Y_{...}^2}{abc}$

Source	d.f.	SS
Fertilizer γ_k	c-1	$\sum_k \frac{Y^2_{..k}}{ab} - \frac{Y^2_{...}}{abc}$
D x F $(\beta\gamma)_{jk}$	bc-b-c+1	$\sum_{jk} \frac{Y^2_{.jk}}{a} - \sum_j \frac{Y^2_{.j.}}{ac} - \sum_k \frac{Y^2_{..k}}{ab} + \frac{Y^2_{...}}{abc}$
Err $(\alpha\beta)_{ij}$ + $(\alpha\gamma)_{ik}$ + $(\alpha\beta\gamma)_{ijk}$	abc-bc-a+1	$\sum_{ijk} Y^2_{ijk} - \sum_{jk} \frac{Y^2_{.jk}}{a} - \sum_i \frac{Y^2_{i..}}{bc} + \frac{Y^2_{...}}{abc}$

SAMPLE INPUT

```
  2   1 16   3   2   1   1   1   1   1    96    4    6    4     0 0 0
(4X,2F3.2)
    4.0             2.5
011048830538158
011149531631558
012038422034358
012139224334862
013039620234360
013149831334660
021043127230158
021147230530858
022040822329555
022148529027655
023048528828245
023143022832352
031039624740442
031148932042045
032041922440848
032149028740850
033043722037738
033147525642438
041039523937450
041148731438645
042042423035240
042155731640515
043045523739035
043146124437830
051037524336255
051145027938852
052042623239055
052145727837652
053034317638652
053153828037352
061036623435652
```

0611453292390 30
0620365199359 52
0621456265381 38
0630382191387 48
0631425208398 40
0710353222334 42
0711408268350 35
0720385209350 40
0721461282339 48
0730420230338 48
0731366216348 50
0810402251330 38
0811414269331 45
0820348188320 48
0821403229340 48
0830378189343 40
0831437232310 30
0910350232305 35
0911409262312 42
0920449244360 28
0921499312334 15
0930390224336 28
0931444252354 25
1010329197287 40
1011362234324 30
1020323162309 32
1021383234274 28
1030347174325 32
1031396199323 30
1110374227409 48
1111398256331 42
1120446265335 45
1121429270356 45
1130386216358 42
1131427222337 42

```
121040225441745
121144529843048
122042024739840
122146128541750
123039121643845
123145226240950
131032020631832
131146429130230
132032816930645
132142724231838
133039219931335
133141522931542
141027415928850
141138426028848
142027412729750
142143823528245
143039218128942
143144623028542
151026616024465
151132420925458
152025813226052
152140723826055
153031416327355
153137319326065
161037220825948
161141227025248
162033517326255
162135721226455
163036019325242
163139420224852
          10000000 03 1     0 0
          01000000 04 1     0 0
          00100000 05 1     0 0
          01100000 06 1     0 0
TOT               7  02  01  -2
```

```
A                8  02  03  -2
B                9  02  04  -2
C               10  02  05  -2
BC              11  04  06  -5  -4  02
ERR             12  04  01  -6  -3  02
ERROR           -1   4   1   1   1   2 -1   3 -1   6
ERR+B            2   4   1   1 -1   3   1   4 -1   6
ERR+C            3   4   1   1 -1   3   1   5 -1   6
ERR+BC           4   5   1   1   2   2 -1   3 -1   4 -1   5
  1
  0  2 0 0 1
   1   2
```

SAMPLE OUTPUT

```
  2  1 16  3  2  1  1  1  1  1   96   4   6   4   0. 0 0 0
(4X,2F3.2)
   .4000000E+01   .2500000E+01
```

VARIABLE 1

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	96.	.4072708E+01
10000000	3	1	0	0	0	0	0	0	0	6.	.4421667E+01
10000000	3	2	0	0	0	0	0	0	0	6.	.4518333E+01
10000000	3	3	0	0	0	0	0	0	0	6.	.4510000E+01
10000000	3	4	0	0	0	0	0	0	0	6.	.4631667E+01
10000000	3	5	0	0	0	0	0	0	0	6.	.4315000E+01
10000000	3	6	0	0	0	0	0	0	0	6.	.4078333E+01
10000000	3	7	0	0	0	0	0	0	0	6.	.3988333E+01
10000000	3	8	0	0	0	0	0	0	0	6.	.3970000E+01
10000000	3	9	0	0	0	0	0	0	0	6.	.4235000E+01
10000000	3	10	0	0	0	0	0	0	0	6.	.3566667E+01
10000000	3	11	0	0	0	0	0	0	0	6.	.4100000E+01
10000000	3	12	0	0	0	0	0	0	0	6.	.4285000E+01
10000000	3	13	0	0	0	0	0	0	0	6.	.3910000E+01
10000000	3	14	0	0	0	0	0	0	0	6.	.3680000E+01
10000000	3	15	0	0	0	0	0	0	0	6.	.3236667E+01
10000000	3	16	0	0	0	0	0	0	0	6.	.3716667E+01
01000000	4	0	1	0	0	0	0	0	0	32.	.3987188E+01
01000000	4	0	2	0	0	0	0	0	0	32.	.4091875E+01
01000000	4	0	3	0	0	0	0	0	0	32.	.4139063E+01
00100000	5	0	0	1	0	0	0	0	0	48.	.3781875E+01
00100000	5	0	0	2	0	0	0	0	0	48.	.4363542E+01
01100000	6	0	1	1	0	0	0	0	0	16.	.3683125E+01
01100000	6	0	1	2	0	0	0	0	0	16.	.4291250E+01

061145329239030
062036519935952
062145626538138
063038219138748
063142520839840
071035322233442
071140826835035
072038520935040
072146128233948
073042023033848
073136621634850
081040225133038
081141426933145
082034818832048
082140322934048
083037818934340
083143723231030
091035023230535
091140926231242
092044924436028
092149931233415
093039022433628
093144425235425
101032919728740
101136223432430
102032316230932
102138323427428
103034717432532
103139619932330
111037422740948
111139825633142
112044626533545
112142927035645
113038621635842
113142722233742

```
121040225441745
121144529843048
122042024739840
122146128541750
123039121643845
123145226240950
131032020631832
131146429130230
132032816930645
132142724231838
133039219931335
133141522931542
141027415928850
141138426028848
142027412729750
142143823528245
143039218128942
143144623028542
151026616024465
151132420925458
152025813226052
152140723826055
153031416327355
153137319326065
161037220825948
161141227025248
162033517326255
162135721226455
163036019325242
163139420224852
          10000000 03 1     0 0
          01000000 04 1     0 0
          00100000 05 1     0 0
          01100000 06 1     0 0
TOT             7  02  01  -2
```

```
A                8   02   03   -2
B                9   02   04   -2
C               10   02   05   -2
BC              11   04   06   -5   -4   02
ERR             12   04   01   -6   -3   02
ERROR           -1    4    1    1    1    2   -1    3   -1    6
ERR+B            2    4    1    1   -1    3    1    4   -1    6
ERR+C            3    4    1    1   -1    3    1    5   -1    6
ERR+BC           4    5    1    1    2    2   -1    3   -1    4   -1    5
  1
  0   2 0 0 1
   1    2
```

SAMPLE OUTPUT

```
  2  1 16  3  2  1  1  1  1  1   96   4   6   4   0. 0 0 0
(4X,2F3.2)
   .4000000E+01   .2500000E+01
```

VARIABLE 1

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	96.	.4072708E+01
10000000	3	1	0	0	0	0	0	0	0	6.	.4421667E+01
10000000	3	2	0	0	0	0	0	0	0	6.	.4518333E+01
10000000	3	3	0	0	0	0	0	0	0	6.	.4510000E+01
10000000	3	4	0	0	0	0	0	0	0	6.	.4631667E+01
10000000	3	5	0	0	0	0	0	0	0	6.	.4315000E+01
10000000	3	6	0	0	0	0	0	0	0	6.	.4078333E+01
10000000	3	7	0	0	0	0	0	0	0	6.	.3988333E+01
10000000	3	8	0	0	0	0	0	0	0	6.	.3970000E+01
10000000	3	9	0	0	0	0	0	0	0	6.	.4235000E+01
10000000	3	10	0	0	0	0	0	0	0	6.	.3566667E+01
10000000	3	11	0	0	0	0	0	0	0	6.	.4100000E+01
10000000	3	12	0	0	0	0	0	0	0	6.	.4285000E+01
10000000	3	13	0	0	0	0	0	0	0	6.	.3910000E+01
10000000	3	14	0	0	0	0	0	0	0	6.	.3680000E+01
10000000	3	15	0	0	0	0	0	0	0	6.	.3236667E+01
10000000	3	16	0	0	0	0	0	0	0	6.	.3716667E+01
01000000	4	0	1	0	0	0	0	0	0	32.	.3987188E+01
01000000	4	0	2	0	0	0	0	0	0	32.	.4091875E+01
01000000	4	0	3	0	0	0	0	0	0	32.	.4139063E+01
00100000	5	0	0	1	0	0	0	0	0	48.	.3781875E+01
00100000	5	0	0	2	0	0	0	0	0	48.	.4363542E+01
01100000	6	0	1	1	0	0	0	0	0	16.	.3683125E+01
01100000	6	0	1	2	0	0	0	0	0	16.	.4291250E+01

01100000	6	0	2	1	0	0	0	0	0	16.	.3745000E+01
01100000	6	0	2	2	0	0	0	0	0	16.	.4438750E+01
01100000	6	0	3	1	0	0	0	0	0	16.	.3917500E+01
01100000	6	0	3	2	0	0	0	0	0	16.	.4360625E+01

LINEAR FUNCTION CARDS

TOT	7	2	1	-2		
A	8	2	3	-2		
B	9	2	4	-2		
C	10	2	5	-2		
BC	11	4	6	-5	-4	2
ERR	12	4	1	-6	-3	2

ANALYSIS OF VARIANCE, VARIABLE 1

SOURCE	DF	SS	MS
TOT	95	.3161910E+02	.3328326E+00
A	15	.1341043E+02	.8940286E+00
B	2	.3866896E+00	.1933448E-00
C	1	.8120067E+01	.8120067E+01
BC	2	.2596521E+00	.1298261E-00
ERR	75	.9442259E+01	.1258968E-00

VARIABLE 2

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	96.	.2356875E+01
10000000	3	1	0	0	0	0	0	0	0	6.	.2665000E+01
10000000	3	2	0	0	0	0	0	0	0	6.	.2676667E+01
10000000	3	3	0	0	0	0	0	0	0	6.	.2590000E+01

10000000	3	4	0	0	0	0	0	0	0	6.	.2633333E+01
10000000	3	5	0	0	0	0	0	0	0	6.	.2480000E+01
10000000	3	6	0	0	0	0	0	0	0	6.	.2315000E+01
10000000	3	7	0	0	0	0	0	0	0	6.	.2378333E+01
10000000	3	8	0	0	0	0	0	0	0	6.	.2263333E+01
10000000	3	9	0	0	0	0	0	0	0	6.	.2543333E+01
10000000	3	10	0	0	0	0	0	0	0	6.	.2000000E+01
10000000	3	11	0	0	0	0	0	0	0	6.	.2426667E+01
10000000	3	12	0	0	0	0	0	0	0	6.	.2603333E+01
10000000	3	13	0	0	0	0	0	0	0	6.	.2226667E+01
10000000	3	14	0	0	0	0	0	0	0	6.	.1986667E+01
10000000	3	15	0	0	0	0	0	0	0	6.	.1825000E+01
10000000	3	16	0	0	0	0	0	0	0	6.	.2096667E+01
01000000	4	0	1	0	0	0	0	0	0	32.	.2530938E+01
01000000	4	0	2	0	0	0	0	0	0	32.	.2331875E+01
01000000	4	0	3	0	0	0	0	0	0	32.	.2207813E+01
00100000	5	0	0	1	0	0	0	0	0	48.	.2124792E+01
00100000	5	0	0	2	0	0	0	0	0	48.	.2588958E+01
01100000	6	0	1	1	0	0	0	0	0	16.	.2285000E+01
01100000	6	0	1	2	0	0	0	0	0	16.	.2776875E+01
01100000	6	0	2	1	0	0	0	0	0	16.	.2027500E+01
01100000	6	0	2	2	0	0	0	0	0	16.	.2636250E+01
01100000	6	0	3	1	0	0	0	0	0	16.	.2061875E+01
01100000	6	0	3	2	0	0	0	0	0	16.	.2353750E+01

LINEAR FUNCTION CARDS

TOT	7	2	1	-2		
A	8	2	3	-2		
B	9	2	4	-2		
C	10	2	5	-2		
BC	11	4	6	-5	-4	2
ERR	12	4	1	-6	-3	2

ANALYSIS OF VARIANCE, VARIABLE 2

SOURCE	DF	SS	MS
TOT	95	.1766886E+02	.1859880E+00
A	15	.6518729E+01	.4345819E-00
B	2	.1700556E+01	.8502781E+00
C	1	.5170817E+01	.5170817E+01
BC	2	.4108522E+00	.2054261E-00
ERR	75	.3867910E+01	.5157213E-01

UNCORRECTED MATRICES

LINE	NO OBS	ROW		
1	96	1	.3212660E+02	.1954670E+02
1	96	2	.1963540E+02	

LINE	NO OBS	ROW		
2	1	1	.5075042E+00	-.9990125E+00
2	1	2	.1966538E+01	

LINE	NO OBS	ROW		
3	16	1	.1391793E+02	.8078150E+01
3	16	2	.8485267E+01	

LINE	NO OBS	ROW		
4	3	1	.8941938E+00	-.1807206E+01
4	3	2	.3667094E+01	

LINE	NO OBS	ROW		
5	2	1	.8627571E+01	.5480754E+01
5	2	2	.7137354E+01	

LINE	NO OBS	ROW		
6	6	1	.9273913E+01	.4999025E+01
6	6	2	.9248763E+01	

CORRECTED MATRICES

ERROR -1 4 1. 1 1. 2-1. 3-1. 6

LINE	DF	ROW		
-1	75	1	.9442259E+01	.5470513E+01
-1	75	2	.3867909E+01	

ERR+B 2 4 1. 1-1. 3 1. 4-1. 6

LINE	DF	ROW		
2	77	1	.9828948E+01	.4662319E+01
2	77	2	.5568465E+01	

ERR+C 3 4 1. 1-1. 3 1. 5-1. 6

LINE	DF	ROW		
3	76	1	.1756233E+02	.1195028E+02
3	76	2	.9038726E+01	

ERR+BC 4 5 1. 1 2. 2-1. 3-1. 4-1. 5

LINE	DF	ROW		
4	77	1	.9701912E+01	.5796977E+01
4	77	2	.4278762E+01	

0 2 0 0 1
1 2

LINE NUMBER

ERR MATRIX		DF	ROW	COL	SS AND SP	MS AND MP
	-1	75.	1	1	.9442259E+01	.1258968E-00

-1	75.	1	2	.5470513E+01	.7294017E-01
-1	75.	2	2	.3867909E+01	.5157212E-01
				ERROR DET =	.6595289E+01

TRT MATRIX

2	2.	1	1	.3866890E+00	.1933445E-00
2	2.	1	2	-.8081940E+00	-.4040970E-00
2	2.	2	2	.1700556E+01	.8502780E+00
				TRT+ERR DET =	.3299494E+02
				MUL F =	.4575771E+02
				DF =	4. AND 148.

TRT MATRIX

3	1.	1	1	.8120066E+01	.8120066E+01
3	1.	1	2	.6479766E+01	.6479766E+01
3	1.	2	2	.5170817E+01	.5170817E+01
				TRT+ERR DET =	.1593188E+02
				MUL F =	.4101336E+02
				DF =	2. AND 148.

TRT MATRIX

4	2.	1	1	.2596530E+00	.1298265E-00
4	2.	1	2	.3264640E+00	.1632320E-00
4	2.	2	2	.4108530E+00	.2054265E-00
				TRT+ERR DET =	.7907233E+01
				MUL F =	.3513248E+01
				DF =	4. AND 148.

Fractional replication

The data for this example is a Latin Square design taken from Snedecor (8, p.411). A Latin Square of "t" treatments can be visualized as one "t"th replication of a t^3 factorial. The format is as follows:

Columns	Description
1	Treatment
2	Row
3	Column
4-6	Independent variable
7-10	Dependent variable
11-14	Control variable for missing observations.

Model

$$Y_{ijk} = \mu + \tau_i + \rho_j + \gamma_k + \varepsilon_{ijk} + B(X_{ijk} - \bar{X}_{...})$$

$i = 1 \ldots a \qquad a = 4$

$j = 1 \ldots b \qquad b = 4$

$k = 1 \ldots c \qquad c = 4$

Source	d.f.	SS
Tot	$\frac{abc}{4} - 1$	$\sum_{ijk} Y_{ijk}^2 - \frac{Y_{...}^2}{16}$
Trt	a-1	$\sum_{i} \frac{Y_{i..}^2}{4} - \frac{Y_{...}^2}{16}$

Source	d.f.	SS
Row	b-1	$\sum_j \frac{Y^2_{\cdot j \cdot}}{4} - \frac{Y^2_{\cdots}}{16}$
Column	c-1	$\sum_k \frac{Y^2_{\cdot\cdot k}}{4} - \frac{Y^2_{\cdots}}{16}$
Error	$\frac{abc}{4}$ -a-b-c+2	$\sum_{ijk} Y^2_{ijk} - \sum_i \frac{Y^2_{i\cdot\cdot}}{4} - \sum_j \frac{Y^2_{\cdot j \cdot}}{4} - \sum_k \frac{Y^2_{\cdot\cdot k}}{4} + \frac{Y^2_{\cdots}}{16} + \frac{Y^2_{\cdots}}{16}$

It should be noticed that the correction term has a divisor of 16 instead of the normal divisor abc(64). The other terms needed for calculation of the sum of squares have divisors of 4 instead of the normal divisor 16. These divisors are supplied on the control card, for the correction term, and on the raw sum of squares trail cards for the other terms.

SAMPLE INPUT

```
  2   1   4   4   4   1   1   1   1   1    64    3    5    2    16 1 1
(3X,F3.1,F4.1,F4.0)
   15.8            25.6
111         9999
112193 213
113         9999
114         9999
121292 197
122         9999
123         9999
124         9999
131         9999
132         9999
133         9999
134 10 287
141         9999
142         9999
143 64 273
144         9999
211         9999
212         9999
213101 283
214         9999
221         9999
222347 207
223         9999
224         9999
231140 260
232         9999
233         9999
234         9999
241         9999
242         9999
243         9999
```

```
244 56 341
311 43 267
312        9999
313        9999
314        9999
321        9999
322        9999
323        9999
324482 147
331        9999
332        9999
333 63 290
334        9999
344        9999
342 67 290
343        9999
344        9999
411        9999
412        9999
413        9999
414140 251
421        9999
422        9999
423302 201
424        9999
431        9999
432 72 249
433        9999
434        9999
441 89 298
442        9999
443        9999
444        9999
          10000000  3 1    4 1
          01000000  4 1    4 1
```

```
          00100000  5 1    4 1
TOT             6   2   1  -2
TRT             7   2   3  -2
ROW             8   2   4  -2
COL             9   2   5  -2
ERR            10   4   6  -7  -8  -9
ERROR          -1   5   1   1 -1   3 -1   4 -1   5   2   2
TRT+ERR         1   4   1   1 -1   4 -1   5   1   2
  1
  1  1 1 1 1 0
   1   2
```

SAMPLE OUTPUT

```
  2  1  4  4  4  1  1  1  1  1   64   3   5   2  16.  1  1  0
(3X,F3.1,F4.1,F4.0)
   .1580000E+02   .2560000E+02


VARIABLE  1


 BINARY   LINE          TREAT IDENT          NO OBS   AVERAGE

00000000    2     0  0  0  0  0  0  0  0     16.    .1538125E+02
10000000    3     1  0  0  0  0  0  0  0      4.    .1397500E+02
10000000    3     2  0  0  0  0  0  0  0      4.    .1610000E+02
10000000    3     3  0  0  0  0  0  0  0      4.    .1637500E+02
10000000    3     4  0  0  0  0  0  0  0      4.    .1507500E+02
01000000    4     0  1  0  0  0  0  0  0      4.    .1192500E+02
01000000    4     0  2  0  0  0  0  0  0      4.    .3557500E+02
01000000    4     0  3  0  0  0  0  0  0      4.    .7125000E+01
01000000    4     0  4  0  0  0  0  0  0      4.    .6900000E+01
00100000    5     0  0  1  0  0  0  0  0      4.    .1410000E+02
00100000    5     0  0  2  0  0  0  0  0      4.    .1697500E+02
00100000    5     0  0  3  0  0  0  0  0      4.    .1325000E+02
00100000    5     0  0  4  0  0  0  0  0      4.    .1720000E+02

            LINEAR FUNCTION CARDS

TOT           6   2   1  -2
TRT           7   2   3  -2
ROW           8   2   4  -2
COL           9   2   5  -2
ERR          10   4   6  -7  -8  -9
```

ANALYSIS OF VARIANCE, VARIABLE 1

SOURCE	DF	SS	MS
TOT	15	.2680624E+04	.1787083E+03
TRT	3	.1430188E+02	.4767292E+01
ROW	3	.2239322E+04	.7464406E+03
COL	3	.4812688E+02	.1604229E+02
ERR	6	.3788738E+03	.6314564E+02

VARIABLE 2

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	16.	.2533750E+02
10000000	3	1	0	0	0	0	0	0	0	4.	.2425000E+02
10000000	3	2	0	0	0	0	0	0	0	4.	.2727500E+02
10000000	3	3	0	0	0	0	0	0	0	4.	.2485000E+02
10000000	3	4	0	0	0	0	0	0	0	4.	.2497500E+02
01000000	4	0	1	0	0	0	0	0	0	4.	.2535000E+02
01000000	4	0	2	0	0	0	0	0	0	4.	.1880000E+02
01000000	4	0	3	0	0	0	0	0	0	4.	.2715000E+02
01000000	4	0	4	0	0	0	0	0	0	4.	.3005000E+02
00100000	5	0	0	1	0	0	0	0	0	4.	.2555000E+02
00100000	5	0	0	2	0	0	0	0	0	4.	.2397500E+02
00100000	5	0	0	3	0	0	0	0	0	4.	.2617500E+02
00100000	5	0	0	4	0	0	0	0	0	4.	.2565000E+02

LINEAR FUNCTION CARDS

TOT	6	2	1	-2		
TRT	7	2	3	-2		
ROW	8	2	4	-2		
COL	9	2	5	-2		
ERR	10	4	6	-7	-8	-9

ANALYSIS OF VARIANCE, VARIABLE 1

SOURCE	DF	SS	MS
TOT	15	.2680624E+04	.1787083E+03
TRT	3	.1430188E+02	.4767292E+01
ROW	3	.2239322E+04	.7464406E+03
COL	3	.4812688E+02	.1604229E+02
ERR	6	.3788738E+03	.6314564E+02

VARIABLE 2

BINARY	LINE	TREAT IDENT								NO OBS	AVERAGE
00000000	2	0	0	0	0	0	0	0	0	16.	.2533750E+02
10000000	3	1	0	0	0	0	0	0	0	4.	.2425000E+02
10000000	3	2	0	0	0	0	0	0	0	4.	.2727500E+02
10000000	3	3	0	0	0	0	0	0	0	4.	.2485000E+02
10000000	3	4	0	0	0	0	0	0	0	4.	.2497500E+02
01000000	4	0	1	0	0	0	0	0	0	4.	.2535000E+02
01000000	4	0	2	0	0	0	0	0	0	4.	.1880000E+02
01000000	4	0	3	0	0	0	0	0	0	4.	.2715000E+02
01000000	4	0	4	0	0	0	0	0	0	4.	.3005000E+02
00100000	5	0	0	1	0	0	0	0	0	4.	.2555000E+02
00100000	5	0	0	2	0	0	0	0	0	4.	.2397500E+02
00100000	5	0	0	3	0	0	0	0	0	4.	.2617500E+02
00100000	5	0	0	4	0	0	0	0	0	4.	.2565000E+02

LINEAR FUNCTION CARDS

TOT	6	2	1	-2		
TRT	7	2	3	-2		
ROW	8	2	4	-2		
COL	9	2	5	-2		
ERR	10	4	6	-7	-8	-9

ANALYSIS OF VARIANCE, VARIABLE 2

SOURCE	DF	SS	MS
TOT	15	.3601775E+03	.2401183E+02
TRT	3	.2122250E+02	.7074167E+01
ROW	3	.2729275E+03	.9097583E+02
COL	3	.1080250E+02	.3600833E+01
ERR	6	.5522500E+02	.9204167E+01

UNCORRECTED MATRICES

LINE	NO OBS	ROW		
1	16	1	.2683430E+04	-.8817000E+03
1	16	2	.3612800E+03	

LINE	NO OBS	ROW		
2	1	1	.2805625E+01	.1758750E+01
2	1	2	.1102500E+01	

LINE	NO OBS	ROW		
3	4	1	.1710750E+02	.1195250E+02
3	4	2	.2232500E+02	

LINE	NO OBS	ROW		
4	4	1	.2242128E+04	-.7462100E+03
4	4	2	.2740300E+03	

LINE	NO OBS	ROW		
5	4	1	.5093250E+02	-.1288250E+02
5	4	2	.1190500E+02	

CORRECTED MATRICES

ERROR -1 5 1. 1-1. 3-1. 4-1. 5 2. 2

```
 LINE    DF    ROW
  -1      6     1     .3788738E+03    -.1310425E+03
  -1      6     2     .5522500E+02

TRT+ERR           1    4 1.   1-1.   4-1.   5 1.   2

 LINE    DF    ROW
   1      9     1     .3931756E+03    -.1208488E+03
   1      9     2     .7644750E+02


  1   1 1 1 1 0
    1    2

            LINE
           NUMBER

INVERSE                ROW COL      ELEMENT
                -1      1   1     .2639402E-02

REG COEF                 X   Y     COEFFICIENT
                -1      1   2    -.3458738E+00

DUE TO REG                 DF  ROW COL     SS AND SP        MS AND MP
                -1          1.   2   2    .4532416E+02     .4532416E+02

DEV FR REG
                -1          5.   2   2    .9900836E+01     .1980167E+01

TRT ADJ
                 1          3.   2   2    .2940189E+02     .9800630E+01
```

Appendix C

Basic Designs Program

The following listing is a listing as this program ran on a CDC 3100.

```
C       PROGRAM BASIC                                                          BA000010
        DIMENSION NOBS(25),IX(16),CON(15),FMT(20),G(15),C(25,15),R(25,15),BA000020
       1TRT(25,15),A(16,15),B(16,15),ZN(25),X(16),Z(15)                        BA000030
        COMMON Z, X,CON,A,B,TRT,G,NX,NVAR,NT,IZ,NERR                          BA000040
C     NJB= NO. OF JOBS (MODELS)                                                BA000050
        READ (5,101) NJB                                                       BA000060
        DO 60 IXZ=1,NJB                                                        BA000070
  301 FORMAT (1H1,5I4,2I2,16X,10A4)                                            BA000080
  101 FORMAT (    5I4,2I2,16X,10A4)                                            BA000090
C     MI= MODEL IDENTIFICATION 1=CRD  2=RBD   3=LSD                            BA000100
C     NT= NO. OF TREATMENTS                                                    BA000110
C     NB= NO. OF BLOCKS                                                        BA000120
C     NX= NO. OF X'S                                                           BA000130
C     NY= NO. OF Y'S                                                           BA000140
C     IZ= CONTROL FOR REG. WITHIN TREATMENT                                    BA000150
        READ (5,101) MI,NT,NB,NX,NY,IZ,IO,(FMT(I),I=1,10)                      BA000160
        WRITE(6,301) MI,NT,NB,NX,NY,IZ,IO,(FMT(I),I=1,10)                      BA000170
        IF (IO) 52,52,51                                                       BA000180
   51 REWIND 4                                                                 BA000190
   52 IN=5-IO                                                                  BA000200
        NVAR=NX+NY                                                             BA000210
        NVP=NVAR+1                                                             BA000220
C     IND=NVAR  IF MI=1,2                                                      BA000230
C     IND=NVAR+1  IF MI=3                                                      BA000240
        IND=NVAR+MI/3                                                          BA000250
        GO TO (201,203,202),MI                                                 BA000260
C     NOBS(I)= NO. OF OBSERVATIONS FOR TREATMENT I                             BA000270
  201 READ  (5,102) (NOBS(I),I=1,NT)                                           BA000280
        WRITE (6,302) (NOBS(I),I=1,NT)                                         BA000290
  102 FORMAT(20I4)                                                             BA000300
  302 FORMAT(1H 20I4)                                                          BA000310
  202 NB=NT                                                                    BA000320
  203 READ  (5,105) (FMT(I),I=1,20)                                            BA000330
        WRITE (6,305) (FMT(I),I=1,20)                                          BA000340
  105 FORMAT(20A4)                                                             BA000350
```

```
  305 FORMAT(1H 20A4)                                                    BA000360
C   IX(I)= ORDER IN INPUT LIST OF VARIABLE I                             BA000370
      READ  (5,103) (IX(I),I=1,IND)                                      BA000380
      WRITE (6,303) (IX(I),I=1,IND)                                      BA000390
  303 FORMAT (1H 20I4)                                                   BA000400
  103 FORMAT (   20I4)                                                   BA000410
      READ  (5,104) (CON(I),I=1,NVAR)                                    BA000420
      WRITE (6,304) (CON(I),I=1,NVAR)                                    BA000430
  104 FORMAT (   5E15.7)                                                 BA000440
  304 FORMAT (1H 5E15.7)                                                 BA000450
C   ZERO MATRIX AREAS                                                    BA000460
      DO 2 K=1,NVAR                                                      BA000470
      G(K)=0.0                                                           BA000480
      DO 4 I=1,NT                                                        BA000490
      GO TO (4,4,7),MI                                                   BA000500
    7 C(I,K)=0.0                                                         BA000510
    4 TRT(I,K)=0.0                                                       BA000520
      DO 5 J=1,NB                                                        BA000530
    5 R(J,K)=0.0                                                         BA000540
      DO 2 J=1,NVP                                                       BA000550
      A(  J,K)=0.0                                                       BA000560
    2 B(  J,K)=0.0                                                       BA000570
      NDF=0.0                                                            BA000580
      DO 71 I=1,NT                                                       BA000590
      GO TO (204,205,205),MI                                             BA000600
  204 NB=NOBS(I)                                                         BA000610
  205 ZN(I)=NB                                                           BA000620
      NDF=NDF+NB                                                         BA000630
C   READ AND REARRANGE VARIABLES                                         BA000640
      DO 10 J=1,NB                                                       BA000650
      READ  (IN,FMT) (X(K),K=1,IND)                                      BA000660
      L=IX(IND)                                                          BA000670
      LK=X(L)                                                            BA000680
      DO 10 K=1,NVAR                                                     BA000690
      L=IX(K)                                                            BA000700
```

```
      Z(K)=X(L)-CON(K)                                                  BA000710
      GO TO (213,212,211),MI                                            BA000720
  211 C(LK,K)=C(LK,K)+Z(K)                                              BA000730
  212 R(J,K)=R(J,K)+Z(K)                                                BA000740
  213 TRT(I,K)=TRT(I,K)+Z(K)                                            BA000750
      DO 10 M=1,K                                                       BA000760
   10 A(M,K)=A(M,K)+Z(K)*Z(M)                                           BA000770
      DO 21 K=1,NVAR                                                    BA000780
      G(K)=G(K)+TRT(I,K)                                                BA000790
       DO 20 M=K,NVAR                                                   BA000800
      B(K,M)=B(K,M)+A(K,M)                                              BA000810
      IF (IZ) 20,20,29                                                  BA000820
   29 A(K,M)=A(K,M)-TRT(I,K)*TRT(I,M)/ZN(I)                             BA000830
      A(M,K)=A(K,M)                                                     BA000840
   20 B(M+1,K)=B(M+1,K)+TRT(I,M)*TRT(I,K)/ZN(I)                         BA000850
   21 Z(K)=SQRT(A(K,K))                                                 BA000860
      IF (IZ) 67,67,66                                                  BA000870
   66 GO TO (62,67,67),MI                                               BA000880
   62 IF (NX)67,67,68                                                   BA000890
C   COMPUTE REGRESSION ANALYSIS WITHIN TREATMENT                        BA000900
   68 WRITE (6,405) I                                                   BA000910
  405 FORMAT (////30H REGRESSION ANALYSIS TREATMENT I4)                 BA000920
  400 FORMAT (//33H CORRELATION MATRIX FOR TREATMENT  I4)               BA000930
      WRITE (6,400) I                                                   BA000940
      DO 61 K=1,NVAR                                                    BA000950
      DO 65 M=K,NVAR                                                    BA000960
   65 X(M)=A(K,M)/(Z(M)*Z(K))                                           BA000970
   61 WRITE (6,401) K,(X(M),M=K,NVAR)                                   BA000980
  401 FORMAT (1H I4,5E15.7/(5X,5E15.7))                                 BA000990
      NXP=NX+1                                                          BA001000
      CALL INVERT (A,1,NX,NXP,NVAR)                                     BA001010
      WRITE (6,402) I                                                   BA001020
  402 FORMAT (/29H INVERSE MATRIX FOR TREATMENT  I4)                    BA001030
      DO 501 K=1,NX                                                     BA001040
      DO 500 M=K,NX                                                     BA001050
```

```
500 X(M)=-A(K,M)                                                    BA001060
501 WRITE (6,401) K,(X(M),M=K,NX)                                   BA001070
    WRITE (6,403)                                                   BA001080
403 FORMAT  (/13H COEFFICIENTS )                                    BA001090
    DO 502 K=NXP,NVAR                                               BA001100
    DO 502 M=1,NX                                                   BA001110
502 WRITE (6,404) M,K,A(M,K)                                        BA001120
404 FORMAT (1H 2I4,E15.7)                                           BA001130
    DO 550 K=NXP,NVAR                                               BA001140
    WRITE (6,406) K                                                 BA001150
406 FORMAT ( /9H VARIABLE I4)                                       BA001160
    WRITE (6,308)                                                   BA001170
    ZA=A(K,K)                                                       BA001180
    ZB=0.0                                                          BA001190
    DO 530 M=1,NX                                                   BA001200
530 ZB=ZB+A(K,M)*A(M,K)                                             BA001210
    ZD=ZA-ZB                                                        BA001220
    IDF=ZN(I)-1.0                                                   BA001230
    WRITE (6,309) IDF,ZA                                            BA001240
    AX=NX                                                           BA001250
    IDF=IDF-NX                                                      BA001260
    D=IDF                                                           BA001270
    RMS=ZB/AX                                                       BA001280
    ERRMS=ZD/D                                                      BA001290
    F=RMS/ERRMS                                                     BA001300
    WRITE (6,407) NX,ZB,RMS,F                                       BA001310
407 FORMAT (7H    REG,I7,3(2X,E15.7))                               BA001320
550 WRITE (6,313) IDF,ZD,ERRMS                                      BA001330
 67 DO 69 K=1,NVAR                                                  BA001340
    DO 69 M=K,NVAR                                                  BA001350
    A(K,M)=0.0                                                      BA001360
    A(M,K)=0.0                                                      BA001370
 69 CONTINUE                                                        BA001380
 71 CONTINUE                                                        BA001390
    T1=NDF                                                          BA001400
```

```
      ZNT=NT                                                          BA001410
C     COMPUTE ANALYSIS OF VARIANCE FOR EACH VARIABLE                  BA001420
      DO 43 K=1,NVAR                                                  BA001430
      DO 30 M=K,NVAR                                                  BA001440
      A(K,M)=B(M+1,K)                                                 BA001450
      B(M+1,K)=0.0                                                    BA001460
      B(K,M)=B(K,M)-G(K)*G(M)/T1                                      BA001470
      GO TO (30,23,23),MI                                             BA001480
   23 DO 25 I=1,NB                                                    BA001490
       GO TO (30,25,24),MI                                            BA001500
   24 B(M+1,K)=B(M+1,K)+(C(I,K)*C(I,M))/ZNT                           BA001510
   25 A(M+1,K)=A(M+1,K)+(R(I,K)*R(I,M))/ZNT                           BA001520
   30 CONTINUE                                                        BA001530
      WRITE (6,306) K                                                 BA001540
  306 FORMAT(////31H ANALYSIS OF VARIANCE, VARIABLE I3)               BA001550
      CT=G(K)*G(K)/T1                                                 BA001560
      WRITE (6,308)                                                   BA001570
  308 FORMAT(/8H  SOURCE3X2HDF10X2HSS15X2HMS16X1HF)                   BA001580
      TOTDF=T1-1.0                                                    BA001590
      ROWDF=NB-1                                                      BA001600
      TRTDF=NT-1                                                      BA001610
      ERRDF=NDF-NT-(MI-1)*(NB-1)                                      BA001620
      IDF=TOTDF                                                       BA001630
      WRITE (6,309) IDF,B(K,K)                                        BA001640
  309 FORMAT(7H    TOT,I7,2X,E15.7)                                   BA001650
      GO TO (33,31,31),MI                                             BA001660
   31 ZA=A(K+1,K)-CT                                                  BA001670
      IDF=ROWDF                                                       BA001680
      B(K,K)=B(K,K)-ZA                                                BA001690
      GO TO (33,214,215),MI                                           BA001700
  214 WRITE (6,310) IDF,ZA                                            BA001710
  310 FORMAT (7H    BLK,I7,2X,E15.7)                                  BA001720
      GO TO 216                                                       BA001730
  215 WRITE (6,317)IDF,ZA                                             BA001740
  317 FORMAT (7H    ROW ,I7,2X,E15.7)                                 BA001750
```

```
216 GO TO (33,33,32),MI                                                    BA001760
 32 ZA=B(K+1,K)-CT                                                         BA001770
    B(K,K)=B(K,K)-ZA                                                       BA001780
    WRITE (6,311) IDF,ZA                                                   BA001790
311 FORMAT(7H    COL,I7,2X,E15.7)                                          BA001800
 33 T=A(K,K)-CT                                                            BA001810
    TRTMS=T/TRTDF                                                          BA001820
    A(K,K)=B(K,K)-T                                                        BA001830
    ERRMS=A(K,K)/ERRDF                                                     BA001840
    F=TRTMS/ERRMS                                                          BA001850
    IDF=TRTDF                                                              BA001860
    WRITE (6,312) IDF,T,TRTMS,F                                            BA001870
312 FORMAT(7H    TRT,I7,3(2X,E15.7))                                       BA001880
    NERR=ERRDF                                                             BA001890
    WRITE (6,313) NERR,A(K,K),ERRMS                                        BA001900
313 FORMAT(7H    ERR,I7,2(2X,E15.7))                                       BA001910
    IF (K-NVAR)70,53,53                                                    BA001920
 70 L=K+1                                                                  BA001930
    DO 45 J=L,NVAR                                                         BA001940
    CT=G(K)*G(J)/T1                                                        BA001950
    GO TO (40,41,41),MI                                                    BA001960
 41 B(K,J)=B(K,J)-A(J+1,K)+CT                                              BA001970
    GO TO (40,40,42),MI                                                    BA001980
 42 B(K,J)=B(K,J)-B(J+1,K)+CT                                              BA001990
 40 A(K,J)=B(K,J)-A(K,J)+CT                                                BA002000
 45 A(J,K)=A(K,J)                                                          BA002010
 53 WRITE(6,315)                                                           BA002020
315 FORMAT (/19H  TRT      TRT MEANS ,12X,2HSE)                           BA002030
    DO 15 I=1,NT                                                           BA002040
    TRT(I,K)=TRT(I,K)/ZN(I)+CON(K)                                         BA002050
    SE= SQRT(ERRMS/ZN(I))                                                  BA002060
 15 WRITE (6,307) I,TRT(I,K) ,SE                                           BA002070
307 FORMAT(1H I4,2(2X,E15.7))                                              BA002080
    G(K)=G(K)/T1+CON(K)                                                    BA002090
    CV=SQRT(ERRMS)/G(K)                                                    BA002100
```

```
 43 WRITE (6,316) G(K) ,CV                                              BA002110
316 FORMAT (/12H  EXP MEAN  E15.8, 9H   C.V.  E15.8)                    BA002120
    IF (NX)60,60,50                                                     BA002130
 50 CALL COVAR                                                          BA002140
 60 CONTINUE                                                            BA002150
    STOP                                                                BA002160
    END                                                                 BA002170
```

```
      SUBROUTINE INVERT(A,N1,N2,NPX,NK)                                  BA003020
C     MATRIX INVERSION ROUTINE INVERTS UPPER TRIANGULAR PORTION          BA003030
C     OF MATRIX BETWEEN ROW N1 AND ROW N2.  WITH SOLUTION FROM           BA003040
C     ROW NPX TO ROW NK.  THE INVERSE IS THE NEGATIVE OF THE INVERSE     BA003050
      DIMENSION A(16,15)                                                 BA003060
      DO 501 L=N1,N2                                                     BA003070
      RECIP=1.0/A(L,L)                                                   BA003080
      DO 502 I=N1,N2                                                     BA003090
      IF(I-L) 503,504,505                                                BA003100
  503 R=A(I,L)*RECIP                                                     BA003110
      GO TO 506                                                          BA003120
  504 R=0.0                                                              BA003130
      GO TO 506                                                          BA003140
  505 R=A(L,I)*RECIP                                                     BA003150
  506 DO 507 J=I,N2                                                      BA003160
      IF(J-L) 508,507,509                                                BA003170
  508 A(I,J)=A(I,J)-R*A(J,L)                                             BA003180
      GO TO 507                                                          BA003190
  509 A(I,J)=A(I,J)-R*A(L,J)                                             BA003200
  507 CONTINUE                                                           BA003210
      DO 510 J=NPX,NK                                                    BA003220
  510 A(I,J)=A(I,J)-R*A(L,J)                                             BA003230
      IF(I-L) 511,512,513                                                BA003240
  511 A(I,L)=R                                                           BA003250
      GO TO 502                                                          BA003260
  512 A(L,L)=-RECIP                                                      BA003270
      GO TO 502                                                          BA003280
  513 A(L,I)=R                                                           BA003290
  502  CONTINUE                                                          BA003300
      DO 501 N=NPX,NK                                                    BA003310
  501 A(L,N)=A(L,N)*RECIP                                                BA003320
      RETURN                                                             BA003330
      END                                                                BA003340
```

Appendix D

Basic Program Sample Problems

Three sample problems have been used to demonstrate the capabilities of this program. The first is a completely randomized design with three treatments with four, eleven and seven observations per treatment (Snedecor 8, p. 403). The format for the data is

Column	Description
1	Treatment identification
2-3	Observation within treatment
4-6	Dependent variable
7-8	Independent variable

The second sample is a subset of the randomized block design used for the factorial program. For this program ten blocks, three treatments and two additional variables were selected. The format for the data is

Column	Description
1-2	Block identification
3	Treatment identification
5-7	First dependent variable
8-10	Second dependent variable
11-13	First independent variable
14-15	Second independent variable

The third sample is the same as the fractional replication used for the factorial program. It is a latin square design with four treatments (Snedecor 8, p. 411). The format for the data is

Column	Description
1	Row identification
2	Column identification
3	Treatment identification
4-6	Independent variable
7-9	Dependent variable

SAMPLE INPUT

```
   3
   1   3   0   1   1 1                        TEST DATA FOR A CRD
   4  11   7
(3X,F3.1,F2.0)
   2   1
   33.0           8.0
1 1 7724
1 2 5431
1 3 5226
1 4 4030
2 1 9633
2 2 7833
2 3 9632
2 4 7736
2 5 8233
2 6 7338
2 711330
2 8 9538
2 9 8831
210 8432
211 6832
3 1 4831
3 2 9233
3 3 8533
3 4 8833
3 5 9227
3 6 7932
3 7 5936
   2   3  10   2   2                        RBD TEST DATA
(4X,3F3.2,F2.2)
   3   4   1   2
   5.0            4.0             7.0             0.5
011149531631558
021147230530858
```

```
031148932042045
041148731438645
051145027938852
061145329239030
071140826835035
081141426933145
091140926231242
101136223432430
012139224334862
022148529027655
032149028740850
042155731640515
052145727837652
062145626538138
072146128233948
082140322934048
092149931233415
102138323427428
013149831334660
023143022832352
033147525642438
043146124437830
053153828037352
063142520839840
073136621634850
083143723231030
093144425235425
103139619932330
   3    4    4    1    1                    LSD TEST DATA
(1X,F1.0,1X,2F3.1)
   2    3    1
  15.8           25.6
121193213
211292197
341010287
```

431064273
132101283
222347207
312140260
442056341
113043267
243482147
333063290
423067290
144140251
234302201
324072249
414089298

SAMPLE OUTPUT

```
   1   3   0   1   1 1 0                    TEST DATA FOR A CRD
   4  11   7
(3X,F3.1,F2.0)
   2   1
   .3300000E+02   .8000000E+01



REGRESSION ANALYSIS TREATMENT   1


CORRELATION MATRIX FOR TREATMENT   1
   1   .1000000E+01  -.7457044E+00
   2   .1000000E+01

INVERSE MATRIX FOR TREATMENT   1
   1   .3053435E-01

COEFFICIENTS
   1   2  -.3488550E+00

VARIABLE   2

 SOURCE   DF          SS                MS                F
   TOT     3     .7167500E+01
   REG     1     .3985668E+01     .3985668E+01     .2505266E+01
   ERR     2     .3181832E+01     .1590916E+01



REGRESSION ANALYSIS TREATMENT   2
```

```
CORRELATION MATRIX FOR TREATMENT    2
   1    .1000000E+01  -.3552275E+00
   2    .1000000E+01

INVERSE MATRIX FOR TREATMENT    2
   1    .1375000E-01

COEFFICIENTS
   1    2  -.1702500E+00

VARIABLE    2

 SOURCE    DF           SS                  MS                  F
   TOT      10      .1670546E+02
   REG       1      .2108004E+01      .2108004E+01      .1299682E+01
   ERR       9      .1459745E+02      .1621939E+01


REGRESSION ANALYSIS TREATMENT    3


CORRELATION MATRIX FOR TREATMENT    3
   1    .1000000E+01  --.2974849E-00
   2    .1000000E+01

INVERSE MATRIX FOR TREATMENT    3
   1    .2229299E-01

COEFFICIENTS
   1    2  -.1885350E+00

VARIABLE    2
```

SOURCE	DF	SS	MS	F
TOT	6	.1801714E+02		
REG	1	.1594468E+01	.1594468E+01	.4854469E+00
ERR	5	.1642268E+02	.3284535E+01	

ANALYSIS OF VARIANCE, VARIABLE 1

SOURCE	DF	SS	MS	F
TOT	21	.2460000E+03		
TRT	2	.9566557E+02	.4783279E+02	.6045341E+01
ERR	19	.1503344E+03	.7912338E+01	

TRT	TRT MEANS	SE
1	.2775000E+02	.1406444E+01
2	.3345455E+02	.8481176E-00
3	.3214286E+02	.1063172E+01

EXP MEAN .32000000E+02 C.V. .87902746E-01

ANALYSIS OF VARIANCE, VARIABLE 2

SOURCE	DF	SS	MS	F
TOT	21	.6940000E+02		
TRT	2	.2750990E+02	.1375495E+02	.6238803E+01
ERR	19	.4189010E+02	.2204742E+01	

TRT	TRT MEANS	SE
1	.5575000E+01	.7424187E+00

```
   2      .8636364E+01       .4476953E-00
   3      .7757143E+01       .5612158E+00

 EXP MEAN     .78000000E+01    C.V.     .19036375E+00



RESIDUAL CORRELATION MATRIX
   1    .1000000E+01  -.4065676E+00
   2    .1000000E+01

INVERSE MATRIX, ERROR LINE
   1    .6651836E-02

COEFFICIENTS
  1  2     -.2146146E+00



ADJUSTED ANALYSIS, VAR   2

 SOURCE    DF           MS              ADJ F
   TRT      2      .1649107E+02      .8489422E+01
   REG      1      .6924316E+01      .3564562E+01
   ERR     18      .1942544E+01

 COEF OF DET     .1652972E-00  C.V.     .1786861E+00

 ADJUSTED MEANS
   1      .4662888E+01
   2      .8948530E+01
   3      .7787802E+01
```

```
   2    3   10    2    2 0 0                    RBD TEST DATA
(4X,3F3.2,F2.2)
   3    4    1    2
   .5000000E+01    .4000000E+01    .7000000E+01    .5000000E+00


ANALYSIS OF VARIANCE, VARIABLE  1

 SOURCE    DF           SS                MS                 F
   TOT      29      .4643187E+01
   BLK       9      .4074118E+01
   TRT       2      .4624700E-01      .2312350E-01      .7961084E+00
   ERR      18      .5228220E+00      .2904567E-01

 TRT      TRT MEANS             SE
   1      .3524000E+01      .5389403E-01
   2      .3481000E+01      .5389403E-01
   3      .3577000E+01      .5389403E-01

 EXP MEAN     .35273334E+01   C.V.     .48316354E-01


ANALYSIS OF VARIANCE, VARIABLE  2

 SOURCE    DF           SS                MS                 F
   TOT      29      .4780000E+00
   BLK       9      .3481200E+00
   TRT       2      .6500000E-02      .3250000E-02      .4741449E+00
   ERR      18      .1233800E+00      .6854444E-02

 TRT      TRT MEANS             SE
```

1	.4400000E+00	.2618099E-01
2	.4110000E+00	.2618099E-01
3	.4070000E+00	.2618099E-01

EXP MEAN .41933340E+00 C.V. .19743614E-00

ANALYSIS OF VARIANCE, VARIABLE 3

SOURCE	DF	SS	MS	F
TOT	29	.6682990E+01		
BLK	9	.3761180E+01		
TRT	2	.1148900E+00	.5744500E-01	.3683789E-00
ERR	18	.2806920E+01	.1559400E-00	

TRT	TRT MEANS	SE
1	.4439000E+01	.1248759E-00
2	.4583000E+01	.1248759E-00
3	.4470000E+01	.1248759E-00

EXP MEAN .44973334E+01 C.V. .87805896E-01

ANALYSIS OF VARIANCE, VARIABLE 4

SOURCE	DF	SS	MS	F
TOT	29	.3617140E+01		
BLK	9	.1403990E+01		
TRT	2	.9858500E+00	.4929250E-00	.7229406E+01
ERR	18	.1227300E+01	.6818333E-01	

TRT	TRT MEANS	SE
1	.2859000E+01	.8257320E-01
2	.2736000E+01	.8257320E-01
3	.2428000E+01	.8257320E-01

EXP MEAN .26743333E+01 C.V. .97639056E-01

RESIDUAL CORRELATION MATRIX

1	.1000000E+01	-.1475314E-00	-.1448805E-00	-.1355269E+00
2	.1000000E+01	-.4339768E+00	-.3813352E+00	
3	.1000000E+01	.9011704E+00		
4	.1000000E+01			

INVERSE MATRIX, ERROR LINE

1	.1955254E+01	.5938025E-00
2	.8285376E+01	

COEFFICIENTS

1	3	-.4948178E+00
2	3	-.2220220E+01
1	4	-.3003806E+00
2	4	-.1293931E+01

ADJUSTED ANALYSIS, VAR 3

SOURCE	DF	MS	ADJ F
TRT	2	.1418090E-01	.1053827E-00
REG	2	.3269338E-00	.2429546E+01
ERR	16	.1345658E-00	

COEF OF DET .2329484E-00 C.V. .8156657E-01

ADJUSTED MEANS

1	.4483235E+01
2	.4541572E+01
3	.4467193E+01

ADJUSTED ANALYSIS, VAR 4

SOURCE	DF	MS	ADJ F
TRT	2	.5007718E+00	.7990904E+01
REG	2	.1123082E-00	.1792122E+01
ERR	16	.6266773E-01	

COEF OF DET .1830167E-00 C.V. .9360659E-01

ADJUSTED MEANS

1	.2884740E+01
2	.2711300E+01
3	.2426960E+01

```
   3    4    4    1    1 0 0                    LSD TEST DATA
(1X,F1.0,1X,2F3.1)
   2    3    1
   .1580000E+02    .2560000E+02



ANALYSIS OF VARIANCE, VARIABLE  1

 SOURCE    DF           SS                MS                F
   TOT      15      .2680624E+04
   ROW       3      .2239322E+04
   COL       3      .4812688E+02
   TRT       3      .1430188E+02      .4767292E+01      .7549678E-01
   ERR       6      .3788738E+03      .6314563E+02

 TRT      TRT MEANS             SE
   1      .1397500E+02      .3973211E+01
   2      .1610000E+02      .3973211E+01
   3      .1637500E+02      .3973211E+01
   4      .1507500E+02      .3973211E+01

 EXP MEAN     .15381250E+02   C.V.     .51663045E-00



ANALYSIS OF VARIANCE, VARIABLE  2

 SOURCE    DF           SS                MS                F
   TOT      15      .3601775E+03
   ROW       3      .2729275E+03
   COL       3      .1080250E+02
   TRT       3      .2122250E+02      .7074167E+01      .7685831E+00
```

ERR	6	.5522500E+02	.9204167E+01

TRT	TRT MEANS	SE
1	.2425000E+02	.1516918E+01
2	.2727500E+02	.1516918E+01
3	.2485000E+02	.1516918E+01
4	.2497500E+02	.1516918E+01

EXP MEAN .25337500E+02 C.V. .11973702E-00

RESIDUAL CORRELATION MATRIX

1	.1000000E+01	-.9059351E+00
2	.1000000E+01	

INVERSE MATRIX, ERROR LINE

1	.2639402E-02

COEFFICIENTS

1 2 -.3458738E+00

ADJUSTED ANALYSIS, VAR 2

SOURCE	DF	MS	ADJ F
TRT	3	.9800630E+01	.4949395E+01
REG	1	.4532416E+02	.2288906E+02
ERR	5	.1980167E+01	

COEF OF DET .8207182E+00 C.V. .5553761E-01

ADJUSTED MEANS

1	.2376362E+02
2	.2752360E+02
3	.2519371E+02
4	.2486908E+02

Appendix E

Modified Factorial Program

This is a modification of the factorial program. By alternating tape drives in subroutine GAOV the program will run faster. This modification restricts the problem to analysis of variance only. If more than four tape drives are available similar modifications could be made to the original program without eliminating the covariance analysis capabilities.

```
C      PROGRAM FACOV                                                    GF000010
C      THIS IS THE PRIMARY INPUT SECTION                                GF000020
       DIMENSION CONST(25),FMT(20),X(26),NIN(8),DES(3),IX(75),A(50,50)  GF000030
       COMMONA,NV,MC,IX,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,ISPD,SPD,CONSTGF000040
      1 ,DES,KON                                                        GF000050
       EQUIVALENCE (A(20),X(1)),(IX(1),NIN(1))                          GF000060
       REWIND 1                                                         GF000070
       REWIND 02                                                        GF000080
       REWIND 3                                                         GF000090
       READ  (5,100)NV,KON,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,MC,SPD,ISPDGF000100
      1,IFR,IO                                                          GF000110
       WRITE (6,300)NV,KON,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,MC,SPD,ISPDGF000120
      1,IFR,IO                                                          GF000130
  300 FORMAT (1H110I3,I5,3I4,F5.0,3I2)                                  GF000140
  100 FORMAT (   10I3,I5,3I4,F5.0,3I2)                                  GF000150
       IN=5-IO                                                          GF000160
       READ  (5,101) (FMT(K),K=1,20)                                    GF000170
  101 FORMAT(20A4)                                                      GF000180
       WRITE (6,111) (FMT(K),K=1,20)                                    GF000190
  111 FORMAT(1H ,20A4)                                                  GF000200
       X(NV+1)=0.0                                                      GF000210
       INC=NV+IFR                                                       GF000220
       READ (5,102) (CONST(I),I=1,NV)                                   GF000230
  302 FORMAT (1H 5E15.7)                                                GF000240
  102 FORMAT    ( 5E15.7)                                               GF000250
       WRITE (6,302) (CONST(I),I=1,NV)                                  GF000260
       KK=NV+1                                                          GF000270
       IF (IO) 52,52,51                                                 GF000280
   51  REWIND 4                                                         GF000290
   52  DO 10 J=1,NOBS                                                  GF000300
       READ (IN,FMT) (X(I),I=1,INC)                                     GF000310
       IF (X(KK)-9999.0)5,10,5                                          GF000320
    5  DO 6 I=1,NV                                                      GF000330
    6  X(I)=X(I)-CONST(I)                                               GF000340
   10  WRITE (2) (X(IL),IL=1,NV)                                        GF000350
```

```
      IF (IO)2,2,1                                                          GF000360
    1 REWIND 4                                                              GF000370
      PAUSE                                                                 GF000380
    2 DO 15 LN=1,LI                                                         GF000390
      READ  (5,1001) (NIN(I),I=1,8),ILINE,IP,PD,IPD                         GF000400
   15 WRITE (02)     (NIN(I),I=1,8),ILINE,IP,PD,IPD                         GF000410
 1001 FORMAT(9X,8I1,I3,I2,F5.0,I2)                                          GF000420
      IF (LC)18,18,13                                                       GF000430
   13 DO 14 LN=1,LC                                                         GF000440
      READ  (5,1003) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)             GF000450
   14 WRITE (02) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)                 GF000460
 1003 FORMAT(3A4,17I4,/(20X,15I4))                                          GF000470
   18 REWIND 02                                                             GF000480
      CALL GAOV                                                             GF000490
      STOP                                                                  GF000500
      END                                                                   GF000510
```

```
      SUBROUTINE GAOV                                                    GF000520
C     THIS IS THE FACTORIAL ANALYSIS OF VARIANCE PORTION                 GF000530
      DIMENSIONA(50,50),TOT(2500),NDF(128),SS(128),NL(8),NX(8),NOUT(8)   GF000540
     1 ,NIN(8),IX(75),DES(3),CONST(25)                                   GF000550
      COMMONA,NV,MC,IX,NA,NB,NC,ND,NE,NF,NG,NH,NOBS,LI,LC,ISPD,SPD,CONSTGF000560
     1 ,DES KON                                                          GF000570
      EQUIVALENCE (A(1),TOT(1)),(IX(1),NIN(1)),(IX(9),NOUT(1))           GF000580
  650 DO 17 IXX=1,NV                                                     GF000590
      WRITE (6,413)IXX                                                   GF000600
  413 FORMAT (9H1VARIABLE ,I3)                                           GF000610
      WRITE (6,333)                                                      GF000620
  333 FORMAT(//2X6HBINARY,3X4HLINE,9X11HTREAT IDENT,                     GF000630
     1  7X6HNO OBS,3X7HAVERAGE/)                                        GF000640
      SS(1)=0.0                                                          GF000650
      SUM=0.0                                                            GF000660
      OBS=NOBS                                                           GF000670
      NL(1)=NA                                                           GF000680
      NL(2)=NB                                                           GF000690
      NL(3)=NC                                                           GF000700
      NL(4)=ND                                                           GF000710
      NL(5)=NE                                                           GF000720
      NL(6)=NF                                                           GF000730
      NL(7)=NG                                                           GF000740
      NL(8)=NH                                                           GF000750
C     READ DATA                                                          GF000760
C     COMPUTE GRAND TOTAL AND TOTAL SUM OF SQUARES                       GF000770
      DO 40 L=1,NOBS                                                     GF000780
      READ (2) (TOT(J),J=1,NV)                                           GF000790
      Y=TOT(IXX)                                                         GF000800
      SS(1)=SS(1)+Y*Y                                                    GF000810
      SUM=SUM+Y                                                          GF000820
      WRITE (3) Y                                                        GF000830
   40 WRITE (01)Y                                                        GF000840
      REWIND 1                                                           GF000850
      REWIND 3                                                           GF000860
```

```
   41 IF(ISPD)20,21,20                                                    GF000870
   20 NDF(1)=SPD                                                          GF000880
      GO TO 22                                                            GF000890
   21 NDF(1)=NOBS                                                         GF000900
C     COMPUTE AND WRITE THE CORRECTION TERM                               GF000910
      IW=0                                                                GF000920
   22 IF(ISPD)23,24,23                                                    GF000930
   23 SS(2)=SUM*SUM/SPD                                                   GF000940
      DIV=SPD                                                             GF000950
      GO TO 25                                                            GF000960
   24 SS(2)=SUM*SUM/OBS                                                   GF000970
      DIV=OBS                                                             GF000980
   25 NDF(2)=1                                                            GF000990
      LEN=2                                                               GF001000
      AV=SUM/DIV+CONST(IXX)                                               GF001010
      WRITE (6,102) IW,IW,IW,IW,Iw,wI,IW,IW,LEN,IW,IW,IW,IW,IW,IW,IW,IW,GF001020
     1DIV,AV                                                              GF001030
C     REPEAT DOWN TO 5 FOR EACH RAW SS WANTED                             GF001040
      K1=1                                                                GF001050
      K2=3                                                                GF001060
      DO 5 LN=1,LI                                                        GF001070
C     COMPUTE OPERATIONAL CONSTANTS                                       GF001080
      READ (2)   (NIN(I),I=1,8),ILINE,IP,RPD,IRPD                        GF001090
      LEN=1                                                               GF001100
      DO 50 I=1,8                                                         GF001110
      IF(NIN(I)) 52,51,52                                                 GF001120
   51 NX(I)=0                                                             GF001130
      NOUT(I)=1                                                           GF001140
      GO TO 50                                                            GF001150
   52 K=I+1                                                               GF001160
      NOUT(I)=NL(I)                                                       GF001170
      NZ=1                                                                GF001180
   55 IF (K-8)56,56,58                                                    GF001190
   56 IF (NIN(K))54,57,54                                                 GF001200
   54 NZ=NZ*NL(K)                                                         GF001210
```

```
   57 K=K+1                                                                GF001220
      GO TO 55                                                             GF001230
   58 NX(I)=NZ                                                             GF001240
      LEN=LEN*NL(I)                                                        GF001250
   50 CONTINUE                                                             GF001260
C     ZERO THE TOTALS REQUIRED FOR THIS SET                                GF001270
      DO 6 I=1,LEN                                                         GF001280
    6 TOT(I)=0.0                                                           GF001290
C     ACCUMLATE A SET OF TOTALS                                            GF001300
C     OPERATE ON ALL OBSERVATIONS                                          GF001310
      DO 7 I=1,NA                                                          GF001320
      DO 7 J=1,NB                                                          GF001330
      DO 7 K=1,NC                                                          GF001340
      DO 7 L=1,ND                                                          GF001350
      DO 7 M=1,NE                                                          GF001360
      DO 7 N=1,NF                                                          GF001370
      DO 7 IZA=1,NG                                                        GF001380
      DO 7 IZB=1,NH                                                        GF001390
      READ (K1) Y                                                          GF001400
C     FIND IDENTIFICATION OF TOTAL                                         GF001410
      IA=(I-1)*NX(1)+(J-1)*NX(2)+(K-1)*NX(3)+(L-1)*NX(4)+(M-1)*NX(5)+1     GF001420
      IA=IA+(N-1)*NX(6)+(IZA-1)*NX(7)+(IZB-1)*NX(8)                        GF001430
C     INCREMENT THE SPECIFIED TOTAL                                        GF001440
    7 TOT(IA)=TOT(IA)+Y                                                    GF001450
      REWIND K1                                                            GF001460
      IDD=K1                                                               GF001470
      K1=K2                                                                GF001480
      K2=IDD                                                               GF001490
      SS(ILINE)=0.0                                                        GF001500
      NDF(ILINE)=LEN                                                       GF001510
      IF(IRPD)26,27,26                                                     GF001520
   26 DIV=RPD                                                              GF001530
      GO TO 28                                                             GF001540
   27 DIV=NOBS/LEN                                                         GF001550
C     EACH OF THE FOLLOWING SHOULD BE EITHER ONE OR THE NUMBER OF LEVELS   GF001560
```

```
   28 NAA=NOUT(1)                                                        GF001570
      NBB=NOUT(2)                                                        GF001580
      NCC=NOUT(3)                                                        GF001590
      NDD=NOUT(4)                                                        GF001600
      NEE=NOUT(5)                                                        GF001610
      NFF=NOUT(6)                                                        GF001620
      NGG=NOUT(7)                                                        GF001630
      NHH=NOUT(8)                                                        GF001640
      LL=1                                                               GF001650
      DO 8 I=1,NAA                                                       GF001660
      II=I*NIN(1)                                                        GF001670
      DO 8 J=1,NBB                                                       GF001680
      IJ=J*NIN(2)                                                        GF001690
      DO 8 K=1,NCC                                                       GF001700
      IK=K*NIN(3)                                                        GF001710
      DO 8 L=1,NDD                                                       GF001720
      IL=L*NIN(4)                                                        GF001730
      DO 8 M=1,NEE                                                       GF001740
      IM=M*NIN(5)                                                        GF001750
      DO 8 N=1,NFF                                                       GF001760
      IN=N*NIN(6)                                                        GF001770
      DO 8 IZA=1,NGG                                                     GF001780
      IIZA=IZA*NIN(7)                                                    GF001790
      DO 8 IZB=1,NHH                                                     GF001800
      IIZB=IZB*NIN(8)                                                    GF001810
      IF(IP) 9,18,9                                                      GF001820
C     WRITE MEANS IF REQUESTED                                           GF001830
    9 AVE=TOT(LL)/DIV+CONST(IXX)                                         GF001840
      WRITE (6,102) (NIN(IIM),IIM=1,8),ILINE,II,IJ,IK,IL,IM,IN,IIZA,IIZBGF001850
     1,DIV,AVE                                                           GF001860
  102 FORMAT(1H 8I1,2I5,7I3,F6.0,2X,E14.7)                               GF001870
   18 SS(ILINE)=SS(ILINE)+TOT(LL)*TOT(LL)                                GF001880
    8 LL=LL+1                                                            GF001890
    5 SS(ILINE)=SS(ILINE)/DIV                                            GF001900
      REWIND K1                                                          GF001910
```

```
      IF (LC) 10,17,10                                                    GF001920
C     FORM CORRECTED SUMS OF SQUARES                                      GF001930
   10 WRITE  (6,1103)                                                     GF001940
 1103 FORMAT(/ 13X21HLINEAR FUNCTION CARDS/)                              GF001950
      DO 15 I=1,LC                                                        GF001960
      NDOF=0                                                              GF001970
      SQS=0.0                                                             GF001980
      READ  (02) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)               GF001990
      WRITE (6,1004) (DES(IYY),IYY=1,3),LCN,LZZ,(IX(K),K=1,LZZ)           GF002000
 1004 FORMAT(1H ,3A4,17I4,/(21X,15I4))                                    GF002010
      DO 14 K=1,LZZ                                                       GF002020
      IF(IX(K)) 11,12,13                                                  GF002030
   11 IZ=-IX(K)                                                           GF002040
      SQS=SQS-SS(IZ)                                                      GF002050
      NDOF=NDOF-NDF(IZ)                                                   GF002060
      GO TO 14                                                            GF002070
   13 IZ=IX(K)                                                            GF002080
      SQS=SQS+SS(IZ)                                                      GF002090
      NDOF=NDOF+NDF(IZ)                                                   GF002100
   14 CONTINUE                                                            GF002110
   12 DOF=NDOF                                                            GF002120
      AMS=SQS/DOF                                                         GF002130
      SS(LCN)=SQS                                                         GF002140
      NDF(LCN)=NDOF                                                       GF002150
   15 WRITE (K2) (DES(IYY),IYY=1,3),LCN,NDOF,SQS,AMS                      GF002160
      REWIND 2                                                            GF002170
      REWIND K2                                                           GF002180
      WRITE (6,84) IXX                                                    GF002190
   84 FORMAT (36H1      ANALYSIS OF VARIANCE, VARIABLE,I3//               GF002200
     17H SOURCE, 9X2HDF,8X2HSS,14X2HMS )                                  GF002210
      DO 30 I=1,LC                                                        GF002220
      READ  (K2) (DES(IYY),IYY=1,3),LCN,NDOF,SQS,AMS                      GF002230
   30 WRITE  (6,103) (DES(IYY),IYY=1,3), NDOF,SQS,AMS                     GF002240
  103 FORMAT(1H 3A4,I5,2X,E14.7,2X,E14.7)                                 GF002250
      REWIND K2                                                           GF002260
```

```
 17 CONTINUE                                                    GF002270
202 STOP                                                        GF002280
    END                                                         GF002290
```

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