

USE OF PROGRAMMABLE CALCULATORS FOR
ANALYSIS OF STATISTICAL DATA

By

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ABSTRACT

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From the alternative computational processes available, researchers in the United States predominantly use computerized programs to analyze experimental design data. However, in developing nations, such computations are usually either done by hand or at centrally located computer centers. Under such conditions, programmable calculators offer a highly flexible alternative.

A set of 18 programs was developed for a programmable calculator, the Texas Instruments TI-59, to allow users to analyze different classical experimental designs. The programs that already exist for such analyses were revised and implemented in order to make them conformable with the machine procedures suggested in this work.

To my parents

VITA

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CHAPTER I

INTRODUCTION

Students, teachers, and researchers who must analyze data have to consider alternative computational procedures. These procedures include computer programs, turning the analysis over to someone else at a central computer location, sending the data to a larger distant center to be processed, or performing the analysis by hand.

The use of large statistical computer packages for statistical analyses is not widespread in Brazil. Most researchers still do not have access to computers, although usage is increasing rapidly.

Statistical analysis is an activity that one cannot afford to turn over to other people. This phase of the research process, depending on the amount of data and complexity, can be done on programmable calculators. By doing so, the researcher avoids errors that may occur when other people handle the data, achieving a higher degree of reliability.

Programmable calculators are equipped with a large number of programs covering a wide range of applications, including different statistical analyses. However, for specific types of analysis, such as analysis of variance

for different types of experimental designs, only a few restricted programs exist. The objective of this study is to provide a set of programs that will allow the user to analyze classic experimental designs using a portable, easy-to-handle, and relatively inexpensive electronic programmable calculator.

For thousands of years only a few relatively primitive machines were available to count, measure, and perform simple mathematics. From the oriental abacus of the 6th century, B.C., up to the invention of the first actual machine by the French scientist-philosopher, Blaise Pascal, in the 17th century, few advances or improvements were made. In 1671, Gottfried Leibniz invented a more advanced machine which could add, multiply, divide and extract square roots. Charles Babbage, during the 1800's, unsuccessfully tried to improve calculating machines by using punched-card automation systems as a way to store data and operations to be performed. The beginning of the 20th century was marked by the appearance of both the first electric card reader for data processing and the electromechanical calculator (1925). In 1963, the prototype of the electronic calculator was presented for the first time in Boston (Sippl, 1978).

The reduction in size of the central processing unit (C.P.U), the principal component of all computers, made electronic calculators accessible to the general public. Electronic calculators have advanced to the stage where current programmable calculators perform many of the

functions once restricted to computers. Properly programmed, they readily solve problems where they happen, when they happen. In addition, such calculators are simpler to operate, less expensive to acquire and maintain, are directly accessible, and do not require special programming languages.

Programmable calculators help users to cope with large amounts of data with increased speed and accuracy, eliminating long and tedious manual calculations. They can easily replace computers for a wide range of repetitive and complex calculations. Considering the cost, the ease of use, and the operational advantages, programmable calculators can be viewed as a favorable alternative method for handling statistical analyses, especially the analysis of variance.

For developing countries, where funds for equipment constitutes a major problem, statistical analysis is infeasible or impractical by computers. The analytical programs developed in this study will provide an alternative way to quickly and accurately perform statistical analyses on classical experimental designs.

CHAPTER II

LITERATURE REVIEW

This review is primarily concerned with the use of programmable calculators for statistical analyses, with special emphasis on the analysis of different experimental designs. In conducting this review, it was found that a limited amount of literature exists in this specific field. The relatively short time that these calculators have been on the market, and the fact that their application to statistical analyses still does not constitute an acceptable topic for publication in statistical journals, may explain why more literature is not available.

Sipl (1978), in an excellent book, has summarized much of the recent information on programmable calculators.

References for specific applied fields are already available. Smith (1975) and Aronofsky et al. (1975), respectively, presented techniques for numerical methods and business applications. Little and Hills (1978), and Sokal and Rohlf (1969), in their statistical methods books, provide instructions for the use of pre-programmed calculators to simplify calculations in statistical analysis. Papers related to programmable calculators can be found in

professional journals dealing with specific areas, but much of the available material has been issued by calculator manufacturers.

Applications of Programmable Calculators

The programmable calculator, as an intermediate-level computational device, has been used in different scientific fields. Killingback (1976, 1977) reviewed the use of pocket electronic calculators in simple scientific calculations, with emphasis on methods of computations feasible even with the simple four-function calculator. The latter paper discusses the uses of more advanced models, describing the functions available and giving some simple examples which the reader can apply to his own machine. Much of Killingbacks' work is devoted to the use of programmable calculators in physics. Noble (1964) and Scraton (1965) introduced some numerical methods solution, such as Lagrange interpolation and Runge-Kutta solution, using electronic calculators.

Sullivan (1976) explored the use of calculators as a teaching instrument. He conducted classroom trials of hand-held calculators with two sixth-grade classes to investigate how (and if) calculators could enrich, supplement, support and motivate daily mathematics lessons. Schnur (1976) and Mastbaum (1969) used programmable calculators in teaching mathematics for high school students.

Basic applications of programmable calculators for

business and financial analyses are discussed by Smith (1976) and Aronofsky et al. (1978).

Randall (1976) discussed the pocket calculators' place in statistical analyses and statistical education. He highlights some of the problems that might occur when statistical analyses are performed with statistical packages on large computer systems, and recommends programmable calculators as an alternative analytical procedure. He also mentions that a research worker having data to analyze could find that turn-around time on the computer (including time for consultation on the package employed, punching and verifying) is such that analysis could profitably have been done by using a calculator.

General Characteristics of Electronic Calculators

The selection of a calculator is closely related to its characteristics. Murphy and Chalmers (1973) discussed calculator characteristics, operational conditions, price, purpose, service and reliability. They also analyzed hardware and programming features. In their opinion, one necessary feature of a programmable calculator is the capacity to record programs. They point out that entering a long program via keyboard each time it is required is tedious, time-consuming and subject to errors. As a minimum requirement for its use in simple statistical calculations, they stated that a calculator should be able to accumulate simultaneously the sum and the sum of squares

for one variable. For advanced and repetitive calculations, a programmable calculator is required. They advise a minimum of six memories and fifty program steps for general statistical work.

A general and complete classification system for calculators is given by Sippl (1978). He classifies calculators by class (hand-held, desk-top, and computing), types (four-six function, preprogrammed, and programmable), memory types (intermediate, addressable, and automatic input-output storage), logic types (arithmetic, algebraic, and reverse polish notation), software and peripherals. Mins (1976) classifies programmable calculators, according to their programmability, as elementary, intermediate or full. Free (1976), Gilbert (1976), and Mins (1976) discuss and analyze the most recent models of programmable calculators on the market.

One cause of controversy among different authors is the notation system used by different brands of calculators. Ball (1975) after an evaluation of different algorithms, concluded that reverse polish notation (RPN) was better than algebraic notation, but stated that his choice was a subjective decision. Mins (1976) on the other hand considered algebraic entry the simpler of the two, only because it follows the familiar method in which the problem is written. Both authors agree that the reverse polish notation requires fewer keystrokes, which is an important advantage when writing long programs. Mins (1976) also

points out that reverse polish notation requires a longer learning period.

Mins (1976) stated that the only practical device to follow when considering buying a programmable calculator is to speak to people who own programmable calculators to get their personal reactions. Sippl (1978) presents a list of 14 functions that calculators should have, to give the programmer enough flexibility to perform more complicated calculations. The calculator's intended use is considered to be one of the most important decision factors when selecting a particular type of calculator.

Available Software

Software is used to both read in and read out data and program instructions from or to the memory of a computer or calculator. The software in programmable calculators usually consists of a magnetic tape strip, a magnetic card strip, or a tape cassette. Practically all programmable calculators now have a software commitment for pre-prepared, prepackaged program libraries in both general and specific areas.

Calculator producers also maintain user libraries as a customer service. These libraries provide users with additional material through program exchange clubs. Catalogs of the programs available are provided and constitute the main source of information of new developments.

Programs for a wide range of applications can be

found in the calculators' and users' libraries. Statistics, mathematics, engineering, business, medicine, physics, surveying, navigation aviation, natural sciences, biology, and leisure programs are available.

Within the statistical field, programs are available for basic statistics, histograms, random number generator, normal and inverse normal distributions, F distribution, multiple linear regression, moving averages, curve fits and combinations, permutations and factorials.

Within professional fields few statistically related programs are available. Blaedel and Iverson (1976) developed a program for calculating the confidence limits for least squares straight line. Guenther (1977a) discussed the use of programmable calculators to compute distribution functions and concluded that generally calculators provide more information than voluminous tables. The same author (1977b) demonstrated that a programmable calculator can be used to quickly and accurately calculate probabilities for the distribution of the sample correlation coefficient.

Available Statistical Programs

A limited number of programs for analyzing experimental design data by analysis of variance are available. Software for both the Texas Instruments TI-59 and the Hewlett Packard HP 97/67, the most sophisticated calculators on the market, contain programs for one-way analysis

of variance, moments, skewness, kurtosis, and for paired or unpaired t-tests.

For both calculators, the one-way analysis of variance program accepts any number of treatments and replications and generates a complete analysis of variance table. The program for two-way analysis of variance in both calculators requires the data to be entered twice, once by rows and once by columns. For the TI-59, the number of columns plus the number of rows cannot exceed 15 because the data are entered in a separate program. For the HP 97/67, there are no restrictions. The complete analysis of variance table is generated by both programs. The HP 97/67 also has a program generating the complete analysis of covariance table for completely randomized designs. No limitations on the number of treatments or replications are imposed.

In the TI-59 users' library, several programs are available for different analyses of variance. Molina (1977) developed a program for randomized complete block designs, for any number of treatments or replications. One drawback of the program is that the data must be entered twice, by both rows and columns. The same kind of analysis, called a two-way analysis of variance, is provided by Hayashi (1977). Ziegelmler (1977) programmed a two-way analysis of variance (without replication), following the procedure given by Sokal and Rohlf (1969). This program also performs an analysis of variance for

randomized complete block designs. Any number of treatments and replications can be used. The program generates an estimate for a single missing observation, automatically updates the appropriate sums, degrees of freedom, and adjusts the sum of squares.

Cox (1977) developed a program for the TI-59 to perform an analysis of variance for two treatment factors arranged factorially in a completely randomized design. The data are entered only once, and there are no limitations on the number of treatment combinations and replications. This program can also be used for the analysis of variance for randomized complete block designs, but some manipulation of results is necessary to get the correct answers.

Programs to handle latin square designs, factorial designs, and split-plot designs are also available in the users' library. Barker (1978a, 1978b, 1978c, 1978d) programmed analyses of variance for latin square designs with up to 10 treatments, as well as for two types of split-plot designs, and a three factor factorial. For the first split-plot analysis any number of main-plot factors, and a maximum of 10 sub-plot factors, and up to 9 replications may be used. The second analysis involves split-plot designs where time is the split-plot factor. The maximum number of levels for the main-plot factor is five, with any number of levels for the sub-plot factor, and up to five replications. The three factor factorial program

allows any number of levels for the first factor and up to 4 levels for the others. A maximum of eight replications can be used and the data is entered only once.

Programs to calculate basic statistics along with analysis of variance are also available in the users' library. Patterson (1978a) developed a program to calculate mean, standard deviation, coefficient of variation, standard error, coefficients of skewness and kurtosis, as well as standard errors for treatment means in one-way analysis of variance. The same author (1978b) developed another program that allows the user to compute a complete one-way analysis of variance using the sample size, mean, and standard deviation of each treatment. Lathan (1978) developed a program to calculate arithmetic, geometric and harmonic means, the second, third and fourth moments, and the coefficients of skewness and kurtosis for grouped and ungrouped data.

CHAPTER III

DESCRIPTION OF THE STUDY

Capabilities and components of several calculators were compared, and from the models currently available a programmable calculator was selected.

Having defined the type of calculator that would be used, all characteristics of the calculator were studied to determine the strategy that should be applied to fulfill the study's objectives as well as to define the limitations which the calculator would impose on the proposed study. The software already available for the calculator was studied and programming techniques and general program structure determined.

Finally, the types of statistical analyses that could be programmed were selected, programmed and tested.

Calculator Selection

According to the classification given by Sippl (1978), the type of calculator to be used in this study should be hand-held, advanced-programmable with indirect storage, algebraic or reverse polish notation, with simple formula software, and with an optional printer.

Bearing in mind the objectives of the study, the

calculator chosen should be portable, easy to handle, and capable of working in conditions where electrical power is not available. An essential requirement is that it be programmable, i.e., that it be able to accept a set of instructions in specific order to be executed at one's will.

Once a programmable type of calculator was decided on, the next decision concerned the number and type of data registers. One of the most common sources of errors in statistical analyses is data manipulation. The data storage capability should keep this manipulation to a minimum. The calculator should be able to store and retrieve a reasonable amount of data by either direct or indirect access, the latter being preferred. This feature would greatly simplify some of the programming techniques.

The type of notation used by the calculator was of little concern; notation is a matter of personal preference although it implies some differences in programming. Algebraic notation keys in a problem just as it would be stated, as opposed to RPN. For example, in algebraic notation we say "two times four equals eight," while with reverse polish notation, we would say "two and four multiplied." This is an oversimplification, but hopefully it points out the fundamental difference. I have worked with both types of notation, and I believe that either system can be easily operated with experience.

It was also desirable that software be available for the calculator. Software here is defined as programs

currently sold with the calculators. The availability of software implies stronger reliability, and at the same time indicates the sophistication of the calculator as well as its degree of complexity and capability. By analyzing the available software, I was able to precisely define my programming strategies and program structure.

An optional printer unit would be useful, since it facilitates programming and editing. It represents an additional cost, but its editing and program listing capabilities reduces the probabilities of errors, justifying its use.

The calculator should also be able to record programs and data by some device so that the user will not need to key in an entire program each time it is used. Otherwise most of the advantages of using a programmable calculator are lost.

Considering all aspects, two calculators qualified to be used in the study: the Texas Instruments TI-59 and the Hewlett Packard HP-97. The Texas Instruments TI-59 was chosen due to the following advantages and technical capabilities:

1. The cost of the TI-59 with its printer unit is half the price of the HP-97.
2. The data register (memory) capacity of the TI-59 is four times greater than that of the HP-97. Also all registers are directly accessible, unlike the HP-97.

3. The maximum number of program steps of the TI-59 is also four times greater than the maximum number of steps in the HP-97, allowing more flexibility in programming.
4. The TI-59 can be used as either a portable pocket calculator or as a desk top unit when the printer is attached. The HP-97 is too large to be easily portable.

All other technical aspects are quite similar in both calculators, except for notation. The TI-59 has algebraic notation and the HP-97 has reverse polish notation. The HP-97 requires fewer steps to store an instruction and also has a different programming method because of its notation. Either the HP-97 or its version without a printer, the HP-67, could have been used in this study if some of the programming techniques were changed. Based on previous experience with both calculators, I prefer the TI-59.

Characteristics of the Texas Instruments TI-59

The Texas Instruments TI-59 programmable calculator is a hand-held calculator which uses the algebraic operating system (A.O.S.). It has 120 general purpose memory registers allocated between data registers (memories) and program storage space (program steps). One data register is equivalent to eight program steps. The configuration varies from zero data memories and 960 program steps to a combination of 100 data registers and 160 program steps.

Through partitioning of registers (in increments of 10 registers), 11 configurations are possible (Figure 1). Partitioning/repartitioning can be done from the keyboard or under program control; once a partition has been established, boundaries cannot be crossed.

PROGRAM		STEPS	960
		880	10
		800	20
		720	30
		640	40
		560	50
		480	60
		400	70
		320	80
		240	90
160	100	MEMORIES	

Figure 1. Calculator configuration of program steps and memory registers

The TI-59 has several program packages, called Solid-State Software Modules, accessible by program number. These packages are run by subroutine name for execution through the keyboard or under user's program control (Figure 2). These modules are plugged into the back of the calculator and, being preprogrammed at the factory, cannot be altered by the user.

The TI-59 also has 10 programming flags whose function is to remember one of the two possible states. Flags are either set (true) or clear (false). These flags are

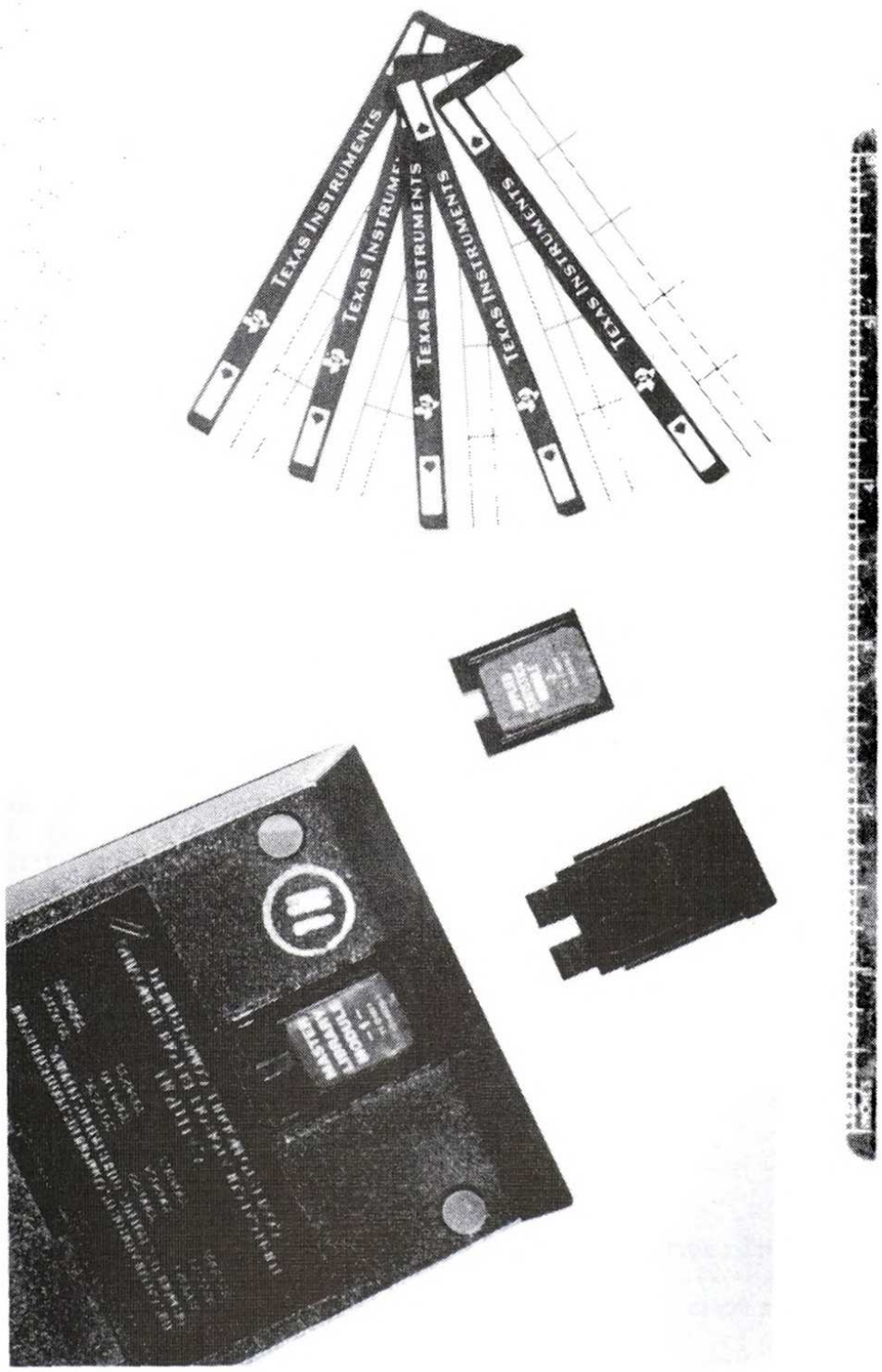


Figure 2. Magnetic cards and a Master Solid-State Software Library Module

useful when program branches are needed. Depending on the status of a flag the process will branch to a specific section of the program and execute that portion of instructions. Some flags have special features for determining error conditions and for controlling printer operation.

Among other characteristics, the calculator has a set of 40 special control functions. These functions control the printer; list programs, data registers and labels; calculate statistical functions for both populations and samples; control and announce partitioning; and control either increment or decrement of any of the first 10 data registers. These control operations can be executed either manually or under program control.

Other features include up to six levels of subroutine calls, subroutines that can be called from both keyboard and program, fixed and indirect addressing, and a RUN/STOP key to halt program execution.

The TI-59 also has the basic mathematical, scientific and statistical functions found on more advanced machines. These functions include:

- Absolute value, integer and fractional part
- Display control functions
Fixed point, scientific and engineering notation
- Reciprocal, square, square root, roots and powers
- Polar/rectangular co-ordinate conversion
- Statistics
Summations, means, standard deviations

- Trigonometric functions
Sin, cos, tan, arcsin, arccos, arctan, degrees/
radian conversion, degrees, rads, grads mode
- Logarithmic functions
Decimal, natural logarithms
- Linear regression and correlation coefficients
- Parenthesis and pending operations
- Memory operations
Addition, subtraction, multiplication, division,
store, recall, and exchange

One of the most powerful features of the calculator is its ability of being combined with the printer unit (Figure 3). This unit, when attached, prints letters, numbers, and special symbols. Through manipulation of the number of digits shown in the display, one can print out headings, prompting messages, and plot graphs. It is also able to list program steps, register contents, and to operate under trace mode. If the calculator is under the trace mode all operations, whether from keyboard or from program instructions, are printed. This mode is helpful for testing and debugging programs.

Programs can be recorded and saved for future use by means of magnetic cards (Figure 2), avoiding the necessity of having to key in the program each time it is used. Each magnetic card reads/writes two of four possible memory banks, regardless of partitioning. Each memory bank holds 30 data registers or 240 program steps, or an equivalent mixture. Data registers number from the last of bank four up through the last third of bank one (two-digit addressing

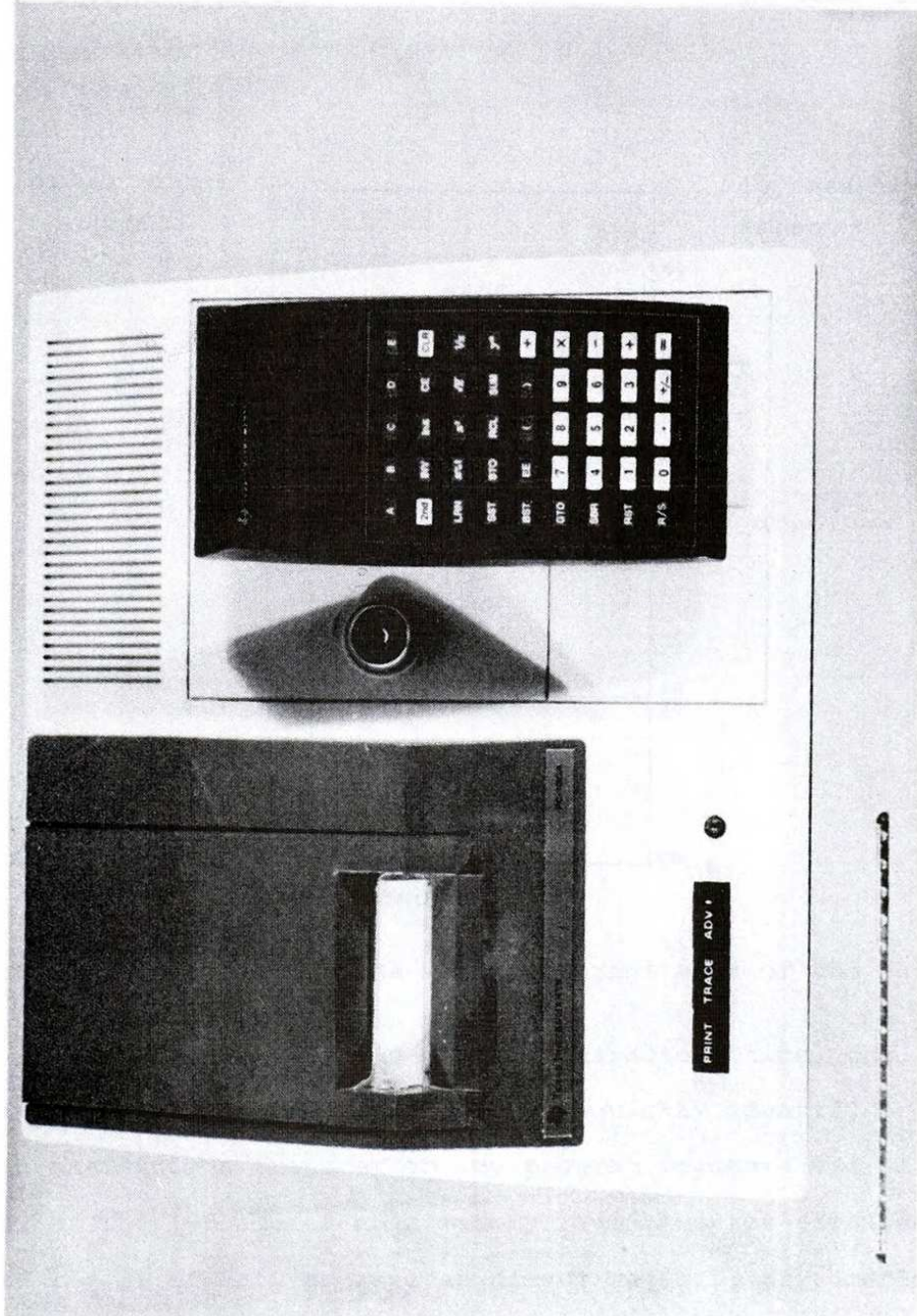


Figure 3. The Texas Instruments Programmable Calculator TI-59 with the Printer Unit PC-100A

does not reach past register 99); program steps start at the beginning of bank one, with step 959 ending bank four (Figure 4).

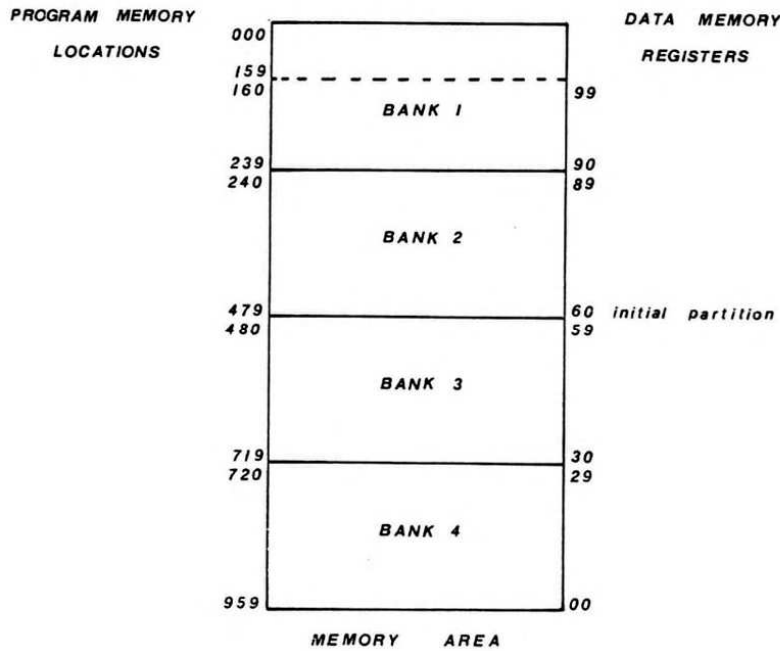


Figure 4. Diagram of the memory storage area of the TI-59

Regarding specific program characteristics, the TI-59 permits use of 72 labels that quickly identify or can assist in a transfer to any program segment; use of any of the 100 addressable memory registers for storage and recall of data as well as direct register arithmetic; use of 10 internal processing registers to hold operands for calculations in progress; use of 10 logical decision

functions to make decisions and branch to appropriate program segments automatically without interruptions; and tests of flags under program control.

The TI-59 can operate in three possible modes. In the calculate mode, the TI-59 is operated manually as a general purpose calculator. In the run mode, the calculator operates using pre-recorded programs or user-developed programs. Finally in the learn mode, instructions or program steps are keyed directly into program memory. Users also can go through programs step by step using the "step-through" function, which displays each program step for editing purposes.

The preceding discussion is in no way a substitute for the user manual provided by the producer. Functions and programming features are analyzed in depth in this manual whereas only relevant characteristics are presented here.

Statistical Analyses Selected

The analysis of variance of experimental designs can be divided in two groups, the classic analyses and the more advanced analyses.

The classic analyses of variance, which appear in most standard reference books, involve relatively simple computations. The more advanced types of analyses of variance are used infrequently, and usually require more complex computing techniques.

I decided to work with the classic analyses of variance because of their availability in the literature, and because these are the analyses that are used most frequently. Based on Snedecor and Cochran (1967), Steel and Torrie (1960), and Sokal and Rohlf (1969), I picked out the following analyses of variance for development. I believe these analyses cover the classic experimental designs most frequently used:

- One treatment factor in a completely randomized design
- One treatment factor in a randomized complete block design
- Latin square design
- Covariance analysis in a completely randomized design
- Covariance analysis in a randomized complete block design
- Two factor factorial in a completely randomized design
- Two factor factorial in a randomized complete block design
- Three factor factorial in a completely randomized design
- Three factor factorial in a randomized complete block design
- Two level nested design
- Three level nested design
- Split-plot in a completely randomized design
- Split-plot in a randomized complete block design

I also programmed auxiliary tests that should be

performed to ensure a proper use of the above designs, or for special cases. They are:

- Bartlett's test for homogeneity of variance
- t-test for unpaired observations
- t-test for paired observations
- Coefficients of skewness and kurtosis
- transformations

A test for nonadditivity, multiple range tests, analysis of split-plot with the treatments arranged factorially, and other designs had to be omitted due to calculator limitations. Regression analysis was also left out because there are several programs already available in the calculators' user library.

In projects using other experimental designs or having frequent missing observations, a computer is advisable to facilitate analysis and interpretation.

Programming Technique and Program Structure

Analysis of available software for both the TI-59 and HP-97 showed that data must be entered more than once for most of the experimental design analysis programs. Since this is a potential source of error, I developed a program to store either the partial or the entire data set on magnetic cards. It is then possible to store data according to a common procedure, regardless of the analysis to be used.

To accomplish this, I had to define the memory

partition of the calculator. Of the 11 configurations possible I chose a combination of 60 data registers and 480 program steps. By using the same initial partition for all programs, the same input program could be used for different analyses. This configuration is also the same partition that the calculator presents when turned on. Due to complexity of some analyses, this partition may change, but for most of the programs it is kept the same. Half of the 60 data registers or memories were assigned to data storage (data registers number 30 through 59) and the remaining (numbers 00 through 29) were used for storing partial and final results.

By the use of indirect addressing, each individual observation is stored in one of the 30 data registers. If the data set contains more than 30 observations, the calculator is programmed to print a message (RECORD DATA) or flash a number (3) telling the user to record the contents of the data registers before the remaining observations are entered. This process can be repeated several times as needed. Indirect addressing means that the location of the storage register is given by a number from another data register, (i.e., by a pointer). By incrementing this pointer each time one observation is stored, it is possible to store the next observation in the adjacent data register.

Once the data are recorded on magnetic cards the user can start the processing phase of the analysis. This phase begins after the data and program cards are loaded

into the calculator.

Programs have two main segments, calculation and results, which are identified by labels. Whenever possible, the same labels were used for similar segments of different programs, allowing the user to develop a common pattern for different programs. Calculation is defined as label A and results as label B. The remaining labels (C, D, E, A', B', C', D', and E') were used according to the necessities of each program.

In the calculation phase, again using indirect addressing, each observation is recalled from the data register in the same way as it was stored. This single value is processed (i.e., summed, multiplied, or squared) into the "workable" space of the data registers. This process is repeated for all observations. If the data set is recorded on more than one magnetic card, the program will ask for more data either by printing a message (DATA) or by flashing a number (3).

During data processing, the program is directed to different sets of calculation instructions through different types of branching functions. A logical sequence of operations was used to avoid duplication of instructions, helping to reduce the number of steps required for each calculation. Sums are performed first, followed by sums of squares, requiring only one recall of each register. The observations must be entered by replication due to this approach (see Appendix B).

In some programs, the data set must be read more than once because data summations are done across both rows and columns. This could have been avoided, but it would require an excessive number of program steps.

Since the data are already recorded on magnetic cards and the program itself controls the number of observations processed, this solution represents a fair alternative.

Special care had to be taken with the number of program steps used. As the complexity of analysis increases, the number of steps required becomes larger. The number of elements that have to be calculated to generate results for each program determines the length of a program. Whenever the program storage area does not have enough space to store all the program instructions, the calculation and the results segment instructions were recorded on different cards. As soon as calculations are completed, the program will ask for the second program card by printing the message "PROG. CARD (2)" or by displaying the number 2. The second program card contains the portion of the program that prints and display the results. At this point a new partition of the data registers may be necessary due to space requirements. Instead of using 60 data registers and 480 program steps, the partition changes to 30 data registers and 720 program steps. Data registers which are no longer needed are used as program steps, since the calculations involving the original

observations are done.

Whenever possible, the programs' structure were kept as similar as possible. For three programs a small departure from the overall pattern was necessary. To avoid imposing heavy restrictions for the use of the three factor factorial in completely randomized and randomized complete block designs, cell totals from the two-way tables are entered along with individual cell values. For latin square designs treatment totals must be entered, since there is no way of identifying each treatment position in each row and column, unless an extra index is used. The use of this extra index would require an excessive amount of data registers, and for this reason the treatment totals must be entered.

The overall structure of any analysis program is to first store the data set using the input program, and then to analyze the data using the desired program.

Programs were tested using examples given in Snedecor and Cochran (1967), Steel and Torrie (1960) and Sokal and Rohlf (1969). No textbook examples were available for split-plot and three factor factorial, both in a completely randomized designs, and so artificial data sets were generated and used.

CHAPTER IV

RESULTS

The objective of this study was to develop a set of programs to analyze classic experimental designs using the TI-59 programmable calculator. Characteristics common to all programs are described first, followed by a description of each program focusing on use, limitations, and capabilities. Examples of each program are presented in the Appendix.

Data Input Program

For all analyses, observations can be stored and recorded on magnetic cards using the same input program. This program can store either univariate or bivariate data. The program is loaded into the calculator by reading only one side of the program card. The card is inserted into the card slot in the right side of the calculator and the contents of that card are placed into the calculators' memory. Through initialization of the program all data registers are cleared and prepared to store observations. There is one initialization for each type of data. When this operation is completed, a zero will be displayed.

Number of treatments and of replications are then

entered. These values are used to calculate total number of observations in the data set. Both values are displayed as well as printed when the printer unit is attached. For factorial or nested designs, the number of treatment combinations or total of nesting combinations should be entered instead of number of treatments and of replications.

The only programs that can handle missing data are those for the completely randomized design, the randomized complete block design, and the latin square design. A code to identify each missing observation must be given; this code can be any number different from the values present in the data set. For each empty cell, the code replaces the missing value in the data set. Whenever the program finds a cell which has the code, it branches to another portion of instructions and an estimate is then generated according to the procedures given by Snedcor and Cochran (1967).

Each observation or pair of observations is then keyed into the calculator and stored, and displayed or printed after storage. If a wrong entry is made, it can be deleted at this time through a keyboard operation. The user just presses B or B', depending on the type of data being entered, and enters the corrected value. When the number of observations in the data set is greater than 30, the program will flash the number three or print "RECORD DATA." Before recording the data, it is possible to review all values entered by pressing D, and to replace

any erroneously entered observations. The position of the wrong number in the data array, plus 29, equals the data register number in which the wrong number is stored. One can then store the right value by using the keyboard procedure STO nn, where nn is the data register number.

After the data register contents are reviewed, they must be recorded on magnetic card for later use. The first recording operation must record memory banks number four and three. Memory bank number four contains the memory space where the partial and final results will be stored. At this stage it also contains the information necessary to begin processing (number of treatments, of replications and total observations). This is why it must be recorded only once, at the beginning of the recording process. Memory bank number three contains the entire data set if it has less than 30 observations, otherwise it will contain the first 30 observations. A re-initialization is necessary before the next 30 values are entered. During analysis, data cards should be loaded in the same order in which they were recorded.

All replications of the first treatment must be entered first, followed by replications of the second treatment, and so on (see input program in the Appendix). When treatments are arranged either factorially or in a nested structure, the factors should be arranged in a nested dendrogram, with the replications forming the columns. All replications for the

first treatment or nested combination are entered first, followed by those of the second treatment or nested combination, and so on. For instance, if we have a three factor factorial with two levels for each factor, the dendrogram should look like Figure 5.

A ₁				A ₂			
B ₁		B ₂		B ₁		B ₂	
C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂
R ₁₁	R ₂₁	R ₃₁	R ₄₁	R ₅₁	R ₆₁	R ₇₁	R ₈₁
R ₁₂	R ₂₂	R ₃₂	R ₄₂	R ₅₂	R ₆₂	R ₇₂	R ₈₂
R ₁₃	R ₂₃	R ₃₃	R ₄₃	R ₅₃	R ₆₃	R ₇₃	R ₈₃

Figure 5. Nested dendrogram for a three factor factorial with two levels for each factor.

The values for the treatment combination $A_1B_1C_1$ are entered first (R_{11} , R_{12} , and R_{13}) followed by the values for treatment combination $A_1B_1C_2$ (R_{21} , R_{22} , R_{23}), and so on. The factor having the highest number of levels must be placed at the top of the dendrogram in order to use the programs efficiently.

Processing

The processing phase is initiated after both sides of the program card and both sides of the first data card are loaded into the calculator's memory. If the number of observations is greater than 30, the program will flash the number three and print "DATA" when the printer unit is connected. The display must then be cleared and the

first side of the second data card read into the memory. Processing is then resumed. This procedure can be repeated as many times as necessary.

For some programs, the entire data set will have to be entered more than once because data summations are done across both rows and columns. The calculator will ask for data by displaying the number three or by printing "DATA" if the printer is connected.

When a program is being processed the display goes blank except for a faint "C" at the far left which indicates that calculations are taking place. Do not key in numbers or ask for results during this time.

Output

Three output procedures are possible. In the first procedure the user can either display the results or, if the printer unit is connected, have them printed with abbreviated descriptions. In the second procedure, only results are displayed; to have them printed another program card must be read. For these two procedures, the display will show the number zero after processing is completed. In the third procedure, the user must enter a second program card to obtain the results. The program will ask for the second program card either by printing "PROG. CARD (2)" or by displaying the number 2. The order in which the results are given are the same, regardless of the procedure used.

The need for different procedures arose from

limitations imposed by the initial partition chosen, and from the large number of steps required for certain complex programs.

Program for Bartlett's Test of
Homogeneity of Variances

One assumption necessary for the correct use of the analysis of variance is that treatments variances are homogeneous. This program performs Bartlett's test for homogeneity of variances. Any number of treatments and replications, equal or not, can be used. This program is intended to be used before any other type of analysis of variance is performed; it produces the corrected chi-square statistic.

Program for Skewness, Kurtosis,
and Data Transformation

Another basic assumption of the analysis of variance is that observations are normally distributed. This program calculates the four moments--mean, variance, third and fourth moments--and the coefficients of skewness and kurtosis.

Skewness is used to measure the lack of symmetry in a distribution, and kurtosis is the relative peakness or flatness of a distribution. Their coefficients indicate deviation from normality.

If either homogeneity of variances or normality of observations are absent, the data must be transformed to correctly use the analysis of variance. Five data

transformation procedures are available: square root; logarithmic; logarithm of $x+1$; reciprocal; and arc sine of square root. After all original observations are transformed, the program will display the number two or print "RECORD DATA." Once data are recorded the user will have a new set of transformed data cards. Moments and coefficients of skewness and kurtosis are printed or displayed for the transformed observations.

In the event that the data set is composed by values too large or too small to be comfortably handled, two types of coding are provided; one will add or subtract a determined value to each observation and the other will multiply or divide.

Program for One Treatment Factor in a
Completely Randomized Design

This program performs an analysis of variance for one treatment factor arranged in a completely randomized design. Any number of treatment levels and replications, equal or not, can be used. The program generates the complete analysis of variance table, giving the results in the following order:

- Treatment, residual, and total degrees of freedom
- Treatment, residual, and total sum of squares
- Treatment and residual mean squares
- F-ratio for treatments

Program for One Treatment Factor in a
Randomized Complete Block Design

This program performs an analysis of variance for one treatment factor arranged in a randomized complete block design. Any number of treatment levels and up to 15 replications can be used.

The program accepts one and only one missing observation. It will generate one estimated value for this empty cell using the procedure given by Snedecor and Cochran (1967), and use the estimated value to complete the analysis.

The program generates the complete analysis of variance table, giving the results in the following order:

- Treatment, block, error, and total degrees of freedom
- Treatment, block, error, and total sum of squares
- Treatment, block, and error mean squares
- F-ratio for treatments

If the data set contains one missing observation, the treatment mean square is adjusted automatically--by subtracting a correction factor--to avoid the natural bias that will occur when one estimate is used in place of a missing value. Degrees of freedom are also adjusted.

Program for Latin Square Design

This program performs an analysis of variance for one treatment factor arranged in a latin square design. Fifteen treatment levels may be used, even though this number will rarely be reached in a latin square design

due to practical problems.

Totals for each treatment must be entered first since there is no way to identify treatments without using an extra index. The use of this extra index would require an excessive amount of data registers; entering the treatment totals represents a fair alternative.

One and only one missing observation in the data set can be handled; the program will generate one estimated value for this empty cell and use it during calculations.

The program generates the complete analysis of variance table, giving the results in the following order:

- Row, column, treatment, residual, and total degrees of freedom
- Row, column, treatment, residual, and total sum of squares
- Row, column, treatment, and residual mean squares
- F-ratio for treatments

If the data set contains one missing observation, the treatment mean square is adjusted automatically--by subtracting a correction factor--to avoid the natural bias that will occur when one estimate is used in place of a missing value. Degrees of freedom are also adjusted.

Program for t-Test of Unpaired
Observations

This program will generate the t-value for comparing two treatment means of unpaired observations. A different number of replications per treatment may be used. The results will be the treatment means and the respective t-value.

Program for t-Test of Paired
Observations

This program will generate the t-value for comparing two treatment means of paired observations.

The results will be the treatment means and the respective t-value.

Program for Covariance Analysis in a
Completely Randomized Design

This program performs an analysis of covariance for one treatment factor and one covariate arranged in a completely randomized design. Any number of treatment levels and replications, equal or not, can be used.

The program generates the complete analysis of covariance table, with both unadjusted and adjusted values, giving the results in the following order:

- Treatment, residual, and treatment plus residual degrees of freedom
- Treatment, residual, and treatment plus residual sum of squares for Y, XY and X
- Residual, treatment plus residual, and treatment adjusted degrees of freedom
- Residual, treatment plus residual, and treatment adjusted sum of squares
- Residual and treatment adjusted mean squares
- F-ratio for adjusted treatments

Program for Covariance Analysis in a
Randomized Complete Block Design

This program performs an analysis of covariance for one treatment factor and one covariate arranged in a

randomized complete block design. Any number of treatment levels and up to six replications or blocks can be used.

The program generates the complete analysis of covariance table, with both unadjusted and adjusted values, giving the results in the following order:

- Block, treatment, residual, and residual plus treatment degrees of freedom
- Block, treatment, residual, and residual plus treatment sum of squares for Y, XY and X
- Residual, treatment plus residual, and treatment adjusted degrees of freedom
- Residual, treatment plus residual, and treatment adjusted sum of squares
- Residual and treatment adjusted mean squares
- F-ratio for adjusted treatments

Program for Two-Factor Factorial in a
Completely Randomized Design

This program performs an analysis of variance for two treatment factors arranged factorially in a completely randomized design. One treatment factor may have any number of levels, while the other has a limit of 15. The factor having the highest number of levels should be placed at the top of the hierarchical dendrogram when the observations are being entered.

The program generates the complete analysis of variance table. The treatment factors are represented by the letters A, for the first factor, and B, for the second factor, when results are printed. Results are given in the following order:

- Treatment, main effect A, main effect B, first-order interaction AB, residual, and total degrees of freedom
- Treatment, main effect A, main effect B, first-order interaction AB, residual, and total sum of squares
- Main effect A, main effect B, first-order interaction AB, and residual mean squares
- F-ratios for main effect A and B, and AB interaction

Program for Two-Factor Factorial in a
Randomized Complete Block Design

This program performs an analysis of variance for two treatment factors arranged factorially in a randomized complete block design. One treatment factor can have any number of levels while the other has a limit of 14 levels. The maximum number of replications or blocks is also 14.

The factor having the highest number of levels should be placed at the top of the hierarchical dendrogram when the observations are being entered. If there are more than 30 observations, the entire data set must be read twice. The program will automatically ask for the data set again when necessary.

The program generates the complete analysis of variance table. Treatment factors are represented by the letters A, for the first factor, and B, for the second factor, when the results are printed. Results are given in the following order:

- Block, main effect A, main effect B, first-order interaction AB, residual, and total degrees of freedom

- block, main effect A, main effect B, first-order interaction AB, residual, and total sum of squares
- Main effect A, main effect B, first-order interaction AB, and residual mean squares
- F-ratio for main effect A and B, and AB interaction

Program for Three Factor Factorial in a
Completely Randomized Design

This program performs an analysis of variance for three treatment factors arranged factorially in a completely randomized design. Any number of levels and replications for each treatment factor can be used.

The user must enter cell totals for the three possible two-way tables (AB, AC, and BC). Each table will be generated by adding, over all levels of the third factor and replications, each of the two factor combinations. Without these auxiliary values, the use of this program would be heavily restricted because of the extensive memory space required for storage.

To create the necessary main effect totals, the two-way tables must be entered in the following way: from the two-way table for factors A and B, enter all values of factor B for each level of factor A; from the two-way table for factors A and C, enter all values of factor A for each level of factor C; finally from the

two-way table for factors B and C, enter all values of factor C for each level of factor B (see Appendix Q).

Letter A represents the first factor, B the second, and C the third when a printed output is given. The program generates the complete analysis of variance table, giving the results in the following order:

- Main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, second-order interaction ABC, residual, and total degrees of freedom
- Main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first order interaction BC, second-order interaction ABC, residual, and total sum of squares
- Main effect A, main effect B, main effect C, first-order interaction AB, first-order Interaction AC, first-order interaction BC, second-order interaction ABC, and residual mean squares
- Main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, and second-order interaction ABC F-ratios

Program for Three-Factor Factorial in a
Randomized Complete Block Design

This program performs an analysis of variance for three treatment factors arranged factorially in a randomized complete block design. Any number of levels for each treatment factor can be used. The number of replications or blocks is limited to 15. Marginal totals for the three possible two-way tables must be generated and entered as in the program for three factor factorial in a completely

randomized design.

Treatment factors are represented by letters A, B, and C for the first, second, and third treatment factors, respectively, in the printed output.

The program generates the complete analysis of variance table, giving the results in the following order:

- Blocks, main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, second-order interaction ABC, residual, and total degrees of freedom
- Blocks, main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, second-order interaction ABC, residual, and total sum of squares
- Main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, second-order interaction ABC, and residual mean squares
- Main effect A, main effect B, main effect C, first-order interaction AB, first-order interaction AC, first-order interaction BC, and second-order interaction ABC F-ratios

Program for Two-Level Nested Design

This program performs an analysis of variance for three factors, (A, B, and C), where C is nested in B and B is nested in A. Any number of treatments (A), levels of subgroups within treatments (B), and replications (or determinations C) within subgroups can be used.

The program generates a complete analysis of variance table. In the printed output, treatments are represented by the letter A, subgroups by the letter B, and

replications by the short form of determination, DET.

The letter W stands for "within." Results are given in the following order:

- Treatment, subgroup within treatments, determination, and total degrees of freedom
- Treatment, subgroup within treatments, determination, and total sum of squares
- Treatment, subgroup within treatments, and determination mean squares
- Treatment and subgroup within treatment F-ratios

Program for Three-Level Nested Design

This program performs an analysis of variance for four treatment factors, (A, B, C, and D), where D is nested in C, C is nested in B, and B is nested in A. Any number of treatments (A), subgroups within treatments (B), sub-subgroups within subgroups (C), and replications (or determinations D) within sub-subgroups can be used.

The program generates the complete analysis of variance table. In the printed output, treatments are represented by the letter A, subgroups within treatments by the letter B, sub-subgroups within subgroups by the letter C, and replications by DET. The letter W stands for "within." Results are given in the following order:

- Treatment, subgroup within treatments, sub-subgroup within subgroup, determination, and total degrees of freedom
- Treatment, subgroup within treatments, sub-subgroups within subgroup, determination, and total sum of squares

- Treatment, subgroup within treatments, sub-subgroups within subgroup, and determination mean squares
- Treatment, subgroup within treatment, and sub-subgroup within subgroup F-ratios

Program for Split-Plot in a Completely
Randomized Design

This program performs an analysis of variance for two treatment factors, where the whole-plot factor is arranged in a completely randomized design and the sub-plot factor is a subdivision of the whole-plots. Any number of levels for the whole-plot factor, up to 15 levels for the sub-plot factor, and any number of replications can be used.

The entire data set will be read twice. Care should be taken when reading the data set the second time. Only memory bank number three, which contains the observations, should be read. On the first data card, side one contains memory bank number four, the so-called "workable" space. Since some calculations have already been done using this memory bank, by reading this side of the data card, these partial values will be lost.

The program generates the complete analysis of variance table. The whole-plot factor is identified by the letter A and the sub-plot factor by the letter B in the printed output. The order in which the results are given is:

- Whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, sub-plot error, and total degrees of freedom

- Whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, sub-plot error, and total sum of squares
- Whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, and sub-plot factor mean squares
- Whole-plot factor, sub-plot factor, and whole-plot/sub-plot interaction F-ratios

Program for Split-Plot in a Randomized
Complete Block Design

This program performs an analysis of variance for two treatment factors, where the whole-plot factor is arranged in a randomized complete block design and the sub-plot factor is a subdivision of the whole plots. Any number of levels for the whole-plot factor, up to 14 levels for the sub-plot factor, and 14 replications or blocks can be used. The entire data set will be read three times. It is first used to calculate treatment factors and interaction sum of squares; the second reading calculates blocks sum of squares; and the final reading calculates the whole-plot sum of squares.

The first side of the first data card is read only at the beginning of the program. The other readings must load only memory banks number three, in the same sequence the cards were recorded. The program will display the number 3 or print "DATA" each time a card must be read.

The program generates the complete analysis of variance table. In the printed output, the letter A represents the whole-plot factor and the letter B the sub-plot

factor. The order in which the results are given is:

- Block, whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, sub-plot error, and total degrees of freedom
- Block, whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, sub-plot error, and total sum of squares
- Whole-plot factor, whole-plot error, sub-plot factor, whole-plot/sub-plot interaction, and sub-plot error mean squares
- Whole-plot factor, sub-plot factor, and whole-plot/sub-plot interaction F-ratios

Error Recovery

Two types of error might occur during the processing of any program. Functional errors occur when the limits of the calculator have been exceeded, or when an invalid operation has been requested. When the limits of the calculator are exceeded due to results of program instructions, the calculator will flash the exceeded limit. This situation can be avoided by transforming the observations using the skewness, kurtosis, and data transformation program. Another kind of functional error can occur when the user requests a label that is not defined for that program, or when absence of some parameter leads to a division by zero.

The second type of error is the logical error. Logical errors are represented by strange results or malfunction of the program. For instance, once the requested data card has been entered, the program will ask for data again. This may happen because the proper procedure has not been followed. Strange or negative results may occur due to

incorrect data set storage. To avoid these types of errors, the user should do the following before using a program:

1. Clean the data registers and the display (2nd CMs and CLR)
2. Reset the calculator (RST key)
3. Clean the printing option (2nd OP 00)
4. Follow the instructions for using the program carefully

It is recommended that the examples given in the Appendices be worked before trying to analyze a new set of data. This will give the user an idea of how the programs work, and what to look for if the program is not working properly. Results will be presented with up to 11 significant digits even though the calculator internally works with 13 digits.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

A set of 18 programs is provided that allow the user to analyze classic experimental designs by using a programmable calculator. These calculators are relatively inexpensive, easy to use, portable, and their use eliminates long and tedious manual calculations. For developing countries, where funds for equipment constitute a major problem, these programs provide an alternative method of problem analysis.

Students, teachers, and researchers who must analyze experimental data will have to consider the alternative analytical procedures. These procedures include use of computer programs, if computers are available, use of a programmable calculator, or doing the analysis by hand. Time, amount of data, and complexity of the problem will be the variables to be considered in this decision.

People working in small towns or remote experimental stations may sometimes not have a computer available for analysis, and therefore may have to send their data to be analyzed by others. Usually, these people want to have some idea of the behavior of the data to make a decision.

Programmable calculators are an alternative solution, since they can solve problems when and where they happen.

Considering the capabilities of the programmable calculator that was used in this study (it can operate 9 x 9 matrices), it is easy to see how valuable these calculators will be in the future, and how important it is to know their current applications.

The programming techniques used in this study proved to be efficient for overall programs. However, it represents only one way of performing these types of analyses. The important point is that this study showed that relatively complex types of repetitive calculations can be done quickly and precisely. Other areas of statistical analysis should be considered for future programs to complement what has already been done.

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APPENDICES

APPENDIX A

GENERAL INSTRUCTIONS

GENERAL INSTRUCTIONS

Before using any of the programs presented, the following considerations should be kept in mind in order to have the programs running properly.

1. Turn the calculator off for a couple of seconds, and back on again before using a program. This procedure will avoid the possibility of having previous results interfering with your current program.

2. Have all cards numbered in advance, to avoid confusion at the recording phase. Always enter cards in the same order that they were recorded.

3. Try one of the examples given before running your own data set. This will help familiarize you with the program procedures.

4. Make sure that you have the right program instructions in the calculator's memory. Use the "STEP THROUGH" instruction to verify that recorded instructions correspond to instructions given for each program.

5. Make sure that the right memory partition for each program is being used.

6. Enter the observations by replication.

7. The keystroke sequence for recording on magnetic cards is simply n 2nd Write, where n represents the card side. Usually sides 1 and 2 are for program instructions and sides 3 and 4 for data. Side number 4 will be

used only once for each data set, at the beginning of the recording process.

8. A magnetic card can be read into the calculators' memory simply by clearing the display and inserting the magnetic card into the slot at the right side of the calculator. If zero flashes in the display after a card is read, the calculator has detected a misread and the card should be reentered.

9. Programs may run for several seconds. On the average each observation will be processed in $2\frac{1}{2}$ seconds.

10. In case of difficulty the user should refer to the Users' Manual for further details in any of the above instructions.

11. The abbreviations used throughout the programs and in the printed output are:

D.F. = degrees of freedom
S.S. = sum of squares
M.S. = Mean squares
Trt. = treatment
Blc. = block
Res. = residual
Tot. = total
Col. = column
T+R = treatment plus residual
W = within
MO = missing observation

Adj. = adjusted

Det. = determination

APPENDIX B

PROGRAM FOR DATA INPUT

PROGRAM DESCRIPTION

PROGRAM TITLE: Data Input

OBJECTIVES: This program stores original observations into the calculators' data registers, allowing the user to record the observations on magnetic cards for later use in any of the programs in this set. Either univariate or bivariate type of observations can be stored.

LIMITS FOR:

- a) **TREATMENTS** : -
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : -

DATA INPUT TYPE: univariate and bivariate

OUTPUT^(*): Number of treatments, of treatment combinations or nesting combinations
Each individual observation or pair of observations

() printed and displayed when **PRINTER UNIT** is used*

PROGRAM CARD DESCRIPTION

Data Input				
CODE	XY	Del XY		In. XY
X	Del X	Tr/Rep	Rev.	In. X

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card <u>FOR UNIVARIATE TYPE OF DATA</u>			1
2	Initialize		E	0
3	Enter # of treatments*	# of trt.	C	# of trt.
4	Enter # of replications	# of rep.	R/S	# of rep.
5	Enter code for missing value For $i = 1, \dots, n$	code	2nd A	code
6	Enter observation X_i	X_1	A	X_i
7	If you made a mistake in entering X_i		B	0
8a	If the number of observations is less than 30 go to step 9			
8b	If the number of observations is greater than 30 go to step 9	X_{31}	A	'3' **
9	To review the observations entered ***		D	X_i $i=1, \dots, n$
10	Record first side of data card ₁	4	2nd WRITE	4
11	Record second side of data card ₁	3	2nd WRITE	3
12	If you have more than 30 observations go to step 6		A	0

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	<u>FOR BIVARIATE TYPE OF DATA</u>			
2	Initialize		2nd E	0
3	Enter # of treatments	# of trt.	C	# of trt.
4	Enter # of replications	# of rep.	R/S	# of rep.
5	Enter code for missing value	code	2nd A	code
	For $i=1, \dots, n$ and $j=1, \dots, n$			
6	Enter observation X_i	X_i	x=y	Y_j
7	Enter observation Y_j	Y_j	2nd B	2
8	If you made a mistake in entering $X_i Y_j$		2nd C	0
9a	If the number of observations is less than 30 go to step 10			last Y_j
9b	If the number of observations is greater than 30 go to step 10			
10	To review the observations entered ***	$x_{31} Y_{31}$	2nd B	'3' **
			D	$X_i Y_j$ $i, j=1, \dots, n$
11	Record first side of data card $_1$	4	2nd WRITE	4
12	Record second side of data card $_1$	3	2nd WRITE	3
13	If you have more than 30 observations go to step 6		2nd E	0
	* For factorials and nested analyses enter the number of treatment combinations or nested combinations			
	** RECORD DATA will be printed if printer is attached			

<i>STEP</i>	<i>PROCEDURE</i>	<i>ENTER</i>	<i>PRESS</i>	<i>DISPLAY</i>
	*** Each observation will be displayed for 3 seconds and printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Examples of univariate and bivariate type of entry will be given using data from Sokal and Rohlf (1969), page 208, and Snedecor and Cochran (1967), page 422, respectively. The data entry for all programs in this set will be demonstrated in the PRINTED OUTPUT of each program. (Data sets are presented on the following page)

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card		<u>UNIVARIATE TYPE</u> display will show # 1	card upright initializing the program
4	E	0	# of treatments
13	C	4	# of replications
0	R/S	13	code for missing values
380	2nd A	0	
376	A	380	X_1
360	A	376	X_2
368	A	360	X_3
	A	368	X_4

UNIVARIATE TYPETREATMENTS

<u>T₁</u>	<u>T₂</u>	<u>T₃</u>	<u>T₄</u>
380	350	354	376
376	356	360	344
360	358	362	342
368	376	352	372
372	338	366	374
366	342	372	360
374	366	362	
382	350	344	
	344	342	
	354	358	
		351	
		348	
		348	

BIVARIATE TYPE

<u>T₁</u>		<u>T₂</u>		<u>T₃</u>	
<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>
11	6	6	0	16	13
8	0	6	2	13	10
5	2	7	3	11	18
14	8	8	1	9	5
19	11	18	18	21	23
6	4	8	4	16	12
10	13	19	14	12	5
6	1	8	9	12	16
11	8	5	1	7	1
3	0	15	9	12	20

ENTER	PRESS	OUTPUT	COMMENTS
372	A	372	X ₅
366	A	366	X ₆
374	A	374	X ₇
382	A	382	X ₈
0	A	0	X ₉ - code
0	A	0	X ₁₀ - code
0	A	0	X ₁₁ - code
0	A	0	X ₁₂ - code
0	A	0	X ₁₃ - code
350	A	350	X ₁₄
356	A	356	X ₁₅
358	A	358	X ₁₆
376	A	376	X ₁₇
338	A	338	X ₁₈
342	A	342	X ₁₉
366	A	366	X ₂₀
350	A	350	X ₂₁
344	A	344	X ₂₂
364	A	364	X ₂₃
0	A	0	X ₂₄ - code
0	A	0	X ₂₅ - code
0	A	0	X ₂₆ - code
354	A	354	X ₂₇
360	A	360	X ₂₈
362	A	362	X ₂₉
352	A	352	X ₃₀
366	A	'3' will flash in the display and RECORD DATA will be printed if printer is attached	data registers are full
	CLR	0	press CLR to stop flashing
4	2nd WRITE	4	enter card into the side slot

ENTER	PRESS	OUTPUT	COMMENTS
3	2nd WRITE	3	enter card into the side slot, this time inver- ted.
	E	0	re-initializing the program
366	A	366	X ₃₁
372	A	372	X ₃₂
362	A	362	X ₃₃
344	A	344	X ₃₄
342	A	342	X ₃₅
358	A	358	X ₃₆
351	A	351	X ₃₇
348	A	348	X ₃₈
348	A	348	X ₃₉
376	A	376	X ₄₀
344	A	344	X ₄₁
342	A	342	X ₄₂
372	A	372	X ₄₃
374	A	374	X ₄₄
360	A	360	X ₄₅
0	A	0	X ₄₆ - code
0	A	0	X ₄₇ - code
0	A	0	X ₄₈ - code
0	A	0	X ₄₉ - code
0	A	0	X ₅₀ - code
0	A	0	X ₅₁ - code
0	A	0	X ₅₂ - code
3	2nd WRITE	3	enter card ₂ into the side slot; card upright

ENTER	PRESS	OUTPUT	COMMENTS
		<u>BIVARIATE TYPE</u>	
Prog. card		display will show # 1	card upright
	2nd E	0	initializing the program
3	C	3	# of treatments
10	R/S	10	# of replications
99	2nd A	0	code for zero values. If you do not enter a code, the zeros will be considered as missing values, and they are not.
11	XY	30	X_1
6	2nd B	2	Y_1
8	XY	6	X_2
0	2nd B	2	Y_2
5	XY	0	X_3
2	2nd B	2	Y_3
14	XY	2	X_4
8	2nd B	2	Y_4
19	XY	8	X_5
11	2nd B	2	Y_5
6	XY	11	X_6
4	2nd B	2	Y_6
10	XY	4	X_7
13	2nd B	2	Y_7
6	XY	13	X_8
1	2nd B	2	Y_8
11	XY	1	X_9
8	2nd B	2	Y_9

ENTER	PRESS	OUTPUT	COMMENTS
3	XY	8	X ₁₀
0	2nd B	2	Y ₁₀
6	XY	0	X ₁₁
0	2nd B	2	Y ₁₁
6	XY	0	X ₁₂
2	2nd B	2	Y ₁₂
7	XY	2	X ₁₃
3	2nd B	2	Y ₁₃
8	XY	3	X ₁₄
1	2nd B	2	Y ₁₄
18	XY	1	X ₁₅
18	2nd B	2	Y ₁₅
8	XY	18	X ₁₆
4	2nd B	'3' will flash in the display and RECORD DATA will be printed if printer is attached	data registers are full
	CLR	0	CLR to stop flashing
4	2nd WRITE	4	enter card into the side slot
3	2nd WRITE	3	enter card into the side slot, this time inverted
	2nd E	0	re-initializing the program
8	XY	4	X ₁₆
4	2nd B	2	Y ₁₆
19	XY	4	X ₁₇
14	2nd B	2	Y ₁₇

ENTER	PRESS	OUTPUT	COMMENTS
8	XY	14	X ₁₈
9	2nd B	2	Y ₁₈
5	XY	9	X ₁₉
1	2nd B	2	Y ₁₉
15	XY	1	X ₂₀
9	2nd B	2	Y ₂₀
16	XY	9	X ₂₁
13	2nd B	2	Y ₂₁
13	XY	13	X ₂₂
10	2nd B	2	Y ₂₂
11	XY	10	X ₂₃
18	2nd B	2	Y ₂₃
9	XY	18	X ₂₄
5	2nd B	2	Y ₂₄
21	XY	5	X ₂₅
23	2nd B	2	Y ₂₅
16	XY	23	X ₂₆
12	2nd B	2	Y ₂₆
12	XY	12	X ₂₇
5	2nd B	2	Y ₂₇
12	XY	5	X ₂₈
16	2nd B	2	Y ₂₈
7	XY	16	X ₂₉
1	2nd B	2	Y ₂₉
12	XY	1	X ₃₀
20	2nd B	2	Y ₃₀
3	2nd WRITE	3	enter card ₂ into the side slot; card upright

PRINTED OUTPUT

UNIVARIATE ENTRY

4.
 13.

 380.
 376.
 360.
 368.
 372.
 366.
 374.
 382.
 0.
 0.
 0.
 0.
 0.
 350.
 356.
 358.
 376.
 338.
 342.
 366.
 350.
 344.
 364.
 0.
 0.
 0.
 354.
 360.
 362.
 352.
 RECORD DATA
 366.
 372.
 362.
 344.
 342.
 358.
 351.
 348.
 348.
 376.

344.
 342.
 372.
 374.
 360.
 0.
 0.
 0.
 0.
 0.
 0.
 0.

BIVARIATE ENTRY

3.
 10.

 11.
 6.

 8.
 0.

 5.
 2.

 14.
 8.

 19.
 11.

 6.
 4.

 10.
 13.

 6.
 1.

11.
8.

3.
0.

6.
0.

6.
2.

7.
3.

8.
1.

10.
18.

RECORD DATA

8.
4.

19.
14.

8.
9.

5.
1.

15.
9.

16.
13.

13.
10.

11.
18.

9.
5.

21.
23.

16.
12.

12.
5.

12.
16.

7.
1.

12.
20.

Data Input

LOC	CODE	KEY
000	76	LBL
001	11	A
002	32	X:T
003	73	RC*
004	00	00
005	69	DP
006	18	18
007	87	IFF
008	07	07
009	00	00
010	17	17
011	86	STF
012	01	01
013	71	SBR
014	96	WRT
015	03	3
016	92	RTN
017	22	INV
018	86	STF
019	07	07
020	32	X:T
021	99	PRT
022	72	ST*
023	00	00
024	32	X:T
025	01	1
026	44	SUM
027	00	00
028	32	X:T
029	92	RTN
030	76	LBL
031	15	E
032	87	IFF
033	01	01
034	00	00
035	37	37
036	47	CMS
037	03	3
038	00	0
039	42	STO
040	00	00
041	25	CLR
042	92	RTN
043	76	LBL
044	12	B
045	32	X:T
046	69	DP

PROGRAM LISTING

LOC	CODE	KEY
047	30	30
048	32	X:T
049	25	CLR
050	92	RTN
051	76	LBL
052	13	C
053	42	STO
054	02	02
055	99	PRT
056	91	R/S
057	42	STO
058	01	01
059	99	PRT
060	32	X:T
061	43	RCL
062	01	01
063	65	*
064	43	RCL
065	02	02
066	95	=
067	42	STO
068	03	03
069	32	X:T
070	98	ADV
071	92	RTN
072	76	LBL
073	14	D
074	03	3
075	00	0
076	42	STO
077	04	04
078	43	RCL
079	00	00
080	32	X:T
081	43	RCL
082	04	04
083	22	INV
084	77	GE
085	00	00
086	92	92
087	00	0
088	42	STO
089	04	04
090	25	CLR
091	92	RTN
092	73	RC*
093	04	04

LOC	CODE	KEY
094	99	PRT
095	66	PAU
096	66	PAU
097	66	PAU
098	01	1
099	44	SUM
100	04	04
101	61	GTO
102	00	00
103	78	78
104	76	LBL
105	16	A'
106	42	STO
107	11	11
108	25	CLR
109	92	RTN
110	76	LBL
111	10	E'
112	87	IFF
113	01	01
114	01	01
115	17	17
116	47	CMS
117	03	3
118	00	0
119	42	STO
120	00	00
121	03	3
122	01	1
123	42	STO
124	09	09
125	25	CLR
126	92	RTN
127	76	LBL
128	18	C'
129	02	2
130	22	INV
131	44	SUM
132	00	00
133	22	INV
134	44	SUM
135	09	09
136	25	CLR
137	92	RTN
138	76	LBL
139	17	B'
140	42	STO

LOC	CODE	KEY
141	08	08
142	32	X:T
143	42	STO
144	07	07
145	73	RC*
146	09	09
147	69	DP
148	18	18
149	87	IFF
150	07	07
151	01	01
152	59	59
153	71	SBR
154	96	WRT
155	86	STF
156	01	01
157	03	3
158	92	RTN
159	22	INV
160	86	STF
161	07	07
162	43	RCL
163	07	07
164	72	ST*
165	00	00
166	99	PRT
167	43	RCL
168	08	08
169	72	ST*
170	09	09
171	99	PRT
172	02	2
173	44	SUM
174	00	00
175	44	SUM
176	09	09
177	98	ADV
178	92	RTN
179	76	LBL
180	96	WRT
181	03	3
182	05	5
183	01	1
184	07	7
185	01	1
186	05	5
187	03	3

LOC	CODE	KEY
188	02	2
189	03	3
190	05	5
191	69	DP
192	01	01
193	01	1
194	06	6
195	00	0
196	00	0
197	01	1
198	06	6
199	01	1
200	03	3
201	03	3
202	07	7
203	69	DP
204	02	02
205	01	1
206	03	3
207	00	0
208	00	0
209	00	0
210	00	0
211	00	0
212	00	0
213	00	0
214	00	0
215	69	DP
216	03	03
217	69	DP
218	05	05
219	69	DP
220	00	00
221	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX C

PROGRAM FOR BARTLETT'S TEST OF
HOMOGENEITY OF VARIANCES

PROGRAM DESCRIPTION

PROGRAM TITLE: Bartlett's Test

OBJECTIVES: This program performs the Bartlett's Test for homogeneity of variances between treatments.

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : -

DATA INPUT TYPE: univariate and bivariate

OUTPUT^(*): Corrected chi-square

() printed and displayed when **PRINTER UNIT** is used*

PROGRAM CARD DESCRIPTION

Bartlett's Test				
Proc.	Resul.			

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card			1
2	Load side 2 of program card			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Process data card		A	
5a	If the number of observations is less than 30			0
5b	If the number of observations is greater than 30			'3' *
6a	If 5a is true go to step 8			
6b	If 5b is true load side 1 of data card ₂			3
7	Process data card		R/S	
7a	If all observations have been processed go to step 8			0
7b	If step 7a is not true			'3' *
7c	Load next data card and go to step 7			
8	Obtain results		B	Corrected chi- square
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Bartlett's test for homogeneity of variances between four treatments. Data from Snedecor and Cochran (1967), pages 259 and 296.

TREATMENTS

<u>T₁</u>	<u>T₂</u>	<u>T₃</u>	<u>T₄</u>
64	78	75	55
72	91	93	66
68	97	78	49
77	82	71	64
56	85	63	70
95	77	76	68

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card		display will show # 1	card upright
Prog. card		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
	A	0 will show in the display	process finished
	B	1.750449383	Corrected chi-square

PRINTED OUTPUT

4.
6.

64.
72.
68.
77.
58.
95.
78.
91.
97.
82.
85.
77.
75.
93.
78.
71.
63.
76.
55.
66.
49.
64.
70.
68.

BARTLETT'S TEST

χ^2 CORRECTED IS
1.750449383

Bartlett's Test

LOC	CODE	KEY
000	76	LBL
001	11	R
002	43	RCL
003	01	01
004	42	STD
005	07	07
006	43	RCL
007	02	02
008	42	STD
009	08	08
010	43	RCL
011	03	03
012	42	STD
013	09	09
014	03	3
015	00	0
016	42	STD
017	00	00
018	00	0
019	42	STD
020	01	01
021	42	STD
022	02	02
023	42	STD
024	03	03
025	42	STD
026	04	04
027	42	STD
028	05	05
029	42	STD
030	06	06
031	43	RCL
032	07	07
033	42	STD
034	10	10
035	29	CP
036	43	RCL
037	10	10
038	22	INV
039	67	EQ
040	00	00
041	98	98
042	43	RCL
043	03	03
044	75	-
045	01	1
046	95	=

LOC	CODE	KEY
047	44	SUM
048	13	13
049	42	STD
050	20	20
051	35	1/X
052	44	SUM
053	16	16
054	43	RCL
055	02	02
056	75	-
057	53	(
058	43	RCL
059	01	01
060	33	X ²
061	55	+
062	43	RCL
063	03	03
064	54)
065	95	=
066	55	+
067	43	RCL
068	20	20
069	95	=
070	42	STD
071	21	21
072	65	x
073	43	RCL
074	20	20
075	95	=
076	44	SUM
077	14	14
078	43	RCL
079	21	21
080	28	LOG
081	65	x
082	43	RCL
083	20	20
084	95	=
085	44	SUM
086	15	15
087	43	RCL
088	09	09
089	32	X!T
090	43	RCL
091	12	12
092	77	GE
093	01	01

PROGRAM LISTING

LOC	CODE	KEY
094	38	38
095	61	GTD
096	00	00
097	18	18
098	73	RC*
099	00	00
100	69	DP
101	19	19
102	87	IFF
103	07	07
104	02	02
105	02	02
106	32	X!T
107	43	RCL
108	11	11
109	22	INV
110	67	EQ
111	01	01
112	25	25
113	01	1
114	44	SUM
115	00	00
116	22	INV
117	44	SUM
118	09	09
119	22	INV
120	44	SUM
121	10	10
122	61	GTD
123	00	00
124	35	35
125	32	X!T
126	78	Σ+
127	01	1
128	44	SUM
129	00	00
130	44	SUM
131	12	12
132	22	INV
133	44	SUM
134	10	10
135	61	GTD
136	00	00
137	35	35
138	43	RCL
139	14	14
140	55	+

LOC	CODE	KEY
141	43	RCL
142	13	13
143	95	=
144	28	LOG
145	65	x
146	43	RCL
147	13	13
148	95	=
149	75	-
150	43	RCL
151	15	15
152	95	=
153	65	x
154	02	2
155	93	.
156	03	3
157	00	0
158	02	2
159	06	6
160	95	=
161	42	STD
162	19	19
163	53	(
164	43	RCL
165	16	16
166	75	-
167	53	(
168	43	RCL
169	13	13
170	35	1/X
171	54)
172	54)
173	65	x
174	53	(
175	53	(
176	03	3
177	65	x
178	53	(
179	43	RCL
180	08	08
181	75	-
182	01	1
183	54)
184	54)
185	35	1/X
186	54)
187	85	+

LOC	CODE	KEY
188	01	1
189	95	=
190	42	STO
191	18	18
192	43	RCL
193	19	19
194	55	+
195	43	RCL
196	18	18
197	95	=
198	42	STO
199	17	17
200	25	CLR
201	92	RTN
202	01	1
203	06	6
204	01	1
205	03	3
206	03	3
207	07	7
208	01	1
209	03	3
210	69	DP
211	01	01
212	69	DP
213	05	05
214	69	DP
215	00	00
216	03	3
217	91	R/S
218	29	CP
219	22	INV
220	86	STF
221	07	07
222	03	3
223	00	0
224	42	STO
225	00	00
226	43	RCL
227	03	03
228	67	EQ
229	00	00
230	25	25
231	61	CTO
232	00	00
233	29	29
234	76	LBL
235	12	B
236	01	1

LOC	CODE	KEY
237	04	4
238	01	1
239	03	3
240	03	3
241	05	5
242	69	DP
243	01	01
244	03	3
245	07	7
246	02	2
247	07	7
248	01	1
249	07	7
250	03	3
251	07	7
252	03	3
253	07	7
254	69	DP
255	02	02
256	06	6
257	05	5
258	03	3
259	06	6
260	00	0
261	00	0
262	03	3
263	07	7
264	01	1
265	07	7
266	69	DP
267	03	03
268	03	3
269	06	6
270	03	3
271	07	7
272	00	0
273	00	0
274	00	0
275	00	0
276	00	0
277	00	0
278	69	DP
279	04	04
280	69	DP
281	05	05
282	69	DP
283	00	00
284	98	ADV
285	98	ADV

LOC	CODE	KEY
286	05	5
287	00	0
288	07	7
289	00	0
290	00	0
291	00	0
292	01	1
293	05	5
294	03	3
295	02	2
296	69	DP
297	01	01
298	03	3
299	05	5
300	03	3
301	05	5
302	01	1
303	07	7
304	01	1
305	05	5
306	03	3
307	07	7
308	69	DP
309	02	02
310	01	1
311	07	7
312	01	1
313	06	6
314	00	0
315	00	0
316	02	2
317	04	4
318	03	3
319	06	6
320	69	DP
321	03	03
322	69	DP
323	05	05
324	43	RCL
325	17	17
326	99	PRT
327	92	RTN

LOC	CODE	KEY
-----	------	-----

APPENDIX D

PROGRAM FOR SKEWNESS, KURTOSIS AND
DATA TRANSFORMATION

PROGRAM DESCRIPTION

PROGRAM TITLE: Skewness, Kurtosis and Data Transformation

OBJECTIVES: This program calculates the four moments--the mean, variance, and third and fourth moments--along with coefficients of skewness and kurtosis for a set of observations. It also provides five different types of data transformations and two types of coding.

LIMITS FOR:

- a) TREATMENTS : -
- b) FACTORS : -
- c) LEVELS : -
- d) REPLICATIONS : -

DATA INPUT TYPE: univariate

OUTPUT^(*): Mean
Variance
Third moment
Fourth moment
Skewness
Kurtosis

() printed and displayed when PRINTER UNIT is used*

PROGRAM CARD DESCRIPTION

Skewness, Kurtosis & Data Trans.				
1/x	$\sin^{-1}\sqrt{x}$	+/-	:/x	No. Ts
Init.	Resul.	\sqrt{x}	lg x	lg x+1

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card			1
2	Load side 2 of program card			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Initialize		A	0
6	Select type of transformation or coding:			
	1. No transformation		2nd E	
	2. Square Root of x		C	
	3. Logarithm of x		D	
	4. Logarithm of (x+1)		E	
	5. Reciprocal 1/x		2nd A	
	6. Arc sin of square root(x)		2nd B	
	7. Addition or subtraction	\pm Value	2nd C	
	8. Multiplication or division	:/x value	2nd D	
6a	If number of observations is less than 30			2 *
6b	If number of observations is greater than 30			'3' **
7a	If 6a is true go to step 9			
7b	If 6b is true load side 1 of data card ₂			3
8	Process data card		R/S	
8a	If all observations have been processed go to step 9			2 *
8b	If step 8a is not true			'3' **
8c	Load next data card and go to step 8			3

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
9	Record transformed data	3	2nd WRITE	3
10	Obtain results * RECORD DATA will be printed if printer is attached ** DATA will be printed if printer is attached		B R/S R/S R/S R/S R/S	Mean Variance 3rd momt. 4th momt. Skewness Kurtosis

SAMPLE PROBLEM

EXAMPLE: Calculation of moments and coefficients of skewness and kurtosis for a data set. Data from Snedecor and Cochran (1967), page 259.

TREATMENTS

<u>T₁</u>	<u>T₂</u>	<u>T₃</u>	<u>T₄</u>
64	78	75	55
72	91	93	66
68	97	78	49
77	82	71	64
56	85	63	70
95	77	76	68

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card		display will show # 1	card upright
Prog. card		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
	A	0	initialization
	2nd E	display will show # 2 and RECORD DATA will be printed if printer is attached	No transformation
	B	73.75	Mean
	R/S	152.2708333	Variance
	R/S	220.2187385	Third moment

ENTER	PRESS	OUTPUT	COMMENTS
	R/S	57462.94839	Fourth moment
	R/S	0.1172004242	Coef. of skewness
	R/S	2.478303308	Coef. of kurtosis
		Trying another trnas- formation	
	CLR	0	clearing the display
	RST	0	resetting the program and clear- ing flags
Data card		display will show # 4	card upright
Data card		display will show #3	card inverted
	A	0	initialization
	C	2 and RECORD DATA if printer is attached	Square root tran.
	B	8.557349436	Mean
	R/S	0.5217706309	Variance
	R/S	-0.028787073	Third moment
	R/S	0.69504863	Fourth moment
	R/S	-0.0763797203	Coef. of skewness
	R/S	2.553162312	Coef. of kurtosis

PRINTED OUTPUT

```

      4.
      6.

      64.
      72.
      68.
      77.
      56.
      95.
      78.
      91.
      97.
      82.
      85.
      77.
      75.
      93.
      78.
      71.
      63.
      76.
      55.
      66.
      49.
      64.
      70.
      68.
RECORD DATA
      73.75      X
152.2708333    S²
220.2187385    M3
57462.94839    M4
.1172004242    SKEW
2.478303308    KURT

```

```

SECOND EXAMPLE (J)

RECORD DATA

      8.557349436      X
      .5217706309      S²
     -0.028787073      M3
      0.69508463       M4
     -.0763797203      SKEW
      2.553162312      KURT

```

Skewness, Kurtosis and Data Transformation

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	A
002	03	3
003	00	0
004	42	STD
005	00	00
006	25	CLR
007	92	RTN
008	76	LBL
009	10	E*
010	86	STF
011	00	00
012	61	GTD
013	00	00
014	65	65
015	76	LBL
016	13	C
017	86	STF
018	01	01
019	61	GTD
020	00	00
021	65	65
022	76	LBL
023	14	D
024	86	STF
025	02	02
026	61	GTD
027	00	00
028	65	65
029	76	LBL
030	15	E
031	86	STF
032	03	03
033	61	GTD
034	00	00
035	65	65
036	76	LBL
037	16	A*
038	86	STF
039	04	04
040	61	GTD
041	00	00
042	65	65
043	76	LBL
044	17	B*
045	86	STF
046	05	05

LOC	CODE	KEY
047	61	GTD
048	00	00
049	65	65
050	76	LBL
051	18	C*
052	42	STD
053	10	10
054	86	STF
055	06	06
056	61	GTD
057	00	00
058	65	65
059	76	LBL
060	19	D*
061	42	STD
062	10	10
063	86	STF
064	08	08
065	73	RC*
066	00	00
067	69	DP
068	19	19
069	87	IFF
070	07	07
071	04	04
072	04	04
073	32	X:T
074	43	RCL
075	11	11
076	22	INV
077	67	EQ
078	00	00
079	83	83
080	61	GTD
081	01	01
082	90	90
083	32	X:T
084	87	IFF
085	06	06
086	01	01
087	21	21
088	87	IFF
089	08	08
090	01	01
091	28	28
092	87	IFF
093	00	00

LOC	CODE	KEY
094	01	01
095	67	67
096	87	IFF
097	01	01
098	01	01
099	35	35
100	87	IFF
101	02	02
102	01	01
103	41	41
104	87	IFF
105	03	03
106	01	01
107	47	47
108	87	IFF
109	04	04
110	01	01
111	56	56
112	87	IFF
113	05	05
114	01	01
115	62	62
116	63	EX*
117	00	00
118	61	GTD
119	01	01
120	67	67
121	85	+
122	43	RCL
123	10	10
124	95	=
125	61	GTD
126	00	00
127	88	88
128	65	x
129	43	RCL
130	10	10
131	95	=
132	61	GTD
133	00	00
134	92	92
135	34	FX
136	63	EX*
137	00	00
138	61	GTD
139	01	01
140	67	67

LOC	CODE	KEY
141	28	LOG
142	63	EX*
143	00	00
144	61	GTD
145	01	01
146	67	67
147	85	+
148	01	1
149	95	=
150	28	LOG
151	63	EX*
152	00	00
153	61	GTD
154	01	01
155	67	67
156	35	1/X
157	63	EX*
158	00	00
159	61	GTD
160	01	01
161	67	67
162	34	FX
163	22	INV
164	38	SIN
165	63	EX*
166	00	00
167	73	RC*
168	00	00
169	44	SUM
170	05	05
171	33	X ²
172	44	SUM
173	06	06
174	73	RC*
175	00	00
176	45	Y*
177	03	3
178	95	=
179	44	SUM
180	08	08
181	73	RC*
182	00	00
183	45	Y*
184	04	4
185	95	=
186	44	SUM
187	09	09

LOC	CODE	KEY
188	69	DP
189	24	24
190	69	DP
191	20	20
192	69	DP
193	33	33
194	43	RCL
195	03	03
196	29	CP
197	67	EQ
198	02	02
199	03	03
200	61	GTO
201	00	00
202	65	65
203	43	RCL
204	05	05
205	55	+
206	43	RCL
207	04	04
208	95	=
209	42	STO
210	12	12
211	43	RCL
212	06	06
213	55	+
214	43	RCL
215	04	04
216	75	-
217	53	(
218	43	RCL
219	12	12
220	33	X ²
221	54)
222	95	=
223	42	STO
224	13	13
225	43	RCL
226	08	08
227	75	-
228	53	(
229	03	3
230	65	X
231	43	RCL
232	12	12
233	65	X
234	43	RCL
235	06	06
236	54)

LOC	CODE	KEY
237	95	=
238	55	+
239	43	RCL
240	04	04
241	85	+
242	53	(
243	02	2
244	65	X
245	53	(
246	43	RCL
247	12	12
248	45	YX
249	03	3
250	54)
251	54)
252	95	=
253	42	STO
254	14	14
255	43	RCL
256	09	09
257	75	-
258	53	(
259	04	4
260	65	X
261	43	RCL
262	12	12
263	65	X
264	43	RCL
265	08	08
266	54)
267	85	+
268	53	(
269	06	6
270	65	X
271	53	(
272	43	RCL
273	12	12
274	33	X ²
275	54)
276	65	X
277	43	RCL
278	06	06
279	54)
280	95	=
281	55	+
282	43	RCL
283	04	04
284	75	-
285	53	(

LOC	CODE	KEY
286	03	3
287	65	X
288	53	(
289	43	RCL
290	12	12
291	45	YX
292	04	4
293	54)
294	54)
295	95	=
296	42	STO
297	15	15
298	43	RCL
299	14	14
300	55	+
301	53	(
302	43	RCL
303	13	13
304	34	FX
305	45	YX
306	03	3
307	54)
308	95	=
309	42	STO
310	16	16
311	43	RCL
312	15	15
313	55	+
314	43	RCL
315	13	13
316	33	X ²
317	95	=
318	42	STO
319	17	17
320	61	GTO
321	04	04
322	35	35
323	76	LBL
324	12	B
325	25	CLR
326	98	ADV
327	06	6
328	07	7
329	69	DP
330	04	04
331	43	RCL
332	12	12
333	69	DP
334	06	06

LOC	CODE	KEY
335	91	R/S
336	98	ADV
337	03	3
338	06	6
339	07	7
340	00	0
341	69	DP
342	04	04
343	43	RCL
344	13	13
345	69	DP
346	06	06
347	91	R/S
348	98	ADV
349	03	3
350	00	0
351	00	0
352	04	4
353	69	DP
354	04	04
355	43	RCL
356	14	14
357	69	DP
358	06	06
359	91	R/S
360	98	ADV
361	03	3
362	00	0
363	00	0
364	05	5
365	69	DP
366	04	04
367	43	RCL
368	15	15
369	69	DP
370	06	06
371	91	R/S
372	98	ADV
373	03	3
374	06	6
375	02	2
376	06	6
377	01	1
378	07	7
379	04	4
380	03	3
381	69	DP
382	04	04
383	43	RCL

LOC	CODE	KEY
384	16	16
385	69	□P
386	06	06
387	91	R/S
388	98	RDV
389	02	2
390	06	6
391	04	4
392	01	1
393	03	3
394	05	5
395	03	3
396	07	7
397	69	□P
398	04	04
399	43	RCL
400	17	17
401	69	□P
402	06	06
403	91	R/S
404	87	IFF
405	00	00
406	04	04
407	11	11
408	61	GTD
409	04	04
410	35	35
411	01	1
412	06	6
413	01	1
414	03	3
415	03	3
416	07	7
417	01	1
418	03	3
419	69	□P
420	01	01
421	69	□P
422	05	05
423	03	3
424	91	R/S
425	22	INV
426	86	STF
427	07	07
428	03	3
429	00	0
430	42	STD
431	00	00
432	61	GTD

LOC	CODE	KEY
433	00	00
434	65	65
435	03	3
436	05	5
437	01	1
438	07	7
439	01	1
440	05	5
441	03	3
442	02	2
443	03	3
444	05	5
445	69	□P
446	01	01
447	01	1
448	06	6
449	00	0
450	00	0
451	01	1
452	06	6
453	01	1
454	03	3
455	03	3
456	07	7
457	69	□P
458	02	02
459	01	1
460	03	3
461	00	0
462	00	0
463	00	0
464	00	0
465	00	0
466	00	0
467	00	0
468	00	0
469	69	□P
470	03	03
471	69	□P
472	05	05
473	69	□P
474	00	00
475	02	2
476	91	R/S
477	61	GTD
478	04	04
479	11	11

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX E

PROGRAM FOR ONE TREATMENT FACTOR IN A
COMPLETELY RANDOMIZED DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: One Treatment Factor in a Completely
Randomized Design

OBJECTIVES: This program performs an analysis of variance for one treatment factor arranged in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : any number, equal or not

DATA INPUT TYPE: univariate

OUTPUT^(*): Treatment degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Treatment sum of squares
Residual sum of squares
Total sum of squares
Treatment mean square
Residual mean square
F-ratio for treatments

() printed and displayed when **PRINTER UNIT** is used*

PROGRAM CARD DESCRIPTION

One Treatment Factor in CRD				
Proc.	Resul.			

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card			1
2	Load side 2 of program card			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Process data card		A	
5a	If number of observations is less than 30			0
5b	If number of observations is greater than 30			'3' *
6a	If 5a is true go to step 8			
6b	If 5b is true load side 1 of data card ₂			3
7	Process data card		R/S	
7a	If all observations have been processed go to step 8			0
7b	If step 7a is not true			'3' *
7c	Load next data card and go to step 7			3
8	Obtain results		B	Trt. D.F.
			R/S	Res. D.F.
			R/S	Tot. D.F.
			R/S	Trt. S.S.
			R/S	Res. S.S.
			R/S	Tot. S.S.
			R/S	Trt. M.S.
			R/S	Res. M.S.
			R/S	F-ratio
				Trt.
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for four treatments arranged in a completely randomized design. Not all treatments have the same number of observations. Data from Sokal and Rohlf (1969), page 208.

TREATMENTS

<u>T₁</u>	<u>T₂</u>	<u>T₃</u>	<u>T₄</u>
380	350	354	376
376	356	360	344
360	358	362	342
368	376	352	372
372	338	366	374
366	342	372	360
374	366	362	
382	350	344	
	344	342	
	364	358	
		351	
		348	
		348	

ENTER	PRESS	OUTPUT	COMMENTS
Prog. Card		display will show # 1	card upright
Prog. Card		display will show # 2	card inverted
Data Card ₁		display will show # 4	card upright
Data Card ₁		display will show #3	card inverted
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data Card ₂		display will show #3	card upright
	R/S	0 will show in the display	process finished

ENTER	PRESS	OUTPUT	COMMENTS
	B	3	Treatment D.F.
	R/S	33	Residual D.F.
	R/S	36	Total D.F.
	R/S	1807.727165	Treatment S.S.
	R/S	3778.002565	Residual S.S.
	R/S	5585.72973	Total S.S.
	R/S	602.5757217	Treatment M.S.
	R/S	114.4849262	Residual M.S.
	R/S	5.263362974	F-ratio for Trt.

PRINTED OUTPUT

```

      4.
     13.

    380.
    376.
    360.
    368.
    372.
    366.
    374.
    382.
      0.
      0.
      0.
      0.
      0.
    350.
    356.
    358.
    376.
    338.
    342.
    366.
    350.
    344.
    364.
      0.
      0.
      0.
    354.
    360.
    362.
    352.
RECORD DATA
    366.
    372.
    362.
    344.
    342.
    358.
    351.
    348.
    348.
    376.
    344.
    342.
    372.
    374.

```

```

    360.
      0.
      0.
      0.
      0.
      0.
      0.
      0.
      0.
'DATA' .....
      ANOVA TABLE

TRT.  D. F.
           3.

RES.  D. F.
           33.

TOT.  D. F.
           36.

TRT.  S. S.
    1807.727165

RES.  S. S.
    3778.002565

TOT.  S. S.
    5585.72973

TRT.  M. S.
    602.5757217

RES.  M. S.
    114.4849262

F-RATIO
    5.263362974

```

One Treatment Factor in CRD

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	A
002	03	S
003	00	0
004	42	STD
005	00	00
006	43	RCL
007	01	01
008	42	STD
009	04	04
010	29	CP
011	43	RCL
012	04	04
013	22	INV
014	67	EQ
015	00	00
016	42	42
017	43	RCL
018	06	06
019	33	X ²
020	55	+
021	43	RCL
022	12	12
023	95	=
024	44	SUM
025	08	08
026	43	RCL
027	03	03
028	32	X↑T
029	43	RCL
030	13	13
031	77	GE
032	00	00
033	91	91
034	00	0
035	42	STD
036	06	06
037	42	STD
038	12	12
039	61	GTD
040	00	00
041	06	06
042	73	RC*
043	00	00
044	69	DP
045	19	19
046	87	IFF

LOC	CODE	KEY
047	07	07
048	04	04
049	16	16
050	32	X↑T
051	43	RCL
052	11	11
053	22	INV
054	67	EQ
055	00	00
056	70	70
057	01	1
058	44	SUM
059	00	00
060	01	1
061	22	INV
062	44	SUM
063	03	03
064	22	INV
065	44	SUM
066	04	04
067	61	GTD
068	00	00
069	10	10
070	32	X↑T
071	44	SUM
072	05	05
073	44	SUM
074	06	06
075	33	X ²
076	44	SUM
077	07	07
078	01	1
079	44	SUM
080	00	00
081	44	SUM
082	12	12
083	44	SUM
084	13	13
085	22	INV
086	44	SUM
087	04	04
088	61	GTD
089	00	00
090	10	10
091	43	RCL
092	05	05
093	33	X ²

LOC	CODE	KEY
094	55	+
095	43	RCL
096	13	13
097	95	=
098	42	STD
099	05	05
100	43	RCL
101	07	07
102	75	-
103	43	RCL
104	05	05
105	95	=
106	42	STD
107	07	07
108	43	RCL
109	08	08
110	75	-
111	43	RCL
112	05	05
113	95	=
114	42	STD
115	06	06
116	43	RCL
117	07	07
118	75	-
119	43	RCL
120	06	06
121	95	=
122	42	STD
123	08	08
124	25	CLR
125	92	RTN
126	76	LBL
127	12	B
128	01	1
129	03	3
130	69	DP
131	01	01
132	03	3
133	01	1
134	03	3
135	02	2
136	04	4
137	02	2
138	01	1
139	03	3
140	00	0

LOC	CODE	KEY
141	00	0
142	69	DP
143	02	02
144	03	3
145	07	7
146	01	1
147	03	3
148	01	1
149	04	4
150	02	2
151	07	7
152	01	1
153	07	7
154	69	DP
155	03	03
156	69	DP
157	05	05
158	69	DP
159	00	00
160	98	ADV
161	01	1
162	06	6
163	04	4
164	00	0
165	02	2
166	01	1
167	04	4
168	00	0
169	00	0
170	00	0
171	69	DP
172	02	02
173	03	3
174	07	7
175	03	3
176	05	5
177	03	3
178	07	7
179	04	4
180	00	0
181	00	0
182	00	0
183	69	DP
184	01	01
185	69	DP
186	05	05
187	43	RCL

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
188	02	02	237	99	PRT	286	08	08	335	53	(
189	75	-	238	91	R/S	287	99	PRT	336	43	RCL
190	01	1	239	98	ADV	288	91	R/S	337	06	06
191	95	=	240	03	3	289	98	ADV	338	55	+
192	99	PRT	241	06	6	290	03	3	339	53	(
193	91	R/S	242	04	4	291	07	7	340	43	RCL
194	98	ADV	243	00	0	292	03	3	341	02	02
195	03	3	244	03	3	293	02	2	342	75	-
196	05	5	245	06	6	294	03	3	343	01	1
197	01	1	246	04	4	295	07	7	344	54)
198	07	7	247	00	0	296	04	4	345	54)
199	03	3	248	00	0	297	00	0	346	42	STD
200	06	6	249	00	0	298	00	0	347	09	09
201	04	4	250	69	DP	299	00	0	348	99	PRT
202	00	0	251	02	02	300	69	DP	349	91	R/S
203	00	0	252	03	3	301	01	01	350	98	ADV
204	00	0	253	07	7	302	69	DP	351	03	3
205	69	DP	254	03	3	303	05	05	352	05	5
206	01	01	255	05	5	304	43	RCL	353	01	1
207	69	DP	256	03	3	305	07	07	354	07	7
208	05	05	257	07	7	306	99	PRT	355	03	3
209	43	RCL	258	04	4	307	91	R/S	356	06	6
210	03	03	259	00	0	308	98	ADV	357	04	4
211	75	-	260	00	0	309	03	3	358	00	0
212	43	RCL	261	00	0	310	00	0	359	00	0
213	02	02	262	69	DP	311	04	4	360	00	0
214	95	=	263	01	01	312	00	0	361	69	DP
215	99	PRT	264	69	DP	313	03	3	362	01	01
216	91	R/S	265	05	05	314	06	6	363	69	DP
217	98	ADV	266	43	RCL	315	04	4	364	05	05
218	03	3	267	06	06	316	00	0	365	53	(
219	07	7	268	99	PRT	317	00	0	366	43	RCL
220	03	3	269	91	R/S	318	00	0	367	08	08
221	02	2	270	98	ADV	319	69	DP	368	55	+
222	03	3	271	03	3	320	02	02	369	53	(
223	07	7	272	05	5	321	03	3	370	43	RCL
224	04	4	273	01	1	322	07	7	371	03	03
225	00	0	274	07	7	323	03	3	372	75	-
226	00	0	275	03	3	324	05	5	373	43	RCL
227	00	0	276	06	6	325	03	3	374	02	02
228	69	DP	277	04	4	326	07	7	375	54)
229	01	01	278	00	0	327	04	4	376	54)
230	69	DP	279	00	0	328	00	0	377	42	STD
231	05	05	280	00	0	329	00	0	378	10	10
232	43	RCL	281	69	DP	330	00	0	379	99	PRT
233	03	03	282	11	01	331	69	DP	380	91	R/S
234	75	-	283	69	DP	332	01	01	381	98	ADV
235	01	1	284	15	05	333	69	DP	382	02	2
236	95	=	285	43	RCL	334	05	05	383	01	1

LOC	CODE	KEY
384	02	2
385	00	0
386	03	3
387	05	5
388	01	1
389	03	3
390	03	3
391	07	7
392	69	DP
393	01	01
394	02	2
395	04	4
396	03	3
397	02	2
398	00	0
399	00	0
400	00	0
401	00	0
402	00	0
403	00	0
404	69	DP
405	02	02
406	69	DP
407	05	05
408	43	RCL
409	09	09
410	55	+
411	43	RCL
412	10	10
413	95	=
414	99	FRT
415	92	RTN
416	69	DP
417	00	00
418	01	1
419	06	6
420	01	1
421	03	3
422	03	3
423	07	7
424	01	1
425	03	3
426	69	DP
427	01	01
428	69	DP
429	05	05
430	69	DP
431	00	00
432	03	3

LOC	CODE	KEY
433	91	R/S
434	29	CP
435	22	INV
436	96	STF
437	07	07
438	03	3
439	00	0
440	42	STO
441	00	00
442	43	RCL
443	06	06
444	67	EQ
445	00	00
446	06	06
447	61	GTO
448	00	00
449	10	10

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX F

PROGRAM FOR ONE TREATMENT FACTOR IN A
RANDOMIZED COMPLETE BLOCK DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: One Treatment Factor in a Randomized Complete Block Design

OBJECTIVES: This program performs an analysis of variance for one treatment factor arranged in a randomized complete block design. It accepts one missing observation, estimating its value by the method given by Snedecor and Cochran (1967).

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : 15

DATA INPUT TYPE: univariate

OUTPUT^(*): Treatment degrees of freedom
Block degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Treatment sum of squares
Block sum of squares
Residual sum of squares
Total sum of squares
Treatment mean square
Residual mean square
F-ratio for treatments

() printed and displayed when PRINTER UNIT is used*

PROGRAM CARD DESCRIPTION

One Treatment Factor in RCB				
Proc.	Resul.			

USERS INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Process data card		A	
5a	If the number of observations is less than 30			0
5b	If the number of observations is greater than 30			'3' *
6a	If 5a is true go to step 8			
6b	If 5b is true load side 1 of data card ₂			3
7	Process data card		R/S	
7a	If all observations have been processed go to step 8			0
7b	If step 7a is not true			'3' *
7c	Load next data card and go to step 7			3
8	For a printed output go to step 9; otherwise go to step 11			
9	Load side 1 of program card ₂			1
10	Load side 2 of program card ₂			2
11	Obtain results		B	Trt. D.F.
			R/S	Blc. D.F.
			R/S	Res. D.F.
			R/S	Tot. D.F.
			R/S	Trt. S.S.
			R/S	Blc. S.S.
			R/S	Res. S.S.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	<p>* DATA will be printed if printer is attached</p>		R/S R/S R/S R/S R/S	Tot. S.S. Trt. M.S. Blc. M.S. Res. M.S. F-ratio Trt.

SAMPLE PROBLEM

EXAMPLE: Analysis of Variance for six treatments arranged in a randomized complete block design. Data from Steel and Torrie (1960), page 136.

		<u>BLOCKS</u>			
		B ₁	B ₂	B ₃	B ₄
<u>TREATMENTS</u>	T ₁	4.4	5.9	6.0	4.1
	T ₂	3.3	1.9	4.9	7.1
	T ₃	4.4	4.0	4.5	3.1
	T ₄	6.8	6.6	7.0	6.4
	T ₅	6.3	4.9	5.9	7.1
	T ₆	6.4	7.3	7.7	6.7

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card		display will show #4	card upright
Data card		display will show #3	card inverted
	A	0 will show in the display	process finished
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
		(You do not have to read this card unless you want a printed output)	

ENTER	PRESS	OUTPUT	COMMENTS
	B	5	Treatment D.F.
	R/S	3	Block D.F.
	R/S	15	Residual D.F.
	R/S	23	Total D.F.
	R/S	31.65208333	Treatment S.S.
	R/S	3.14125	Block S.S.
	R/S	19.71625	Residual S.S.
	R/S	54.509583333	Total S.S.
	R/S	6.33047083333	Treatment M.S.
	R/S	1.047083333	Block M.S.
	R/S	1.314416667	Residual M.S.
	R/S	4.816141508	F-ratio for Trt.

PRINTED OUTPUT

6.
4.
4.4
5.9
6.
4.1
3.3
1.9
4.9
7.1
4.4
4.
4.5
3.1
6.8
6.6
7.
6.4
6.3
4.9
5.9
7.1
6.4
7.3
7.7
6.7

ANOVA TABLE

TRT. D. F.
5.

BLC. D. F.
3.

RES. D. F.
15.

TOT. D. F.
23.

TRT. S. S.
31.65208333

BLC. S. S.
3.14125

RES. S. S.
19.71625

TOT. S. S.
54.50958333

TRT. M. S.
6.330416667

BLC. M. S.
1.047083333

RES. M. S.
1.314416667

F-RATIO (TRT.)
4.816141508

One Treatment Factor in RCB

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	43	RCL	094	04	04	141	53	(
001	11	A	048	13	13	095	61	GTD	142	53	(
002	03	3	049	77	GE	096	00	00	143	43	RCL
003	00	0	050	01	01	097	14	14	144	01	01
004	42	STD	051	20	20	098	32	X:IT	145	75	-
005	00	00	052	00	0	099	44	SUM	146	01	1
006	01	1	053	42	STD	100	05	05	147	54)
007	05	5	054	06	06	101	44	SUM	148	65	x
008	42	STD	055	22	INV	102	06	06	149	53	(
009	09	09	056	86	STF	103	74	SM*	150	43	RCL
010	43	RCL	057	02	02	104	09	09	151	02	02
011	01	01	058	61	GTD	105	33	X²	152	75	-
012	42	STD	059	00	00	106	44	SUM	153	01	1
013	04	04	060	10	10	107	07	07	154	54)
014	29	CP	061	73	RC*	108	69	DP	155	54)
015	43	RCL	062	00	00	109	20	20	156	95	=
016	04	04	063	69	DP	110	69	DP	157	42	STD
017	22	INV	064	19	19	111	29	29	158	11	11
018	67	EQ	065	87	IFF	112	01	1	159	73	RC*
019	00	00	066	07	07	113	44	SUM	160	10	10
020	61	61	067	02	02	114	13	13	161	75	-
021	43	RCL	068	84	84	115	69	DP	162	53	(
022	06	06	069	32	X:IT	116	34	34	163	53	(
023	22	INV	070	43	RCL	117	61	GTD	164	43	RCL
024	87	IFF	071	11	11	118	00	00	165	02	02
025	02	02	072	22	INV	119	14	14	166	75	-
026	00	00	073	67	EQ	120	22	INV	167	01	1
027	33	33	074	00	00	121	87	IFF	168	54)
028	42	STD	075	98	98	122	03	03	169	65	x
029	12	12	076	43	RCL	123	02	02	170	43	RCL
030	61	GTD	077	09	09	124	16	16	171	11	11
031	00	00	078	42	STD	125	43	RCL	172	54)
032	40	40	079	10	10	126	12	12	173	95	=
033	33	X²	080	86	STF	127	65	x	174	33	X²
034	55	+	081	02	02	128	43	RCL	175	55	+
035	43	RCL	082	86	STF	129	02	02	176	53	(
036	01	01	083	03	03	130	85	+	177	43	RCL
037	95	=	084	01	1	131	73	RC*	178	02	02
038	44	SUM	085	44	SUM	132	10	10	179	65	x
039	08	08	086	00	00	133	65	x	180	53	(
040	01	1	087	44	SUM	134	43	RCL	181	53	(
041	05	5	088	09	09	135	01	01	182	43	RCL
042	42	STD	089	22	INV	136	75	-	183	02	02
043	09	09	090	44	SUM	137	43	RCL	184	75	-
044	43	RCL	091	03	03	138	05	05	185	01	1
045	03	03	092	22	INV	139	95	=	186	54)
046	32	X:IT	093	44	SUM	140	55	+	187	33	X²

LOC	CODE	KEY
188	54)
189	54)
190	95	=
191	42	STD
192	00	00
193	43	RCL
194	11	11
195	44	SUM
196	05	05
197	74	SM*
198	10	10
199	44	SUM
200	12	12
201	33	X²
202	44	SUM
203	07	07
204	43	RCL
205	12	12
206	33	X²
207	55	+
208	43	RCL
209	01	01
210	95	=
211	44	SUM
212	08	08
213	01	1
214	44	SUM
215	13	13
216	73	RC*
217	09	09
218	33	X²
219	44	SUM
220	14	14
221	01	1
222	44	SUM
223	09	09
224	44	SUM
225	04	04
226	43	RCL
227	01	01
228	32	X:T
229	43	RCL
230	04	04
231	22	INV
232	77	GE
233	02	02
234	16	16
235	43	RCL
236	05	05

LOC	CODE	KEY
237	33	X²
238	55	+
239	43	RCL
240	13	13
241	95	=
242	42	STD
243	05	05
244	43	RCL
245	07	07
246	75	-
247	43	RCL
248	05	05
249	95	=
250	42	STD
251	07	07
252	43	RCL
253	08	08
254	75	-
255	43	RCL
256	05	05
257	95	=
258	42	STD
259	06	06
260	43	RCL
261	14	14
262	55	+
263	43	RCL
264	02	02
265	75	-
266	43	RCL
267	05	05
268	95	=
269	42	STD
270	12	12
271	43	RCL
272	07	07
273	75	-
274	43	RCL
275	06	06
276	75	-
277	43	RCL
278	12	12
279	95	=
280	42	STD
281	08	08
282	25	CLR
283	91	R/S
284	69	DP
285	00	00

LOC	CODE	KEY
286	01	1
287	06	6
288	01	1
289	03	3
290	03	3
291	07	7
292	01	1
293	03	3
294	69	DP
295	01	01
296	69	DP
297	05	05
298	03	3
299	91	R/S
300	22	INV
301	86	STF
302	07	07
303	03	3
304	00	0
305	42	STD
306	00	00
307	43	RCL
308	06	06
309	67	EQ
310	00	00
311	10	10
312	61	GTD
313	00	00
314	14	14
315	76	LBL
316	12	B
317	43	RCL
318	02	02
319	75	-
320	01	1
321	95	=
322	42	STD
323	15	15
324	91	R/S
325	43	RCL
326	01	01
327	75	-
328	01	1
329	95	=
330	42	STD
331	16	16
332	91	R/S
333	43	RCL
334	03	03

LOC	CODE	KEY
335	75	-
336	01	1
337	75	-
338	43	RCL
339	15	15
340	75	-
341	43	RCL
342	16	16
343	95	=
344	42	STD
345	17	17
346	91	R/S
347	43	RCL
348	03	03
349	75	-
350	01	1
351	95	=
352	42	STD
353	18	18
354	91	R/S
355	43	RCL
356	06	06
357	91	R/S
358	43	RCL
359	12	12
360	91	R/S
361	43	RCL
362	08	08
363	91	R/S
364	43	RCL
365	07	07
366	91	R/S
367	43	RCL
368	06	06
369	55	+
370	43	RCL
371	15	15
372	95	=
373	42	STD
374	19	19
375	22	INV
376	87	IFF
377	03	03
378	03	03
379	85	85
380	43	RCL
381	00	00
382	22	INV
383	44	SUM

LOC	CODE	KEY
384	19	19
385	43	RCL
386	19	19
387	91	R/S
388	43	RCL
389	12	12
390	55	÷
391	43	RCL
392	16	16
393	95	=
394	42	STO
395	20	20
396	91	R/S
397	43	RCL
398	08	08
399	55	÷
400	43	RCL
401	17	17
402	95	=
403	42	STO
404	21	21
405	91	R/S
406	43	RCL
407	19	19
408	55	÷
409	43	RCL
410	21	21
411	95	=
412	92	RTN

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	00	0
044	00	0
045	69	DP
046	02	02
047	03	3
048	07	7

LOC	CODE	KEY
049	03	3
050	05	5
051	03	3
052	07	7
053	04	4
054	00	0
055	00	0
056	00	0
057	69	DP
058	01	01
059	69	DP
060	05	05
061	43	RCL
062	02	02
063	75	-
064	01	1
065	95	=
066	42	STO
067	15	15
068	99	PRT
069	91	R/S
070	98	ADV
071	01	1
072	04	4
073	02	2
074	07	7
075	01	1
076	05	5
077	04	4
078	00	0
079	00	0
080	00	0
081	69	DP
082	01	01
083	69	DP
084	05	05
085	43	RCL
086	01	01
087	75	-
088	01	1
089	95	=
090	42	STO
091	16	16
092	99	PRT
093	91	R/S
094	98	ADV
095	03	3
096	05	5
097	01	1

LOC	CODE	KEY
098	07	7
099	03	3
100	06	6
101	04	4
102	00	0
103	00	0
104	00	0
105	69	DP
106	01	01
107	69	DP
108	05	05
109	43	RCL
110	03	03
111	75	-
112	01	1
113	75	-
114	43	RCL
115	15	15
116	75	-
117	43	RCL
118	16	16
119	95	=
120	42	STO
121	17	17
122	99	PRT
123	91	R/S
124	98	ADV
125	03	3
126	07	7
127	03	3
128	02	2
129	03	3
130	07	7
131	04	4
132	00	0
133	00	0
134	00	0
135	69	DP
136	01	01
137	69	DP
138	05	05
139	43	RCL
140	03	03
141	75	-
142	01	1
143	95	=
144	42	STO
145	16	16
146	99	PRT

LOC	CODE	KEY
147	91	R/S
148	98	ADV
149	03	3
150	06	6
151	04	4
152	00	0
153	03	3
154	06	6
155	04	4
156	00	0
157	00	0
158	00	0
159	69	DP
160	02	02
161	03	3
162	07	7
163	03	3
164	05	5
165	03	3
166	07	7
167	04	4
168	00	0
169	00	0
170	00	0
171	69	DP
172	01	01
173	69	DP
174	05	05
175	43	RCL
176	06	06
177	99	PRT
178	91	R/S
179	98	ADV
180	01	1
181	04	4
182	02	2
183	07	7
184	01	1
185	05	5
186	04	4
187	00	0
188	00	0
189	00	0
190	69	DP
191	01	01
192	69	DP
193	05	05
194	43	RCL
195	12	12

LOC	CODE	KEY
196	99	PRT
197	91	R/S
198	98	ADV
199	03	3
200	05	5
201	01	1
202	07	7
203	03	3
204	06	6
205	04	4
206	00	0
207	00	0
208	00	0
209	69	DP
210	01	01
211	69	DP
212	05	05
213	43	RCL
214	08	08
215	99	PRT
216	91	R/S
217	98	ADV
218	03	3
219	07	7
220	03	3
221	02	2
222	03	3
223	07	7
224	04	4
225	00	0
226	00	0
227	00	0
228	69	DP
229	01	01
230	69	DP
231	05	05
232	43	RCL
233	07	07
234	99	PRT
235	91	R/S
236	98	ADV
237	03	3
238	00	0
239	04	4
240	00	0
241	03	3
242	06	6
243	04	4
244	00	0

LOC	CODE	KEY
245	00	0
246	00	0
247	69	DP
248	02	02
249	03	3
250	07	7
251	03	3
252	05	5
253	03	3
254	07	7
255	04	4
256	00	0
257	00	0
258	00	0
259	69	DP
260	01	01
261	69	DP
262	05	05
263	43	RCL
264	06	06
265	55	+
266	43	RCL
267	15	15
268	95	=
269	42	STD
270	19	19
271	22	INV
272	87	IFF
273	03	03
274	02	02
275	81	81
276	43	RCL
277	00	00
278	22	INV
279	44	SUM
280	19	19
281	43	RCL
282	19	19
283	99	PRT
284	91	R/S
285	98	ADV
286	01	1
287	04	4
288	02	2
289	07	7
290	01	1
291	05	5
292	04	4
293	00	0

LOC	CODE	KEY
294	00	0
295	00	0
296	69	DP
297	01	01
298	69	DP
299	05	05
300	43	RCL
301	12	12
302	55	+
303	43	RCL
304	16	16
305	95	=
306	42	STD
307	20	20
308	99	PRT
309	91	R/S
310	98	ADV
311	03	3
312	05	5
313	01	1
314	07	7
315	03	3
316	06	6
317	04	4
318	00	0
319	00	0
320	00	0
321	69	DP
322	01	01
323	69	DP
324	05	05
325	43	RCL
326	08	08
327	55	+
328	43	RCL
329	17	17
330	95	=
331	42	STD
332	21	21
333	99	PRT
334	91	R/S
335	98	ADV
336	02	2
337	01	1
338	02	2
339	00	0
340	03	3
341	05	5
342	01	1

LOC	CODE	KEY
343	03	3
344	03	3
345	07	7
346	69	DP
347	01	01
348	02	2
349	04	4
350	03	3
351	02	2
352	00	0
353	00	0
354	05	5
355	05	5
356	03	3
357	07	7
358	69	DP
359	02	02
360	03	3
361	05	5
362	03	3
363	07	7
364	04	4
365	00	0
366	05	5
367	06	6
368	00	0
369	00	0
370	69	DP
371	03	03
372	69	DP
373	05	05
374	43	RCL
375	19	19
376	55	-
377	43	RCL
378	21	21
379	95	=
380	99	PRT
381	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX G

PROGRAM FOR LATIN SQUARE DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: One Treatment Factor in a Latin Square Design

OBJECTIVES: This program performs an analysis of variance for one treatment factor arranged in a latin square design. It accepts one missing observation, estimating its value by the method given by Snedecor and Cochran (1967).

LIMITS FOR:

- a) **TREATMENTS** : 15
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : 15

DATA INPUT TYPE: univariate, entering the observations by
ROWS

OUTPUT^(*): Row degrees of freedom
Column degrees of freedom
Treatment degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Row sum of squares
Column sum of squares
Treatment sum of squares
Residual sum of squares
Total sum of squares
Row mean square
Column mean square
Treatment mean square
Residual mean square
F-ratio for treatments

() Printed and displayed when **PRINTER UNIT** is used*

PROGRAM CARD DESCRIPTION

One Treatment Factor in LS				
Proc.	Resul.	Totals	Tot.MO	

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Input treatment totals	Total _i	C	Total _i
5a	If you have a missing obsv.	Total-MO	D	Total-MO
6	Process data card		A	
6a	If the number of observations is less than 30			0
6b	If the number of observations is greater than 30			'3' *
7a	If 6a is true go to step 9			
7b	If 6b is true load side 1 of data card ₂			3
8	Process data card		R/S	
8a	If all observations have been processed go to step 9			0
8b	If step 8a is not true			'3' *
8c	Load next data card and go to step 8			3
9	For a printed output go to step 10; otherwise go to step 12			
10	Load side 1 of program card ₂			1
11	Load side 2 of program card ₂			2
12	Obtain results		B	Row D.F.
			R/S	Col. D.F.
			R/S	Trt. D.F.
			R/S	Res. D.F.
			R/S	Tot. D.F.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	<p>* DATA will be printed if printer is attached</p>		<p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p> <p>R/S</p>	<p>Row S.S.</p> <p>Col. S.S.</p> <p>Trt. S.S.</p> <p>Res. S.S.</p> <p>Tot. S.S.</p> <p>Row M.S.</p> <p>Col. M.S.</p> <p>Trt. M.S.</p> <p>Res. M.S.</p> <p>F-Ratio</p> <p>Trt.</p>

SAMPLE PROBLEM

EXAMPLE: Analysis of Variance for four treatments arranged in a latin square design. Data from Steel and Torrie (1960), page 148.

		<u>COLUMNS</u>			
		C_1	C_2	C_3	C_4
<u>ROWS</u>	R_1	C = 10.5	D = 7.7	B = 12.0	A = 13.2
	R_2	B = 11.1	A = 12.0	C = 10.3	D = 7.5
	R_3	D = 5.8	C = 12.2	A = 11.2	B = 13.7
	R_4	A = 11.6	B = 12.3	D = 5.9	C = 10.2
Treatment Totals		A = 48.0			
		B = 49.1			
		C = 43.2			
		D = 26.9			

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
48.0	C	0	treatment _A total
49.1	C	0	treatment _B total
43.2	C	0	treatment _C total
26.9	C	0	treatment _D total
	A	0 will show in the display	process finished
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted

ENTER	PRESS	OUTPUT	COMMENTS
		(You do not have to read this card unless you want a printed output)	
	B	3	Row D.F.
	R/S	3	Column D.F.
	R/S	3	Treatment D.F.
	R/S	6	Residual D.F.
	R/S	15	Total D.F.
	R/S	1.955	Row S.S.
	R/S	6.8	Column S.S.
	R/S	78.925	Treatment S.S.
	R/S	2.72	Residual S.S.
	R/S	90.4	Total S.S.
	R/S	0.6516666667	Row M.S.
	R/S	2.266666667	Column M.S.
	R/S	26.3083333	Treatment M.S.
	R/S	0.453333333	Residual M.S.
	R/S	58.03308824	F-Ratio for Trt.

PRINTED OUTPUT

4.	
4.	
10.5	
7.7	
12.	
13.2	
11.1	
12.	
10.3	
7.5	
5.8	
12.2	
11.2	
13.7	
11.6	
12.3	
5.9	
10.2	
ANOVA TABLE	
ROW	D. F.
	3.
COL.	D. F.
	3.
TRT.	D. F.
	3.
RES.	D. F.
	6.
TOT.	D. F.
	15.
ROW	S. S.
	1.955
COL.	S. S.
	6.8
TRT.	S. S.
	78.925

RES.	S. S.
	2.72
TOT.	S. S.
	90.4
ROW	M. S.
	.6516666667
COL.	M. S.
	2.266666667
TRT.	M. S.
	26.30833333
RES.	M. S.
	.4533333333
F-RATIO (TRT.)	
	58.03308824

Latin Square

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	43	RCL	094	14	14	141	33	X ²
001	11	A	048	13	13	095	32	X↑T	142	55	+
002	03	3	049	77	GE	096	44	SUM	143	53	(
003	00	0	050	01	01	097	05	05	144	53	(
004	42	STD	051	17	17	098	44	SUM	145	43	RCL
005	00	00	052	00	0	099	06	06	146	01	01
006	01	1	053	42	STD	100	74	SM*	147	75	-
007	08	8	054	06	06	101	09	09	148	01	1
008	42	STD	055	22	INV	102	33	X ²	149	54)
009	09	09	056	86	STF	103	44	SUM	150	45	YX
010	43	RCL	057	02	02	104	07	07	151	03	3
011	01	01	058	61	GTO	105	69	DP	152	65	*
012	42	STD	059	00	00	106	20	20	153	53	(
013	04	04	060	10	10	107	69	DP	154	43	RCL
014	29	CP	061	73	RC*	108	29	29	155	01	01
015	43	RCL	062	00	00	109	01	1	156	75	-
016	04	04	063	69	DP	110	44	SUM	157	02	2
017	22	INV	064	19	19	111	13	13	158	54)
018	67	EQ	065	87	IFF	112	69	DP	159	33	X ²
019	00	00	066	07	07	113	34	34	160	54)
020	61	61	067	03	03	114	61	GTO	161	95	=
021	43	RCL	068	13	13	115	00	00	162	42	STD
022	06	06	069	32	X↑T	116	14	14	163	11	11
023	22	INV	070	43	RCL	117	22	INV	164	53	(
024	87	IFF	071	11	11	118	87	IFF	165	43	RCL
025	02	02	072	22	INV	119	03	03	166	02	02
026	00	00	073	67	EQ	120	02	02	167	65	*
027	33	33	074	00	00	121	35	35	168	53	(
028	42	STD	075	95	95	122	43	RCL	169	43	RCL
029	12	12	076	43	RCL	123	05	05	170	12	12
030	61	GTO	077	09	09	124	75	-	171	85	+
031	00	00	078	42	STD	125	43	RCL	172	73	RC*
032	40	40	079	10	10	126	12	12	173	10	10
033	33	X ²	080	86	STF	127	75	-	174	85	+
034	55	+	081	02	02	128	73	RC*	175	43	RCL
035	43	RCL	082	86	STF	129	10	10	176	16	16
036	01	01	083	03	03	130	75	-	177	54)
037	95	=	084	69	DP	131	53	(	178	75	-
038	44	SUM	085	20	20	132	43	RCL	179	02	2
039	08	08	086	69	DP	133	01	01	180	65	*
040	01	1	087	29	29	134	75	-	181	43	RCL
041	08	8	088	69	DP	135	01	1	182	05	05
042	42	STD	089	33	33	136	54	)	183	54)
043	09	09	090	69	DP	137	65	*	184	55	+
044	43	RCL	091	34	34	138	43	RCL	185	53	(
045	03	03	092	61	GTO	139	16	16	186	53	(
046	32	X↑T	093	00	00	140	95	=	187	43	RCL

LOC	CODE	KEY
188	02	02
189	75	-
190	01	1
191	54)
192	65	*
193	53	(
194	43	RCL
195	01	01
196	75	-
197	02	2
198	54)
199	54)
200	95	=
201	42	STD
202	17	17
203	44	SUM
204	05	05
205	74	SM*
206	10	10
207	44	SUM
208	12	12
209	44	SUM
210	16	16
211	33	X ²
212	44	SUM
213	07	07
214	43	RCL
215	12	12
216	33	X ²
217	55	+
218	43	RCL
219	01	01
220	95	=
221	44	SUM
222	08	08
223	43	RCL
224	16	16
225	33	X ²
226	55	+
227	43	RCL
228	01	01
229	95	=
230	44	SUM
231	15	15
232	01	1
233	44	SUM
234	13	13
235	73	RC*
236	09	09

LOC	CODE	KEY
237	33	X ²
238	44	SUM
239	14	14
240	69	DP
241	29	29
242	69	DP
243	24	24
244	43	RCL
245	01	01
246	32	XIT
247	43	RCL
248	04	04
249	22	INV
250	77	GE
251	02	02
252	35	35
253	43	RCL
254	05	05
255	33	X ²
256	55	+
257	43	RCL
258	13	13
259	95	=
260	42	STD
261	05	05
262	43	RCL
263	07	07
264	75	-
265	43	RCL
266	05	05
267	95	=
268	42	STD
269	07	07
270	43	RCL
271	15	15
272	75	-
273	43	RCL
274	05	05
275	95	=
276	42	STD
277	15	15
278	43	RCL
279	08	08
280	75	-
281	43	RCL
282	05	05
283	95	=
284	42	STD
285	06	06

LOC	CODE	KEY
286	43	RCL
287	14	14
288	55	+
289	43	RCL
290	01	01
291	75	-
292	43	RCL
293	05	05
294	95	=
295	42	STD
296	12	12
297	43	RCL
298	07	07
299	75	-
300	43	RCL
301	06	06
302	75	-
303	43	RCL
304	12	12
305	75	-
306	43	RCL
307	15	15
308	95	=
309	42	STD
310	08	08
311	25	CLR
312	91	R/S
313	01	1
314	06	6
315	01	1
316	03	3
317	03	3
318	07	7
319	01	1
320	03	3
321	69	DP
322	01	01
323	69	DP
324	05	05
325	03	3
326	91	R/S
327	22	INV
328	86	STF
329	07	07
330	03	3
331	00	0
332	42	STD
333	00	00
334	43	RCL

LOC	CODE	KEY
335	06	06
336	67	EQ
337	00	00
338	10	10
339	61	GTD
340	00	00
341	14	14
342	76	LBL
343	13	C
344	33	X ²
345	55	+
346	43	RCL
347	01	01
348	95	=
349	44	SUM
350	15	15
351	25	CLR
352	92	RTN
353	76	LBL
354	14	D
355	42	STD
356	16	16
357	25	CLR
358	25	CLR
359	76	LBL
360	12	B
361	43	RCL
362	01	01
363	75	-
364	01	1
365	95	=
366	42	STD
367	09	09
368	91	R/S
369	43	RCL
370	09	09
371	91	R/S
372	43	RCL
373	09	09
374	91	R/S
375	43	RCL
376	03	03
377	75	-
378	01	1
379	95	=
380	42	STD
381	10	10
382	75	-
383	03	3

LOC	CODE	KEY
384	65	X
385	43	RCL
386	09	09
387	95	=
388	42	STD
389	04	04
390	91	R/S
391	43	RCL
392	10	10
393	91	R/S
394	43	RCL
395	06	06
396	91	R/S
397	43	RCL
398	12	12
399	91	R/S
400	43	RCL
401	15	15
402	91	R/S
403	43	RCL
404	08	08
405	91	R/S
406	43	RCL
407	07	07
408	91	R/S
409	43	RCL
410	06	06
411	55	+
412	43	RCL
413	09	09
414	95	=
415	42	STD
416	13	13
417	91	R/S
418	43	RCL
419	12	12
420	55	+
421	43	RCL
422	09	09
423	95	=
424	42	STD
425	14	14
426	91	R/S
427	43	RCL
428	15	15
429	55	+
430	43	RCL
431	09	09
432	95	=

LOC	CODE	KEY
433	42	STD
434	16	16
435	22	INV
436	87	IFF
437	03	03
438	04	04
439	45	45
440	43	RCL
441	11	11
442	22	INV
443	44	SUM
444	16	16
445	43	RCL
446	16	16
447	91	R/S
448	43	RCL
449	08	08
450	55	+
451	43	RCL
452	04	04
453	95	=
454	42	STD
455	18	18
456	43	RCL
457	18	18
458	91	R/S
459	43	RCL
460	16	16
461	55	+
462	43	RCL
463	18	18
464	95	=
465	92	RTN

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	00	0
044	00	0
045	69	DP
046	02	02
047	03	3
048	05	5

LOC	CODE	KEY
049	03	3
050	02	2
051	04	4
052	03	3
053	00	0
054	00	0
055	00	0
056	00	0
057	69	DP
058	01	01
059	69	DP
060	05	05
061	43	RCL
062	02	02
063	75	-
064	01	1
065	95	=
066	42	STD
067	09	09
068	99	PRT
069	91	R/S
070	98	ADV
071	01	1
072	05	5
073	03	3
074	02	2
075	02	2
076	07	7
077	04	4
078	00	0
079	00	0
080	00	0
081	69	DP
082	01	01
083	69	DP
084	05	05
085	43	RCL
086	09	09
087	99	PRT
088	91	R/S
089	98	ADV
090	03	3
091	07	7
092	03	3
093	05	5
094	03	3
095	07	7
096	04	4
097	00	0

LOC	CODE	KEY
098	00	0
099	00	0
100	69	DP
101	01	01
102	69	DP
103	05	05
104	43	RCL
105	09	09
106	99	PRT
107	91	R/S
108	98	ADV
109	03	3
110	05	5
111	01	1
112	07	7
113	03	3
114	06	6
115	04	4
116	00	0
117	00	0
118	00	0
119	69	DP
120	01	01
121	69	DP
122	05	05
123	43	RCL
124	03	03
125	75	-
126	01	1
127	95	=
128	42	STD
129	10	10
130	75	-
131	03	3
132	65	×
133	43	RCL
134	09	09
135	95	=
136	42	STD
137	04	04
138	99	PRT
139	91	R/S
140	98	ADV
141	03	3
142	07	7
143	03	3
144	02	2
145	03	3
146	07	7

LOC	CODE	KEY
147	04	4
148	00	0
149	00	0
150	00	0
151	69	DP
152	01	01
153	69	DP
154	05	05
155	43	RCL
156	10	10
157	99	PRT
158	91	R/S
159	98	ADV
160	03	3
161	06	6
162	04	4
163	00	0
164	03	3
165	06	6
166	04	4
167	00	0
168	00	0
169	00	0
170	69	DP
171	02	02
172	03	3
173	05	5
174	03	3
175	02	2
176	04	4
177	03	3
178	00	0
179	00	0
180	00	0
181	00	0
182	69	DP
183	01	01
184	69	DP
185	05	05
186	43	RCL
187	06	06
188	99	PRT
189	91	R/S
190	98	ADV
191	01	1
192	05	5
193	03	3
194	02	2
195	02	2

LOC	CODE	KEY
196	07	7
197	04	4
198	00	0
199	00	0
200	00	0
201	69	DP
202	01	01
203	69	DP
204	05	05
205	43	RCL
206	12	12
207	99	PRT
208	91	R/S
209	98	ADV
210	03	3
211	07	7
212	03	3
213	05	5
214	03	3
215	07	7
216	04	4
217	00	0
218	00	0
219	00	0
220	69	DP
221	01	01
222	69	DP
223	05	05
224	43	RCL
225	15	15
226	99	PRT
227	91	R/S
228	98	ADV
229	03	3
230	05	5
231	01	1
232	07	7
233	03	3
234	06	6
235	04	4
236	00	0
237	00	0
238	00	0
239	69	DP
240	01	01
241	69	DP
242	05	05
243	43	RCL
244	08	08

LOC	CODE	KEY
245	99	PRT
246	91	R/S
247	98	ADV
248	03	3
249	07	7
250	03	3
251	02	2
252	03	3
253	07	7
254	04	4
255	00	0
256	00	0
257	00	0
258	69	DP
259	01	01
260	69	DP
261	05	05
262	43	RCL
263	07	07
264	99	PRT
265	91	R/S
266	98	ADV
267	03	3
268	00	0
269	04	4
270	00	0
271	03	3
272	06	6
273	04	4
274	00	0
275	00	0
276	00	0
277	69	DP
278	02	02
279	03	3
280	05	5
281	03	3
282	02	2
283	04	4
284	03	3
285	00	0
286	00	0
287	00	0
288	00	0
289	69	DP
290	01	01
291	69	DP
292	05	05
293	43	RCL

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
294	06	06	343	43	RCL	392	01	1			
295	55	÷	344	15	15	393	02	2			
296	43	RCL	345	55	÷	394	00	0			
297	09	09	346	43	RCL	395	03	3			
298	95	=	347	09	09	396	05	5			
299	42	STD	348	95	=	397	01	1			
300	13	13	349	42	STD	398	03	3			
301	99	PRT	350	16	16	399	03	3			
302	91	R/S	351	22	INV	400	07	7			
303	98	ADV	352	87	IFF	401	69	DP			
304	01	1	353	03	03	402	01	01			
305	05	5	354	03	03	403	02	2			
306	03	3	355	61	61	404	04	4			
307	02	2	356	43	RCL	405	03	3			
308	02	2	357	11	11	406	02	2			
309	07	7	358	22	INV	407	00	0			
310	04	4	359	44	SUM	408	00	0			
311	00	0	360	16	16	409	05	5			
312	00	0	361	43	RCL	410	05	5			
313	00	0	362	16	16	411	03	3			
314	69	DP	363	99	PRT	412	07	7			
315	01	01	364	91	R/S	413	69	DP			
316	69	DP	365	98	ADV	414	02	02			
317	05	05	366	03	3	415	03	3			
318	43	RCL	367	05	5	416	05	5			
319	12	12	368	01	1	417	03	3			
320	55	÷	369	07	7	418	07	7			
321	43	RCL	370	03	3	419	04	4			
322	09	09	371	06	6	420	00	0			
323	95	=	372	04	4	421	05	5			
324	42	STD	373	00	0	422	06	6			
325	14	14	374	00	0	423	00	0			
326	99	PRT	375	00	0	424	00	0			
327	91	R/S	376	69	DP	425	69	DP			
328	98	ADV	377	01	01	426	03	03			
329	03	3	378	69	DP	427	69	DP			
330	07	7	379	05	05	428	05	05			
331	03	3	380	43	RCL	429	43	RCL			
332	05	5	381	08	08	430	16	16			
333	03	3	382	55	÷	431	55	÷			
334	07	7	383	43	RCL	432	43	RCL			
335	04	4	384	04	04	433	18	18			
336	00	0	385	95	=	434	95	=			
337	00	0	386	42	STD	435	99	PRT			
338	00	0	387	18	18	436	92	RTN			
339	69	DP	388	99	PRT						
340	01	01	389	91	R/S						
341	69	DP	390	98	ADV						
342	05	05	391	02	2						

APPENDIX H

PROGRAM FOR T-TEST OF UNPAIRED OBSERVATIONS

PROGRAM DESCRIPTION

PROGRAM TITLE: T-Test of Unpaired Observations

OBJECTIVES: This program performs a t-test for significant differences between two means (\bar{x}_a , \bar{x}_b) when the observations are unpaired.

LIMITS FOR:

- a) **TREATMENTS** : 2
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** :

DATA INPUT TYPE: bivariate

OUTPUT^(*): Treatment means, \bar{x}_a and \bar{x}_b
t-value

() printed and displayed when PRINTER UNIT is used*

PROGRAM CARD DESCRIPTION

t-Test for Unpaired Observ.				
Proc.	Resul	H ₀ val		

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card			1
2	Load side 2 of program card			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter null hypothesis (H ₀) value, otherwise assume $\mu = 0$	H ₀ value	C	H ₀ value
6	Process data card		A	
6a	If the number of observations is less than 30			0
6b	If the number of observations is greater than 30			'3' *
7a	If 6a is true go to step 9			
7b	If 6b is true load side 1 of data card ₂			3
8	Process data card		R/S	
8a	If all observations have been processed go to step 9			0
8b	If step 8a is not true			'3' *
8c	Load next data card and go to step 8			3
9	Obtain results		B	\bar{x}_a
			R/S	\bar{x}_b
			R/S	t-Value
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: t-test for significant difference between two means, unpaired observations. Data from Sokal and Rohlf (1969), page 218.

<u>A</u>	<u>B</u>
7.2	8.8
7.1	7.5
9.1	7.7
7.2	7.6
7.3	7.4
7.2	6.7
7.5	7.2

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card		display will show # 1	card upright
Prog. card		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
	A	0 will show in the display	process finished
	B	7.514285714	\bar{x}_a
	R/S	7.557142857	\bar{x}_b
	R/S	-0.1185854123	t-value

PRINTED OUTPUT

2.
7.

7.2
8.8

7.1
7.5

9.1
7.7

7.2
7.6

7.3
7.4

7.2
6.7

7.5
7.2

T-TEST

7.514285714 2A

7.557142857 2B

T UNPAIRED IS
-.1185854123

T-test of Unpaired
Observations

LOC	CODE	KEY
000	76	LBL
001	11	A
002	03	3
003	00	0
004	42	STD
005	05	05
006	03	3
007	01	1
008	42	STD
009	06	06
010	00	0
011	42	STD
012	07	07
013	42	STD
014	08	08
015	42	STD
016	09	09
017	29	CP
018	43	RCL
019	01	01
020	22	INV
021	67	EQ
022	00	00
023	87	87
024	43	RCL
025	07	07
026	55	+
027	43	RCL
028	12	12
029	95	=
030	42	STD
031	03	03
032	43	RCL
033	08	08
034	75	-
035	53	(
036	43	RCL
037	07	07
038	33	X ²
039	55	+
040	43	RCL
041	12	12
042	54)
043	95	=
044	55	+
045	53	(
046	43	RCL

LOC	CODE	KEY
047	12	12
048	75	-
049	01	1
050	54)
051	95	=
052	42	STD
053	14	14
054	43	RCL
055	09	09
056	55	+
057	43	RCL
058	13	13
059	95	=
060	42	STD
061	04	04
062	43	RCL
063	10	10
064	75	-
065	53	(
066	43	RCL
067	09	09
068	33	X ²
069	55	+
070	43	RCL
071	13	13
072	54)
073	95	=
074	55	+
075	53	(
076	43	RCL
077	13	13
078	75	-
079	01	1
080	54)
081	95	=
082	42	STD
083	15	15
084	61	GTO
085	01	01
086	62	62
087	73	RC*
088	06	06
089	69	DP
090	19	19
091	87	IFF
092	07	07
093	02	02

PROGRAM LISTING

LOC	CODE	KEY
094	39	39
095	73	RC*
096	05	05
097	32	XIT
098	43	RCL
099	11	11
100	22	INV
101	67	EQ
102	01	01
103	09	09
104	86	STF
105	01	01
106	02	2
107	44	SUM
108	05	05
109	73	RC*
110	06	06
111	32	XIT
112	43	RCL
113	11	11
114	22	INV
115	67	EQ
116	01	01
117	23	23
118	86	STF
119	02	02
120	02	2
121	44	SUM
122	06	06
123	87	IFF
124	01	01
125	01	01
126	40	40
127	73	RC*
128	05	05
129	44	SUM
130	07	07
131	33	X ²
132	44	SUM
133	08	08
134	02	2
135	44	SUM
136	05	05
137	01	1
138	44	SUM
139	12	12
140	87	IFF

LOC	CODE	KEY
141	02	02
142	01	01
143	57	57
144	73	RC*
145	06	06
146	44	SUM
147	09	09
148	33	X ²
149	44	SUM
150	10	10
151	02	2
152	44	SUM
153	06	06
154	01	1
155	44	SUM
156	13	13
157	69	DP
158	31	31
159	61	GTO
160	00	00
161	17	17
162	53	(
163	43	RCL
164	03	03
165	75	-
166	43	RCL
167	04	04
168	54)
169	75	-
170	43	RCL
171	16	16
172	95	=
173	42	STD
174	05	05
175	53	(
176	53	(
177	43	RCL
178	12	12
179	75	-
180	01	1
181	54)
182	65	X
183	43	RCL
184	14	14
185	85	+
186	53	(
187	43	RCL

LOC	CODE	KEY
188	13	13
189	75	-
190	01	1
191	54)
192	65	*
193	43	RCL
194	15	15
195	54)
196	55	+
197	53	(
198	43	RCL
199	12	12
200	85	+
201	43	RCL
202	13	13
203	75	-
204	02	2
205	54)
206	95	=
207	65	*
208	53	(
209	53	(
210	43	RCL
211	12	12
212	85	+
213	43	RCL
214	13	13
215	54)
216	55	+
217	53	(
218	43	RCL
219	12	12
220	65	*
221	43	RCL
222	13	13
223	54)
224	54)
225	95	=
226	34	FX
227	42	STD
228	06	06
229	43	RCL
230	05	05
231	55	+
232	43	RCL
233	06	06
234	95	=
235	42	STD
236	11	11

LOC	CODE	KEY
237	25	CLR
238	91	R/S
239	69	DP
240	00	00
241	01	1
242	06	6
243	01	1
244	03	3
245	03	3
246	07	7
247	01	1
248	03	3
249	69	DP
250	01	01
251	69	DP
252	05	05
253	03	3
254	91	R/S
255	22	INV
256	86	STF
257	07	07
258	03	3
259	00	0
260	42	STD
261	05	05
262	03	3
263	01	1
264	42	STD
265	06	06
266	61	GTD
267	00	00
268	17	17
269	76	LBL
270	12	B
271	69	DP
272	00	00
273	03	3
274	07	7
275	69	DP
276	01	01
277	02	2
278	00	0
279	03	3
280	07	7
281	01	1
282	07	7
283	03	3
284	06	6
285	03	3

LOC	CODE	KEY
286	07	7
287	69	DP
288	02	02
289	69	DP
290	05	05
291	98	ADV
292	98	ADV
293	06	6
294	07	7
295	01	1
296	03	3
297	00	0
298	00	0
299	00	0
300	00	0
301	69	DP
302	04	04
303	43	RCL
304	03	03
305	69	DP
306	06	06
307	98	ADV
308	91	R/S
309	06	6
310	07	7
311	01	1
312	04	4
313	00	0
314	00	0
315	00	0
316	00	0
317	69	DP
318	04	04
319	43	RCL
320	04	04
321	69	DP
322	06	06
323	69	DP
324	00	00
325	98	ADV
326	91	R/S
327	03	3
328	07	7
329	00	0
330	00	0
331	04	4
332	01	1
333	03	3
334	01	1

LOC	CODE	KEY
335	03	3
336	03	3
337	69	DP
338	01	01
339	01	1
340	03	3
341	02	2
342	04	4
343	03	3
344	05	5
345	01	1
346	07	7
347	01	1
348	06	6
349	69	DP
350	02	02
351	02	2
352	04	4
353	03	3
354	06	6
355	00	0
356	00	0
357	00	0
358	00	0
359	69	DP
360	03	03
361	69	DP
362	05	05
363	43	RCL
364	11	11
365	99	FRT
366	92	RTN
367	76	LBL
368	13	C
369	42	STD
370	16	16
371	92	RTN

APPENDIX I

PROGRAM FOR T-TEST OF PAIRED OBSERVATIONS

PROGRAM DESCRIPTION

PROGRAM TITLE: t-Test of Paired Observations

OBJECTIVES: This program performs a t-test for significant differences between two means when observations are paired.

LIMITS FOR:

- a) **TREATMENTS** : 2
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: bivariate

OUTPUT^(*): Treatment means, \bar{x}_a and \bar{x}_b
t-value

() printed and displayed when **PRINTER UNIT** is used*

PROGRAM CARD DESCRIPTION

t-Test Paired Observations				
Proc.	Resul.	H ₀ val		

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card			1
2	Load side 2 of program card			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter null hypothesis (H ₀) value, otherwise assume $\mu = 0$	H ₀ value	C	H ₀ value
6	Process data card		A	
6a	If the number of observations is less than 30			0
6b	If the number of observations is greater than 30			'3' *
7a	If 6a is true go to step 9			
7b	If 6b is true load side 1 of data card ₂			3
8	Process data card		R/S	
8a	If all observations have been processed go to step 9			0
8b	If step 8a is not true			'3' *
8c	Load next data card and go to step 8			3
9	Obtain results		B	\bar{x}_a
			R/S	\bar{x}_b
			R/S	t-value
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: t-Test for significant difference between two means, paired observations. Data from Sokal and Rohlf (1969), page 330.

<u>T₁</u>	<u>T₂</u>
7.33	7.53
7.49	7.70
7.27	7.46
7.93	8.21
7.56	7.81
7.81	8.01
7.46	7.72
6.94	7.13
7.49	7.68
7.44	7.66
7.95	8.11
7.47	7.66
7.04	7.20
7.10	7.25
7.64	7.79

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card		display will show # 1	card upright
Prog. card		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
	A	0 will show in the display	process finished
	B	7.461333333	\bar{x}_a
	R/S	7.661333333	\bar{x}_b
	R/S	19.72026594	t-Value paired

PRINTED OUTPUT

```

      2.
     15.

    7.33
    7.53

    7.49
     7.7

    7.27
    7.46

    7.93
    8.21

    7.56
    7.81

    7.81
    8.01

    7.46
    7.72

    6.94
    7.13

    7.49
    7.68

    7.44
    7.66

    7.95
    8.11

    7.47
    7.66

    7.04
     7.2

```

```

      7.1
      7.25

      7.64
      7.79

      T-TEST

      7.461333333      XB
      7.661333333      XB

T PAIRED IS
  19.72026594

```

T-test of Paired
Observations

LOC	CODE	KEY
000	76	LBL
001	11	A
002	03	3
003	00	0
004	42	STD
005	05	05
006	03	3
007	01	1
008	42	STD
009	06	06
010	00	0
011	42	STD
012	07	07
013	42	STD
014	08	08
015	42	STD
016	09	09
017	29	CP
018	43	RCL
019	01	01
020	22	INV
021	67	EQ
022	00	00
023	57	57
024	43	RCL
025	09	09
026	55	+
027	43	RCL
028	12	12
029	95	=
030	42	STD
031	13	13
032	43	RCL
033	10	10
034	75	-
035	53	(
036	43	RCL
037	09	09
038	33	X ²
039	55	+
040	43	RCL
041	12	12
042	54)
043	95	=
044	55	+
045	53	(
046	43	RCL

LOC	CODE	KEY
047	12	12
048	75	-
049	01	1
050	54)
051	95	=
052	42	STD
053	11	11
054	61	GTO
055	00	00
056	95	95
057	73	RC*
058	06	06
059	69	DP
060	19	19
061	87	IFF
062	07	07
063	01	01
064	38	38
065	73	RC*
066	05	05
067	44	SUM
068	07	07
069	32	X:IT
070	73	RC*
071	06	06
072	44	SUM
073	08	08
074	75	-
075	32	X:IT
076	95	=
077	44	SUM
078	09	09
079	33	X ²
080	44	SUM
081	10	10
082	02	2
083	44	SUM
084	05	05
085	44	SUM
086	06	06
087	01	1
088	44	SUM
089	12	12
090	69	DP
091	31	31
092	61	GTO
093	00	00

PROGRAM LISTING

LOC	CODE	KEY
094	17	17
095	43	RCL
096	07	07
097	55	+
098	43	RCL
099	12	12
100	95	=
101	42	STD
102	01	01
103	43	RCL
104	08	08
105	55	+
106	43	RCL
107	12	12
108	95	=
109	42	STD
110	02	02
111	43	RCL
112	13	13
113	75	-
114	43	RCL
115	14	14
116	95	=
117	42	STD
118	03	03
119	43	RCL
120	11	11
121	55	+
122	43	RCL
123	12	12
124	95	=
125	34	FX
126	42	STD
127	04	04
128	43	RCL
129	03	03
130	55	+
131	43	RCL
132	04	04
133	95	=
134	42	STD
135	05	05
136	25	CLR
137	91	R/S
138	69	DP
139	00	00
140	01	1

LOC	CODE	KEY
141	06	6
142	01	1
143	03	3
144	03	3
145	07	7
146	01	1
147	03	3
148	69	DP
149	01	01
150	69	DP
151	05	05
152	03	3
153	91	R/S
154	22	INV
155	86	STF
156	07	07
157	03	3
158	00	0
159	42	STD
160	05	05
161	03	3
162	01	1
163	42	STD
164	06	06
165	61	GTO
166	00	00
167	17	17
168	76	LBL
169	12	B
170	69	DP
171	00	00
172	03	3
173	07	7
174	69	DP
175	01	01
176	02	2
177	00	0
178	03	3
179	07	7
180	01	1
181	07	7
182	03	3
183	06	6
184	03	3
185	07	7
186	69	DP
187	02	02

LOC	CODE	KEY
188	69	DP
189	05	05
190	98	ADV
191	98	ADV
192	06	6
193	07	7
194	01	1
195	03	3
196	00	0
197	00	0
198	00	0
199	00	0
200	69	DP
201	04	04
202	43	RCL
203	01	01
204	69	DP
205	06	06
206	91	R/S
207	98	ADV
208	06	6
209	07	7
210	01	1
211	04	4
212	00	0
213	00	0
214	00	0
215	00	0
216	69	DP
217	04	04
218	43	RCL
219	02	02
220	69	DP
221	06	06
222	69	DP
223	00	00
224	91	R/S
225	98	ADV
226	03	3
227	07	7
228	00	0
229	00	0
230	03	3
231	03	3
232	01	1
233	03	3
234	02	2
235	04	4
236	69	DP

LOC	CODE	KEY
237	01	01
238	03	3
239	05	5
240	01	1
241	07	7
242	01	1
243	06	6
244	00	0
245	00	0
246	02	2
247	04	4
248	69	DP
249	02	02
250	03	3
251	06	6
252	00	0
253	00	0
254	00	0
255	00	0
256	00	0
257	00	0
258	00	0
259	00	0
260	69	DP
261	03	03
262	69	DP
263	05	05
264	43	RCL
265	05	05
266	99	PRT
267	92	RTN
268	76	LBL
269	13	C
270	42	STO
271	14	14
272	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX J

PROGRAM FOR COVARIANCE ANALYSIS IN A
COMPLETELY RANDOMIZED DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Covariance Analysis in a Completely Randomized Design

OBJECTIVES: This program performs an analysis of covariance for one treatment factor and one covariate arranged in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number, with one covariate
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : any number, equal or not

DATA INPUT TYPE: bivariate

OUTPUT^(*): Treatment degrees of freedom
Residual degrees of freedom
Treatment + residual degrees of freedom
Treatment sum of squares for Y, XY, and X
Residual sum of squares for Y, XY, and X
Treatment+residual sum of squares for Y, XY, and X
Residual adjusted degrees of freedom
Treatment+residual adjusted degrees of freedom
Treatment adjusted degrees of freedom
Residual adjusted sum of squares
Treatment+residual adjusted sum of squares
Treatment adjusted sum of squares
Residual adjusted mean square
Treatment adjusted mean square
F-ratio for adjusted treatments

() printed and displayed when PRINTER UNIT is used*

PROGRAM CARD DESCRIPTION

Covariance Analysis in CRD				
Proc.	Resul.			

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Process data card		A	
5a	If number of observations is less than 30			0
5b	If number of observations is greater than 30			'3' *
6a	If step 5a is true go to step 8			
6b	If step 5b is true load side 1 of data card ₂			3
7	Process data card		R/S	
7a	If all observations have been processed go to step 8			0
7b	If step 7a is not true			'3' *
7c	Load next data card and go to step 7			3
8	For a printed output go to step 9; otherwise go to step 13			
9	Set new partition	3	2nd OP 17	719.29
10	Load side 1 of program card ₂			1
11	Load side 2 of program card ₂			2
12	Load side 1 of program card ₃			3
13	Obtain results		B R/S R/S	Trt. D.F. Res. D.F. T+R D.F.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	Trt. Y S.S.
			R/S	Trt. XY S.S.
			R/S	Trt. X S.S.
			R/S	Res. Y S.S.
			R/S	Res. XY S.S.
			R/S	Res. X S.S.
			R/S	T+R Y S.S.
			R/S	T+R XY S.S.
			R/S	T+R X S.S.
			R/S	Res. adj. D.F.
			R/S	T+R adj. D.F.
			R/S	Trt. adj. D.F.
			R/S	Res. adj. S.S.
			R/S	T+R adj. S.S.
			R/S	Res. adj. M.S.
			R/S	Trt. adj. M.S.
			R/S	F-ratio for Trt. adj.
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Analysis of covariance for three treatments and one covariate arranged in a completely randomized design. Data from Snedecor and Cochran (1967), page 422.

<u>T₁</u>		<u>T₂</u>		<u>T₃</u>	
<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>	<u>X</u>	<u>Y</u>
11	6	6	0	16	13
8	0	6	2	13	10
5	2	7	3	11	18
14	8	8	1	9	5
19	11	18	18	21	23
6	4	8	4	16	12
10	13	19	14	12	5
6	1	8	9	12	16
11	8	5	1	7	1
3	0	15	9	12	20

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂		display will show # 3	card upright
	R/S	0 will show in the display	process finished

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
		(You do not have to read this card unless you want a printed output)	
	B	2	Treatment D.F.
	R/S	27	Residual D.F.
	R/S	29	Trt.+Res. D.F.
	R/S	293.6	Trt. Y S.S.
	R/S	145.8	Trt. XY S.S.
	R/S	72.86666667	Trt. X S.S.
	R/S	995.1	Residual Y S.S.
	R/S	585.4	Residual XY S.S.
	R/S	593.0	Residual X S.S.
	R/S	1288.7	Trt.+Res. Y S.S.
	R/S	731.2	Trt.+Res. XY S.S.
	R/S	665.8666667	Trt.+Res. X S.S.
	R/S	26	Residual D.F. adj.
	R/S	28	Trt.+Res. D.F.adj.
	R/S	2	Trt. D.F. adj.
	R/S	417.202597	Residual S.S. adj.
	R/S	485.7563076	Trt.+Res S.S. adj.
	R/S	68.55371061	Trt. S.S. adj.
	R/S	16.04625373	Residual M.S. adj.
	R/S	34.2768553	Treatment M.S. adj
	R/S	2.136128213	F-Ratio for Trt.

PRINTED OUTPUT

```

3.
10.

11.
6.

8.
0.

5.
2.

14.
8.

19.
11.

6.
4.

10.
13.

6.
1.

11.
8.

3.
0.

6.
0.

6.
2.

7.
3.

```

```

8.
1.

18.
18.

RECORD DATA
8.
4.

19.
14.

8.
9.

5.
1.

15.
9.

16.
13.

13.
10.

11.
18.

9.
5.

21.
23.

16.
12.

12.
5.

```

	12.
	16.
	7.
	1.
	12.
	20.
DATA	
ANCOVA TABLE	
TRT. D. F.	2.
RES. D. F.	27.
T+R D. F.	29.
TRT Y S. S.	293.6
TRTX Y S. S.	145.8
TRT X S. S.	72.86666667
RES Y S. S.	995.1
RESXY S. S.	585.4
RES X S. S.	593.
T+R Y S. S.	1288.7
T+RXY S. S.	731.2

T+R X S. S.	665.8666667
RES. D. F. ADJ.	26.
T+R D. F. ADJ.	28.
TRT. D. F. ADJ.	2.
RES. S. S. ADJ.	417.202597
T+R S. S. ADJ.	485.7563076
TRT. S. S. ADJ.	68.55371061
RES. M. S. ADJ.	16.04625373
TRT. M. S. ADJ.	34.2768553
F-RATIO ADJ.	2.136128213

Covariance Analysis in CRD

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	A
002	43	RCL
003	01	01
004	42	STD
005	07	07
006	43	RCL
007	02	02
008	42	STD
009	08	08
010	43	RCL
011	03	03
012	42	STD
013	09	09
014	03	3
015	00	0
016	42	STD
017	00	00
018	03	3
019	01	1
020	42	STD
021	10	10
022	00	0
023	42	STD
024	01	01
025	42	STD
026	02	02
027	42	STD
028	03	03
029	42	STD
030	04	04
031	42	STD
032	05	05
033	42	STD
034	06	06
035	43	RCL
036	07	07
037	42	STD
038	12	12
039	29	CP
040	43	RCL
041	12	12
042	22	INV
043	67	EQ
044	01	01
045	09	09
046	43	RCL

LOC	CODE	KEY
047	01	01
048	44	SUM
049	13	13
050	33	X ²
051	55	+
052	43	RCL
053	03	03
054	95	=
055	44	SUM
056	14	14
057	43	RCL
058	02	02
059	44	SUM
060	15	15
061	43	RCL
062	03	03
063	42	STD
064	16	16
065	44	SUM
066	17	17
067	43	RCL
068	04	04
069	44	SUM
070	18	18
071	33	X ²
072	55	+
073	43	RCL
074	03	03
075	95	=
076	44	SUM
077	19	19
078	43	RCL
079	05	05
080	44	SUM
081	20	20
082	43	RCL
083	06	06
084	44	SUM
085	21	21
086	43	RCL
087	01	01
088	65	X
089	43	RCL
090	04	04
091	95	=
092	55	+
093	43	RCL

LOC	CODE	KEY
094	03	03
095	95	=
096	44	SUM
097	27	27
098	43	RCL
099	09	09
100	32	XIT
101	43	RCL
102	17	17
103	77	GE
104	01	01
105	54	54
106	61	GTD
107	00	00
108	22	22
109	73	RC*
110	10	10
111	69	DP
112	19	19
113	87	IFF
114	07	07
115	04	04
116	17	17
117	32	XIT
118	43	RCL
119	11	11
120	22	INV
121	67	EQ
122	01	01
123	36	36
124	02	2
125	44	SUM
126	00	00
127	44	SUM
128	10	10
129	01	1
130	22	INV
131	44	SUM
132	09	09
133	61	GTD
134	01	01
135	47	47
136	73	RC*
137	00	00
138	32	XIT
139	73	RC*
140	10	10

LOC	CODE	KEY
141	78	Σ+
142	02	2
143	44	SUM
144	00	00
145	44	SUM
146	10	10
147	01	1
148	22	INV
149	44	SUM
150	12	12
151	61	GTD
152	00	00
153	39	39
154	43	RCL
155	15	15
156	75	-
157	53	(
158	43	RCL
159	13	13
160	33	X ²
161	55	+
162	43	RCL
163	17	17
164	54)
165	95	=
166	42	STD
167	22	22
168	43	RCL
169	20	20
170	75	-
171	53	(
172	43	RCL
173	18	18
174	33	X ²
175	55	+
176	43	RCL
177	17	17
178	54)
179	95	=
180	42	STD
181	23	23
182	43	RCL
183	21	21
184	75	-
185	53	(
186	53	(
187	43	RCL

LOC	CODE	KEY
188	13	13
189	65	X
190	43	RCL
191	18	18
192	54)
193	55	+
194	43	RCL
195	17	17
196	54)
197	95	=
198	42	STD
199	24	24
200	43	RCL
201	14	14
202	75	-
203	53	(
204	43	RCL
205	13	13
206	33	X ²
207	55	+
208	43	RCL
209	17	17
210	54)
211	95	=
212	42	STD
213	25	25
214	43	RCL
215	19	19
216	75	-
217	53	(
218	43	RCL
219	18	18
220	33	X ²
221	55	+
222	43	RCL
223	17	17
224	54)
225	95	=
226	42	STD
227	26	26
228	43	RCL
229	27	27
230	75	-
231	53	(
232	43	RCL
233	13	13
234	65	X
235	43	RCL
236	18	18

LOC	CODE	KEY
237	55	+
238	43	RCL
239	17	17
240	54)
241	95	=
242	42	STD
243	15	15
244	25	CLR
245	92	RTN
246	76	LBL
247	12	B
248	43	RCL
249	08	08
250	75	-
251	01	1
252	95	=
253	42	STD
254	01	01
255	91	R/S
256	53	(
257	43	RCL
258	09	09
259	75	-
260	01	1
261	54)
262	75	-
263	53	(
264	43	RCL
265	08	08
266	75	-
267	01	1
268	54)
269	95	=
270	42	STD
271	02	02
272	91	R/S
273	43	RCL
274	09	09
275	75	-
276	01	1
277	95	=
278	42	STD
279	03	03
280	91	R/S
281	43	RCL
282	25	25
283	91	R/S
284	43	RCL
285	15	15

LOC	CODE	KEY
286	91	R/S
287	43	RCL
288	26	26
289	91	R/S
290	43	RCL
291	22	22
292	75	-
293	43	RCL
294	25	25
295	95	=
296	42	STD
297	17	17
298	91	R/S
299	43	RCL
300	24	24
301	75	-
302	43	RCL
303	15	15
304	95	=
305	42	STD
306	18	18
307	91	R/S
308	43	RCL
309	23	23
310	75	-
311	43	RCL
312	26	26
313	95	=
314	42	STD
315	19	19
316	91	R/S
317	43	RCL
318	22	22
319	91	R/S
320	43	RCL
321	24	24
322	91	R/S
323	43	RCL
324	23	23
325	91	R/S
326	43	RCL
327	02	02
328	75	-
329	01	1
330	95	=
331	42	STD
332	05	05
333	91	R/S
334	43	RCL

LOC	CODE	KEY
335	03	03
336	75	-
337	01	1
338	95	=
339	42	STD
340	04	04
341	91	R/S
342	43	RCL
343	01	01
344	91	R/S
345	43	RCL
346	24	24
347	33	X ²
348	55	+
349	43	RCL
350	23	23
351	95	=
352	42	STD
353	28	28
354	43	RCL
355	18	18
356	33	X ²
357	55	+
358	43	RCL
359	19	19
360	95	=
361	42	STD
362	29	29
363	43	RCL
364	17	17
365	75	-
366	43	RCL
367	29	29
368	95	=
369	42	STD
370	20	20
371	91	R/S
372	43	RCL
373	22	22
374	75	-
375	43	RCL
376	28	28
377	95	=
378	42	STD
379	21	21
380	91	R/S
381	43	RCL
382	21	21
383	75	-

LOC	CODE	KEY
384	43	RCL
385	20	20
386	95	=
387	42	STD
388	16	16
389	91	R/S
390	43	RCL
391	20	20
392	55	÷
393	43	RCL
394	05	05
395	95	=
396	42	STD
397	06	06
398	91	R/S
399	43	RCL
400	16	16
401	55	÷
402	43	RCL
403	01	01
404	95	=
405	42	STD
406	07	07
407	91	R/S
408	43	RCL
409	07	07
410	55	÷
411	43	RCL
412	06	06
413	95	=
414	42	STD
415	10	10
416	92	RTN
417	01	1
418	06	6
419	01	1
420	03	3
421	03	3
422	07	7
423	01	1
424	03	3
425	69	DP
426	01	01
427	69	DP
428	05	05
429	03	3
430	91	R/S
431	29	CP
432	22	INV

LOC	CODE	KEY
433	86	STF
434	07	07
435	03	3
436	00	0
437	42	STD
438	00	00
439	03	3
440	01	1
441	42	STD
442	10	10
443	43	RCL
444	06	06
445	67	EQ
446	00	00
447	35	35
448	61	GTD
449	00	00
450	39	39

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	03	3
005	01	1
006	69	DP
007	01	01
008	01	1
009	05	5
010	03	3
011	02	2
012	04	4
013	02	2
014	01	1
015	03	3
016	00	0
017	00	0
018	69	DP
019	02	02
020	03	3
021	07	7
022	01	1
023	03	3
024	01	1
025	04	4
026	02	2
027	07	7
028	01	1
029	07	7
030	69	DP
031	03	03
032	69	DP
033	05	05
034	69	DP
035	00	00
036	98	ADV
037	01	1
038	06	6
039	04	4
040	00	0
041	02	2
042	01	1
043	04	4
044	00	0
045	00	0
046	00	0
047	69	DP
048	02	02

LOC	CODE	KEY
049	03	3
050	07	7
051	03	3
052	05	5
053	03	3
054	07	7
055	04	4
056	00	0
057	00	0
058	00	0
059	69	DP
060	01	01
061	69	DP
062	05	05
063	43	RCL
064	08	08
065	75	-
066	01	1
067	95	=
068	42	STD
069	01	01
070	99	PRT
071	98	ADV
072	03	3
073	05	5
074	01	1
075	07	7
076	03	3
077	06	6
078	04	4
079	00	0
080	00	0
081	00	0
082	69	DP
083	01	01
084	69	DP
085	05	05
086	53	(
087	43	RCL
088	09	09
089	75	-
090	01	1
091	54)
092	75	-
093	53	(
094	43	RCL
095	08	08
096	75	-
097	01	1

LOC	CODE	KEY
098	54)
099	95	=
100	42	STD
101	02	02
102	99	PRT
103	98	ADV
104	03	3
105	07	7
106	04	4
107	07	7
108	03	3
109	05	5
110	00	0
111	00	0
112	00	0
113	00	0
114	69	DP
115	01	01
116	69	DP
117	05	05
118	69	DP
119	00	00
120	43	RCL
121	09	09
122	75	-
123	01	1
124	95	=
125	42	STD
126	03	03
127	99	PRT
128	91	R/S
129	98	ADV
130	03	3
131	06	6
132	04	4
133	00	0
134	03	3
135	06	6
136	04	4
137	00	0
138	69	DP
139	02	02
140	03	3
141	07	7
142	03	3
143	05	5
144	03	3
145	07	7
146	00	0

LOC	CODE	KEY
147	00	0
148	04	4
149	05	5
150	69	DP
151	01	01
152	69	DP
153	05	05
154	43	RCL
155	25	25
156	99	PRT
157	98	ADV
158	03	3
159	07	7
160	03	3
161	05	5
162	03	3
163	07	7
164	04	4
165	04	4
166	04	4
167	05	5
168	69	DP
169	01	01
170	69	DP
171	05	05
172	43	RCL
173	15	15
174	99	PRT
175	98	ADV
176	03	3
177	07	7
178	03	3
179	05	5
180	03	3
181	07	7
182	00	0
183	00	0
184	04	4
185	04	4
186	69	DP
187	01	01
188	69	DP
189	05	05
190	43	RCL
191	26	26
192	99	PRT
193	91	R/S
194	98	ADV
195	03	3

LOC	CODE	KEY
196	05	5
197	01	1
198	07	7
199	03	3
200	06	6
201	00	0
202	00	0
203	04	4
204	05	5
205	69	DP
206	01	01
207	69	DP
208	05	05
209	43	RCL
210	22	22
211	75	-
212	43	RCL
213	25	25
214	95	=
215	42	STD
216	17	17
217	99	PRT
218	98	ADV
219	03	3
220	05	5
221	01	1
222	07	7
223	03	3
224	06	6
225	04	4
226	04	4
227	04	4
228	05	5
229	69	DP
230	01	01
231	69	DP
232	05	05
233	43	RCL
234	24	24
235	75	-
236	43	RCL
237	15	15
238	95	=
239	42	STD
240	18	18
241	99	PRT
242	98	ADV
243	03	3
244	05	5

LOC	CODE	KEY
245	01	1
246	07	7
247	03	3
248	06	6
249	00	0
250	00	0
251	04	4
252	04	4
253	69	DP
254	01	01
255	69	DP
256	05	05
257	43	RCL
258	23	23
259	75	-
260	43	RCL
261	26	26
262	95	=
263	42	STD
264	19	19
265	99	PRT
266	91	R/S
267	98	ADV
268	03	3
269	07	7
270	04	4
271	07	7
272	03	3
273	05	5
274	00	0
275	00	0
276	04	4
277	05	5
278	69	DP
279	01	01
280	69	DP
281	05	05
282	43	RCL
283	22	22
284	99	PRT
285	98	ADV
286	03	3
287	07	7
288	04	4
289	07	7
290	03	3
291	05	5
292	04	4
293	04	4

LOC	CODE	KEY
294	04	4
295	05	5
296	69	DP
297	01	01
298	69	DP
299	05	05
300	43	RCL
301	24	24
302	99	PRT
303	98	ADV
304	03	3
305	07	7
306	04	4
307	07	7
308	03	3
309	05	5
310	00	0
311	00	0
312	04	4
313	04	4
314	69	DP
315	01	01
316	69	DP
317	05	05
318	43	RCL
319	23	23
320	99	PRT
321	91	R/S
322	98	ADV
323	01	1
324	03	3
325	01	1
326	06	6
327	02	2
328	05	5
329	04	4
330	00	0
331	00	0
332	00	0
333	69	DP
334	03	03
335	01	1
336	06	6
337	04	4
338	00	0
339	02	2
340	01	1
341	04	4
342	00	0

LOC	CODE	KEY
343	00	0
344	00	0
345	69	DP
346	02	02
347	03	3
348	05	5
349	01	1
350	07	7
351	03	3
352	06	6
353	04	4
354	00	0
355	00	0
356	00	0
357	69	DP
358	01	01
359	69	DP
360	05	05
361	43	RCL
362	02	02
363	75	-
364	01	1
365	95	=
366	42	STD
367	05	05
368	99	PRT
369	98	ADV
370	03	3
371	07	7
372	04	4
373	07	7
374	03	3
375	05	5
376	00	0
377	00	0
378	00	0
379	00	0
380	69	DP
381	01	01
382	69	DP
383	05	05
384	43	RCL
385	03	03
386	75	-
387	01	1
388	95	=
389	42	STD
390	04	04
391	99	PRT

LOC	CODE	KEY
392	98	ADV
393	03	3
394	07	7
395	03	3
396	05	5
397	03	3
398	07	7
399	04	4
400	00	0
401	00	0
402	00	0
403	69	DP
404	01	01
405	69	DP
406	05	05
407	43	RCL
408	01	01
409	99	PRT
410	91	R/S
411	43	RCL
412	24	24
413	33	X ²
414	55	+
415	43	RCL
416	23	23
417	95	=
418	42	STD
419	28	28
420	43	RCL
421	18	18
422	33	X ²
423	55	+
424	43	RCL
425	19	19
426	95	=
427	42	STD
428	29	29
429	98	ADV
430	03	3
431	06	6
432	04	4
433	00	0
434	03	3
435	06	6
436	04	4
437	00	0
438	00	0
439	00	0
440	69	DP

LOC	CODE	KEY
441	02	02
442	03	3
443	05	5
444	01	1
445	07	7
446	03	3
447	06	6
448	04	4
449	00	0
450	00	0
451	00	0
452	69	DP
453	01	01
454	69	DP
455	05	05
456	43	RCL
457	17	17
458	75	-
459	43	RCL
460	29	29
461	95	=
462	42	STD
463	20	20
464	99	PRT
465	98	ADV
466	03	3
467	07	7
468	04	4
469	07	7
470	03	3
471	05	5
472	00	0
473	00	0
474	00	0
475	00	0
476	69	DP
477	01	01
478	69	DP
479	05	05
480	43	RCL
481	22	22
482	75	-
483	43	RCL
484	28	28
485	95	=
486	42	STD
487	21	21
488	99	PRT
489	98	ADV

LOC	CODE	KEY
490	03	3
491	07	7
492	03	3
493	05	5
494	03	3
495	07	7
496	04	4
497	00	0
498	00	0
499	00	0
500	69	DP
501	01	01
502	69	DP
503	05	05
504	43	RCL
505	21	21
506	75	-
507	43	RCL
508	20	20
509	95	=
510	42	STO
511	16	16
512	99	PRT
513	91	R/S
514	98	ADV
515	03	3
516	00	0
517	04	4
518	00	0
519	03	3
520	06	6
521	04	4
522	00	0
523	00	0
524	00	0
525	69	DP
526	02	02
527	03	3
528	05	5
529	01	1
530	07	7
531	03	3
532	06	6
533	04	4
534	00	0
535	00	0
536	00	0
537	69	DP
538	01	01

LOC	CODE	KEY
539	69	DP
540	05	05
541	43	RCL
542	20	20
543	55	+
544	43	RCL
545	05	05
546	95	=
547	42	STO
548	06	06
549	99	PRT
550	98	ADV
551	03	3
552	07	7
553	03	3
554	05	5
555	03	3
556	07	7
557	04	4
558	00	0
559	00	0
560	00	0
561	69	DP
562	01	01
563	69	DP
564	05	05
565	43	RCL
566	16	16
567	55	+
568	43	RCL
569	01	01
570	95	=
571	42	STO
572	07	07
573	99	PRT
574	91	R/S
575	98	ADV
576	02	2
577	01	1
578	02	2
579	00	0
580	03	3
581	05	5
582	01	1
583	03	3
584	03	3
585	07	7
586	69	DP
587	01	01

LOC	CODE	KEY
588	02	2
589	04	4
590	03	3
591	02	2
592	00	0
593	00	0
594	00	0
595	00	0
596	00	0
597	00	0
598	69	DP
599	02	02
600	69	DP
601	05	05
602	69	DP
603	00	00
604	43	RCL
605	07	07
606	55	+
607	43	RCL
608	06	06
609	95	=
610	99	PRT
611	92	RTN

LOC	CODE	KEY
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APPENDIX K

PROGRAM FOR COVARIANCE ANALYSIS IN A
RANDOMIZED COMPLETE BLOCK DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Covariance Analysis in a Randomized Complete Block Design

OBJECTIVES: This program performs an analysis of covariance for one treatment factor and one covariate arranged in a randomized complete block design.

LIMITS FOR:

- a) **TREATMENTS** : any number, with one covariate
- b) **FACTORS** : -
- c) **LEVELS** : -
- d) **REPLICATIONS** : 6

DATA INPUT TYPE: bivariate

OUTPUT^(*): Block degrees of freedom

Treatment degrees of freedom

Residual degrees of freedom

Treatment+residual degrees of freedom

Block sum of squares for Y, XY, and X

Treatment sum of squares for Y, XY, and X

Residual sum of squares for Y, XY, and X

Treatment+residual sum of squares for Y, XY, and X

Residual degrees of freedom adjusted

Treatment+residual degrees of freedom adjusted

Treatment degrees of freedom adjusted

Residual sum of squares adjusted

Treatment+residual sum of squares adjusted

Treatment sum of squares adjusted

Residual mean square adjusted

^(*) Printed and displayed when **PRINTER UNIT** is used

Treatment mean square adjusted
F-ratio for adjusted treatments

PROGRAM CARD DESCRIPTION

Covariance Analysis in RCB				
Proc.	Resul.			

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Process data card		A	
5a	If the number of observations is less than 30			0 *
5b	If the number of observations is greater than 30			'3' **
6a	If step 5a is true go to step 8			
6b	If step 5b is true load side 1 of data card ₂			3
7	Process data card		R/S	
7a	If all observations have been processed go to step 8			0 *
7b	If step 7a is not true			'3' **
7c	Load next data card and go to step 7			3
8	Set new partition	3	2nd OP 17	719.29
9	Load side 1 of program card ₂			1
10	Load side 2 of program card ₂			2
11	Load side 1 of program card ₃			3
12	Obtain results		B R/S R/S R/S R/S	Block D.F. Trt. D.F. Res. D.F. T+R D.F. Blc. Y S.S.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	Blc. XY S.S
			R/S	Blc. X S.S.
			R/S	Trt. Y S.S.
			R/S	Trt. XY S.S.
			R/S	Trt. X S.S.
			R/S	Res. Y S.S.
			R/S	Res. XY S.S.
			R/S	Res. X S.S.
			R/S	T+R Y S.S.
			R/S	T+R XY S.S.
			R/S	T+R X S.S.
			R/S	Res. adj. D.F.
			R/S	T+R adj. D.F.
			R/S	Trt. adj. D.F.
			R/S	Res. adj. S.S.
			R/S	T+R adj. S.S.
			R/S	Trt. adj. S.S.
			R/S	Res. adj. M.S.
			R/S	Trt. adj. M.S.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	<p>* PROG. CARD(2) will be printed if printer is attached</p> <p>** DATA will be printed if printer is attached</p>		R/S	F-ratio for Trt.

SAMPLE PROBLEM

EXAMPLE: Analysis of covariance for six treatments and one covariate arranged in a randomized complete block design. Data from Snedecor and Cochran (1967), page 428.

TREATMENTS	BLOCKS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
T ₁	28	202	22	165	27	191	19	134
T ₂	23	145	26	201	28	203	24	180
T ₃	27	188	24	185	27	185	28	220
T ₄	24	201	28	231	30	238	30	261
T ₅	30	201	26	178	26	198	29	226
T ₆	30	228	25	221	27	207	24	204

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁	A	display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₂		display will show # 3	card inverted
		number 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂	R/S	display will show # 3	card upright
		2 will show in the display and PROG. CARD(2) will be printed if printer is attached	

ENTER	PRESS	OUTPUT	COMMENTS
3	2nd		
	OP 17	719.29	new partition
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
Prog. card ₃		display will show # 3	card upright
	B	3	Block D.F.
	R/S	5	Trt. D.F.
	R/S	15	Res. D.F.
	R/S	20	Trt+Res. D.F.
	R/S	436.1666666	Block Y S.S.
	R/S	8.5	Block XY S.S.
	R/S	21.66666667	Block X S.S.
	R/S	9490.0	Trt. Y S.S.
	R/S	559.25	Trt. XY S.S.
	R/S	45.83333334	Trt. X S.S.
	R/S	8752.333333	Res. Y S.S.
	R/S	917.25	Res. XY S.S.
	R/S	113.8333333	Res. X S.S.
	R/S	18242.33333	Trt+Res. Y S.S.
	R/S	1476.5	Trt+Res. XY S.S.
	R/S	159.6666667	Trt+Res X S.S.
	R/S	14	Residual D.F. adj.
	R/S	19	Trt+Res D.F. adj.
	R/S	5	Trt. D.F. adj.
	R/S	1391.285932	Res. S.S. adj.
	R/S	4588.561413	Trt+Res S.S. adj.
	R/S	3227.275481	Trt. S.S. adj.
	R/S	97.23470943	Residual M.S. adj.
	R/S	645.4550962	Trt. M.S. adj.
	R/S	6.638114105	F-Ratio for Trt.
			adjusted

PRINTED OUTPUT

6.
4.

28.
202.

22.
165.

27.
191.

19.
134.

23.
145.

26.
201.

28.
203.

24.
180.

27.
188.

24.
185.

27.
185.

28.
220.

24.
201.

28.
231.

30.
238.

RECORD DATA

30.
261.

30.
202.

26.
178.

26.
198.

29.
226.

30.
228.

25.
221.

27.
207.

24.
204.

DATA
PRDG. CARD (2)
ANCOVA TABLE

BLC. D.F. 3.

TRT. D.F. 5.

RES. D. F.
15.

T+R D. F.
20.

BLC Y S. S.
436.1666666

BLCXY S. S.
8.5

BLC X S. S.
21.66666667

TRT Y S. S.
9490.

TRTX Y S. S.
559.25

TRT X S. S.
45.83333334

RES Y S. S.
8752.333333

RESXY S. S.
917.25

RES X S. S.
113.8333333

T+R Y S. S.
18242.33333

T+RXY S. S.
1476.5

T+R X S. S.
159.6666667

RES. D. F. ADJ.
14.

T+R D. F. ADJ.
19.

TRT. D. F. ADJ.
5.

RES. S. S. ADJ.
1361.285932

T+R S. S. ADJ.
4588.561413

TRT. S. S. ADJ.
3227.275481

RES. M. S. ADJ.
97.23470943

TRT. M. S. ADJ.
645.4550962

F-RATIO ADJ.
6.638114105

Covariance Analysis in RCB

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	R
002	03	3
003	00	0
004	42	STD
005	00	00
006	03	3
007	01	1
008	42	STD
009	04	04
010	00	0
011	42	STD
012	07	07
013	42	STD
014	08	08
015	42	STD
016	09	09
017	01	1
018	08	8
019	42	STD
020	11	11
021	43	RCL
022	01	01
023	42	STD
024	05	05
025	29	CP
026	43	RCL
027	05	05
028	22	INV
029	67	EQ
030	17	B'
031	43	RCL
032	06	06
033	44	SUM
034	12	12
035	33	X ²
036	44	SUM
037	13	13
038	43	RCL
039	08	08
040	44	SUM
041	14	14
042	33	X ²
043	44	SUM
044	15	15
045	43	RCL
046	06	06

LOC	CODE	KEY
047	65	X
048	43	RCL
049	08	08
050	95	=
051	44	SUM
052	16	16
053	29	CP
054	43	RCL
055	03	03
056	67	EQ
057	13	C
058	00	0
059	42	STD
060	06	06
061	42	STD
062	08	08
063	61	GTD
064	00	00
065	17	17
066	76	LBL
067	17	B'
068	73	RC*
069	04	04
070	69	DP
071	19	19
072	87	IFF
073	07	07
074	14	D
075	73	RC*
076	00	00
077	44	SUM
078	06	06
079	74	SM*
080	11	11
081	33	X ²
082	44	SUM
083	07	07
084	01	1
085	44	SUM
086	11	11
087	73	RC*
088	04	04
089	44	SUM
090	08	08
091	74	SM*
092	11	11
093	33	X ²

LOC	CODE	KEY
094	44	SUM
095	09	09
096	73	RC*
097	00	00
098	65	X
099	73	RC*
100	04	04
101	95	=
102	44	SUM
103	10	10
104	02	2
105	44	SUM
106	00	00
107	44	SUM
108	04	04
109	01	1
110	44	SUM
111	11	11
112	22	INV
113	44	SUM
114	05	05
115	22	INV
116	44	SUM
117	03	03
118	61	GTD
119	00	00
120	25	25
121	76	LBL
122	13	C
123	00	0
124	42	STD
125	04	04
126	42	STD
127	06	06
128	42	STD
129	08	08
130	43	RCL
131	01	01
132	42	STD
133	05	05
134	01	1
135	08	8
136	42	STD
137	11	11
138	29	CP
139	43	RCL
140	05	05

LOC	CODE	KEY
141	67	EQ
142	15	E
143	73	RC*
144	11	11
145	42	STD
146	17	17
147	33	X ²
148	44	SUM
149	06	06
150	01	1
151	44	SUM
152	11	11
153	73	RC*
154	11	11
155	33	X ²
156	44	SUM
157	08	08
158	43	RCL
159	17	17
160	65	X
161	73	RC*
162	11	11
163	95	=
164	44	SUM
165	04	04
166	01	1
167	44	SUM
168	11	11
169	22	INV
170	44	SUM
171	05	05
172	61	GTD
173	01	01
174	38	38
175	76	LBL
176	15	E
177	43	RCL
178	01	01
179	65	X
180	43	RCL
181	02	02
182	95	=
183	42	STD
184	03	03
185	43	RCL
186	12	12
187	33	X ²

LOC	CODE	KEY
188	55	+
189	43	RCL
190	03	03
191	95	=
192	42	STD
193	17	17
194	43	RCL
195	14	14
196	33	X ²
197	55	+
198	43	RCL
199	03	03
200	95	=
201	42	STD
202	18	18
203	43	RCL
204	07	07
205	75	-
206	43	RCL
207	17	17
208	95	=
209	42	STD
210	07	07
211	43	RCL
212	09	09
213	75	-
214	43	RCL
215	18	18
216	95	=
217	42	STD
218	09	09
219	43	RCL
220	12	12
221	65	*
222	43	RCL
223	14	14
224	95	=
225	55	+
226	43	RCL
227	03	03
228	95	=
229	42	STD
230	19	19
231	43	RCL
232	10	10
233	75	-
234	43	RCL
235	19	19
236	95	=

LOC	CODE	KEY
237	42	STD
238	10	10
239	43	RCL
240	13	13
241	55	+
242	43	RCL
243	01	01
244	75	-
245	43	RCL
246	17	17
247	95	=
248	42	STD
249	13	13
250	43	RCL
251	15	15
252	55	+
253	43	RCL
254	01	01
255	75	-
256	43	RCL
257	18	18
258	95	=
259	42	STD
260	15	15
261	43	RCL
262	16	16
263	55	+
264	43	RCL
265	01	01
266	75	-
267	43	RCL
268	19	19
269	95	=
270	42	STD
271	16	16
272	43	RCL
273	06	06
274	55	+
275	43	RCL
276	02	02
277	75	-
278	43	RCL
279	17	17
280	95	=
281	42	STD
282	11	11
283	43	RCL
284	08	08
285	55	+

LOC	CODE	KEY
286	43	RCL
287	02	02
288	75	-
289	43	RCL
290	18	18
291	95	=
292	42	STD
293	12	12
294	43	RCL
295	04	04
296	55	+
297	43	RCL
298	02	02
299	75	-
300	43	RCL
301	19	19
302	95	=
303	42	STD
304	14	14
305	43	RCL
306	09	09
307	75	-
308	43	RCL
309	15	15
310	75	-
311	43	RCL
312	12	12
313	95	=
314	42	STD
315	20	20
316	43	RCL
317	07	07
318	75	-
319	43	RCL
320	13	13
321	75	-
322	43	RCL
323	11	11
324	95	=
325	42	STD
326	21	21
327	43	RCL
328	10	10
329	75	-
330	43	RCL
331	16	16
332	75	-
333	43	RCL
334	14	14

LOC	CODE	KEY
335	95	=
336	42	STD
337	22	22
338	61	GTD
339	16	A*
340	25	CLR
341	92	RTN
342	76	LBL
343	14	D
344	01	1
345	06	6
346	01	1
347	03	3
348	03	3
349	07	7
350	01	1
351	03	3
352	69	OP
353	01	01
354	69	OP
355	05	05
356	03	3
357	91	R/S
358	22	INV
359	86	STF
360	07	07
361	03	3
362	00	0
363	42	STD
364	00	00
365	03	3
366	01	1
367	42	STD
368	04	04
369	29	CP
370	43	RCL
371	05	05
372	67	EQ
373	00	00
374	17	17
375	61	GTD
376	00	00
377	25	25
378	76	LBL
379	16	A*
380	03	3
381	03	3
382	03	3
383	05	5

LOC	CODE	KEY
384	03	3
385	02	2
386	02	2
387	02	2
388	04	4
389	00	0
390	69	DP
391	01	01
392	01	1
393	05	5
394	01	1
395	03	3
396	03	3
397	05	5
398	01	1
399	06	6
400	69	DP
401	02	02
402	05	5
403	05	5
404	00	0
405	03	3
406	05	5
407	06	6
408	00	0
409	00	0
410	00	0
411	00	0
412	69	DP
413	03	03
414	69	DP
415	05	05
416	69	DP
417	00	00
418	02	2
419	92	RTH

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	03	3
005	01	1
006	69	DP
007	01	01
008	01	1
009	05	5
010	03	3
011	02	2
012	04	4
013	02	2
014	01	1
015	03	3
016	00	0
017	00	0
018	69	DP
019	02	02
020	03	3
021	07	7
022	01	1
023	03	3
024	01	1
025	04	4
026	02	2
027	07	7
028	01	1
029	07	7
030	69	DP
031	03	03
032	69	DP
033	05	05
034	69	DP
035	00	00
036	98	ADV
037	01	1
038	06	6
039	04	4
040	00	0
041	02	2
042	01	1
043	04	4
044	00	0
045	00	0
046	00	0
047	69	DP
048	02	02

LOC	CODE	KEY
049	01	1
050	04	4
051	02	2
052	07	7
053	01	1
054	05	5
055	04	4
056	00	0
057	00	0
058	00	0
059	69	DP
060	01	01
061	69	DP
062	05	05
063	43	RCL
064	03	03
065	75	-
066	01	1
067	95	=
068	42	STO
069	26	26
070	43	RCL
071	01	01
072	75	-
073	01	1
074	95	=
075	42	STO
076	24	24
077	99	PRT
078	91	R/S
079	98	ADV
080	03	3
081	07	7
082	03	3
083	05	5
084	03	3
085	07	7
086	04	4
087	00	0
088	00	0
089	00	0
090	69	DP
091	01	01
092	69	DP
093	05	05
094	43	RCL
095	02	02
096	75	-
097	01	1

LOC	CODE	KEY
098	95	=
099	42	STO
100	23	23
101	99	PRT
102	91	R/S
103	98	ADV
104	03	3
105	05	5
106	01	1
107	07	7
108	03	3
109	06	6
110	04	4
111	00	0
112	00	0
113	00	0
114	69	DP
115	01	01
116	69	DP
117	05	05
118	43	RCL
119	26	26
120	75	-
121	43	RCL
122	23	23
123	75	-
124	43	RCL
125	24	24
126	95	=
127	42	STO
128	25	25
129	99	PRT
130	91	R/S
131	98	ADV
132	03	3
133	07	7
134	04	4
135	07	7
136	03	3
137	05	5
138	00	0
139	00	0
140	00	0
141	00	0
142	69	DP
143	01	01
144	69	DP
145	05	05
146	43	RCL

LOC	CODE	KEY
147	23	23
148	85	+
149	43	RCL
150	25	25
151	95	=
152	42	STD
153	27	27
154	99	PRT
155	91	R/S
156	98	ADV
157	03	3
158	06	6
159	04	4
160	00	0
161	03	3
162	06	6
163	04	4
164	00	0
165	69	DP
166	02	02
167	01	1
168	04	4
169	02	2
170	07	7
171	01	1
172	05	5
173	00	0
174	00	0
175	04	4
176	05	5
177	69	DP
178	01	01
179	69	DP
180	05	05
181	43	RCL
182	12	12
183	99	PRT
184	91	R/S
185	98	ADV
186	01	1
187	04	4
188	02	2
189	07	7
190	01	1
191	05	5
192	04	4
193	04	4
194	04	4
195	05	5

LOC	CODE	KEY
196	69	DP
197	01	01
198	69	DP
199	05	05
200	43	RCL
201	14	14
202	99	PRT
203	91	R/S
204	98	ADV
205	01	1
206	04	4
207	02	2
208	07	7
209	01	1
210	05	5
211	00	0
212	00	0
213	04	4
214	04	4
215	69	DP
216	01	01
217	69	DP
218	05	05
219	43	RCL
220	11	11
221	99	PRT
222	91	R/S
223	98	ADV
224	03	3
225	07	7
226	03	3
227	05	5
228	03	3
229	07	7
230	00	0
231	00	0
232	04	4
233	05	5
234	69	DP
235	01	01
236	69	DP
237	05	05
238	43	RCL
239	15	15
240	99	PRT
241	91	R/S
242	98	ADV
243	03	3
244	07	7

LOC	CODE	KEY
245	03	3
246	05	5
247	03	3
248	07	7
249	04	4
250	04	4
251	04	4
252	05	5
253	69	DP
254	01	01
255	69	DP
256	05	05
257	43	RCL
258	16	16
259	99	PRT
260	91	R/S
261	98	ADV
262	03	3
263	07	7
264	03	3
265	05	5
266	03	3
267	07	7
268	00	0
269	00	0
270	04	4
271	04	4
272	69	DP
273	01	01
274	69	DP
275	05	05
276	43	RCL
277	13	13
278	99	PRT
279	91	R/S
280	98	ADV
281	03	3
282	05	5
283	01	1
284	07	7
285	03	3
286	06	6
287	00	0
288	00	0
289	04	4
290	05	5
291	69	DP
292	01	01
293	69	DP

LOC	CODE	KEY
294	05	05
295	43	RCL
296	20	20
297	99	PRT
298	91	R/S
299	98	ADV
300	03	3
301	05	5
302	01	1
303	07	7
304	03	3
305	06	6
306	04	4
307	04	4
308	04	4
309	05	5
310	69	DP
311	01	01
312	69	DP
313	05	05
314	43	RCL
315	22	22
316	99	PRT
317	91	R/S
318	98	ADV
319	03	3
320	05	5
321	01	1
322	07	7
323	03	3
324	06	6
325	00	0
326	00	0
327	04	4
328	04	4
329	69	DP
330	01	01
331	69	DP
332	05	05
333	43	RCL
334	21	21
335	99	PRT
336	91	R/S
337	98	ADV
338	03	3
339	07	7
340	04	4
341	07	7
342	03	3

LOC	CODE	KEY
343	05	5
344	00	0
345	00	0
346	04	4
347	05	5
348	69	DP
349	01	01
350	69	DP
351	05	05
352	43	RCL
353	15	15
354	85	+
355	43	RCL
356	20	20
357	95	=
358	42	STO
359	28	28
360	99	PRT
361	91	R/S
362	98	ADV
363	03	3
364	07	7
365	04	4
366	07	7
367	03	3
368	05	5
369	04	4
370	04	4
371	04	4
372	05	5
373	69	DP
374	01	01
375	69	DP
376	05	05
377	43	RCL
378	16	16
379	85	+
380	43	RCL
381	22	22
382	95	=
383	42	STO
384	29	29
385	99	PRT
386	91	R/S
387	98	ADV
388	03	3
389	07	7
390	04	4
391	07	7

LOC	CODE	KEY
392	03	3
393	05	5
394	00	0
395	00	0
396	04	4
397	04	4
398	69	DP
399	01	01
400	69	DP
401	05	05
402	43	RCL
403	13	13
404	85	+
405	43	RCL
406	21	21
407	95	=
408	42	STO
409	00	00
410	99	PRT
411	91	R/S
412	98	ADV
413	01	1
414	03	3
415	01	1
416	06	6
417	02	2
418	05	5
419	04	4
420	00	0
421	00	0
422	00	0
423	69	DP
424	03	03
425	01	1
426	06	6
427	04	4
428	00	0
429	02	2
430	01	1
431	04	4
432	00	0
433	00	0
434	00	0
435	69	DP
436	02	02
437	03	3
438	05	5
439	01	1
440	07	7

LOC	CODE	KEY
441	03	3
442	06	6
443	04	4
444	00	0
445	00	0
446	00	0
447	69	DP
448	01	01
449	69	DP
450	05	05
451	43	RCL
452	25	25
453	75	-
454	01	1
455	95	=
456	42	STO
457	17	17
458	99	PRT
459	91	R/S
460	98	ADV
461	03	3
462	07	7
463	04	4
464	07	7
465	03	3
466	05	5
467	00	0
468	00	0
469	00	0
470	00	0
471	69	DP
472	01	01
473	69	DP
474	05	05
475	43	RCL
476	27	27
477	75	-
478	01	1
479	95	=
480	42	STO
481	18	18
482	99	PRT
483	91	R/S
484	98	ADV
485	03	3
486	07	7
487	03	3
488	05	5
489	03	3

LOC	CODE	KEY
490	07	7
491	04	4
492	00	0
493	00	0
494	00	0
495	69	DP
496	01	01
497	69	DP
498	05	05
499	43	RCL
500	23	23
501	99	PRT
502	91	R/S
503	98	ADV
504	03	3
505	06	6
506	04	4
507	00	0
508	03	3
509	06	6
510	04	4
511	00	0
512	00	0
513	00	0
514	69	DP
515	02	02
516	03	3
517	05	5
518	01	1
519	07	7
520	03	3
521	06	6
522	04	4
523	00	0
524	00	0
525	00	0
526	69	DP
527	01	01
528	69	DP
529	05	05
530	43	RCL
531	22	22
532	33	X ²
533	55	+
534	43	RCL
535	21	21
536	95	=
537	42	STO
538	05	05

LOC	CODE	KEY
539	43	RCL
540	29	29
541	33	X ²
542	55	÷
543	43	RCL
544	00	00
545	95	=
546	42	STD
547	04	04
548	43	RCL
549	20	20
550	75	-
551	43	RCL
552	05	05
553	95	=
554	42	STD
555	24	24
556	99	PRT
557	91	R/S
558	98	ADV
559	03	3
560	07	7
561	04	4
562	07	7
563	03	3
564	05	5
565	00	0
566	00	0
567	00	0
568	00	0
569	69	DP
570	01	01
571	69	DP
572	05	05
573	43	RCL
574	28	28
575	75	-
576	43	RCL
577	04	04
578	95	=
579	42	STD
580	25	25
581	99	PRT
582	91	R/S
583	98	ADV
584	03	3
585	07	7
586	03	3
587	05	5

LOC	CODE	KEY
588	03	3
589	07	7
590	04	4
591	00	0
592	00	0
593	00	0
594	69	DP
595	01	01
596	69	DP
597	05	05
598	43	RCL
599	25	25
600	75	-
601	43	RCL
602	24	24
603	95	=
604	42	STD
605	28	28
606	99	PRT
607	91	R/S
608	98	ADV
609	03	3
610	00	0
611	04	4
612	00	0
613	03	3
614	06	6
615	04	4
616	00	0
617	00	0
618	00	0
619	69	DP
620	02	02
621	03	3
622	05	5
623	01	1
624	07	7
625	03	3
626	06	6
627	04	4
628	00	0
629	00	0
630	00	0
631	69	DP
632	01	01
633	69	DP
634	05	05
635	43	RCL
636	24	24

LOC	CODE	KEY
637	55	÷
638	43	RCL
639	17	17
640	95	=
641	42	STD
642	26	26
643	99	PRT
644	91	R/S
645	98	ADV
646	03	3
647	07	7
648	03	3
649	05	5
650	03	3
651	07	7
652	04	4
653	00	0
654	00	0
655	00	0
656	69	DP
657	01	01
658	69	DP
659	05	05
660	43	RCL
661	28	28
662	55	÷
663	43	RCL
664	23	23
665	95	=
666	42	STD
667	27	27
668	99	PRT
669	91	R/S
670	98	ADV
671	02	2
672	01	1
673	02	2
674	00	0
675	03	3
676	05	5
677	01	1
678	03	3
679	03	3
680	07	7
681	69	DP
682	01	01
683	02	2
684	04	4
685	03	3

LOC	CODE	KEY
686	02	2
687	00	0
688	00	0
689	00	0
690	00	0
691	00	0
692	00	0
693	69	DP
694	02	02
695	69	DP
696	05	05
697	69	DP
698	00	00
699	43	RCL
700	27	27
701	55	÷
702	43	RCL
703	26	26
704	95	=
705	99	PRT
706	92	RTN

APPENDIX L

**PROGRAM FOR TWO-FACTOR FACTORIAL IN A
COMPLETELY RANDOMIZED DESIGN**

PROGRAM DESCRIPTION

PROGRAM TITLE: Two Factor Factorial in a Completely Randomized Design

OBJECTIVES: This program performs an analysis of variance for two treatment factors arranged factorially in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number of treatment combinations
- b) **FACTORS** : 2
- c) **LEVELS** : First factor - any number
Second factor - 15
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: univariate

OUTPUT^(*): Treatment degrees of freedom
Main effect A degrees of freedom
Main effect B degrees of freedom
First-order interaction AB degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Treatment sum of squares
Main effect A sum of squares
Main effect B sum of squares
First-order interaction AB sum of squares
Residual sum of squares
Total sum of squares
Main effect A mean square
Main effect B mean square
First-order interaction AB mean square

() printed and displayed when PRINTER UNIT is used*

Residual mean square

F-ratios for main effects A and B and first-
order interaction AB

PROGRAM CARD DESCRIPTION

Two Factor Factorial in CRD				
Proc.	Resul.	# A	# B	

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter number of levels of A	# A	C	# A
6	Enter number of levels of B	# B	D	# B
7	Process data card		A	
7a	If number of observations is less than 30			0
7b	If number of observations is greater than 30			'3' *
8a	If step 7a is true go to step 10			
8b	If step 7b is true load side 1 of data card ₂			3
9	Process data card		R/S	
9a	If all observations have been processed go to step 10			0
9b	If step 9a is not true			'3' *
9c	Load next data card and go to step 9			3
10	For a printed output go to step 11; otherwise go to step 13			
11	Load side 1 of program card ₂			1
12	Load side 1 of program card ₂			2
13	Obtain results		B	Trt. D.F.
			R/S	A D.F.
			R/S	B D.F.
			R/S	AB D.F.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	Res. D.F.
			R/S	Tot. D.F.
			R/S	Trt. S.S.
			R/S	A S.S.
			R/S	B S.S.
			R/S	AB S.S.
			R/S	Res. S.S.
			R/S	Tot. S.S.
			R/S	A M.S.
			R/S	B M.S.
			R/S	AB M.S.
			R/S	Res. M.S.
			R/S	F-ratio A
			R/S	F-ratio B
			R/S	F-ratio AB
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for two treatment factors, the first factor at 2 levels and the second at 3 levels, arranged factorially in a completely randomized design. Data from Snedecor and Cochran (1967), page 347.

<u>A₁</u>			<u>A₂</u>		
<u>B₁</u>	<u>B₂</u>	<u>B₃</u>	<u>B₁</u>	<u>B₂</u>	<u>B₃</u>
73	98	94	90	107	49
102	74	79	76	95	82
118	56	96	90	97	73
104	111	98	64	80	86
81	95	102	86	98	81
107	88	102	51	74	97
100	82	108	72	74	106
87	77	91	90	67	70
117	86	120	95	89	61
111	92	105	78	58	82

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
2	C	2	# of levels of A
3	D	3	# of levels of B
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂	R/S	display will show # 3 0 will show in display	card upright process finished

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₂ Prog. card ₂		display will show # 1 display will show # 2 (You do not have to read this card unless you want a printed output)	card upright card inverted
	B	5	Treatment D.F.
	R/S	1	Main effect A D.F.
	R/S	2	Main effect B D.F.
	R/S	2	Interaction AB D.F.
	R/S	54	Residual D.F.
	R/S	59	Total D.F.
	R/S	4612.933333	Treatment S.S.
	R/S	3168.266667	Main effect A S.S.
	R/S	266.5333334	Main effect B S.S.
	R/S	1178.133333	Interaction AB S.S.
	R/S	11586.0	Residual S.S.
	R/S	16198.93333	Total S.S.
	R/S	3168.266667	Main effect A M.S.
	R/S	133.2666667	Main effect B M.S.
	R/S	589.0666667	Interaction AB M.S.
	R/S	214.5555556	Residual M.S.
	R/S	14.7666494	F-Ratio for A
	R/S	0.6211289489	F-Ratio for B
	R/S	2.745520456	F-Ratio for AB

PRINTED OUTPUT

```

      6.
     10.

      73.
    102.
    118.
    104.
      81.
    107.
    100.
      87.
    117.
    111.
      98.
      74.
      56.
    111.
      95.
      88.
      82.
      77.
      86.
      92.
      94.
      79.
      96.
      98.
    102.
    102.
    108.
      91.
    120.
    105.
RECORD DATA
      90.
      76.
      90.
      64.
      86.
      51.
      72.
      90.
      95.
      78.
    107.
      95.
      97.
      80.

```

```

      98.
      74.
      74.
      67.
      89.
      58.
      49.
      82.
      73.
      86.
      81.
      97.
    106.
      70.
      61.
      82.

DATA
  ANOVA TABLE

TRT.  D. F.
           5.

  A   D. F.
           1.

  B   D. F.
           2.

  AB  D. F.
           2.

RES.  D. F.
           54.

TOT.  D. F.
           59.

TRT.  S. S.
      4612.933333

  A   S. S.
      3168.266667

  B   S. S.
      266.5333334

```

AB S. S.
1178.133333

RES. S. S.
11586.

TOT. S. S.
16198.93333

A M. S.
3168.266667

B M. S.
133.2666667

AB M. S.
589.0666667

RES. M. S.
214.5555556

F-RATIO A
14.7666494

F-RATIO B
.6211289489

F-RATIO AB
2.745520456

Two-Factor Factorial in CRD

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	A
002	03	3
003	00	0
004	42	STD
005	00	00
006	01	1
007	05	5
008	42	STD
009	04	04
010	43	RCL
011	14	14
012	42	STD
013	11	11
014	43	RCL
015	01	01
016	42	STD
017	05	05
018	29	CP
019	43	RCL
020	05	05
021	22	INV
022	67	EQ
023	00	00
024	75	75
025	43	RCL
026	06	06
027	74	SM*
028	04	04
029	44	SUM
030	09	09
031	33	X ²
032	44	SUM
033	10	10
034	01	1
035	22	INV
036	44	SUM
037	11	11
038	69	DP
039	24	24
040	43	RCL
041	11	11
042	67	EQ
043	00	00
044	48	48
045	61	GTD
046	00	00

LOC	CODE	KEY
047	69	69
048	01	1
049	05	5
050	42	STD
051	04	04
052	43	RCL
053	09	09
054	33	X ²
055	44	SUM
056	12	12
057	00	0
058	42	STD
059	09	09
060	43	RCL
061	14	14
062	42	STD
063	11	11
064	43	RCL
065	03	03
066	67	EQ
067	00	00
068	99	99
069	00	0
070	42	STD
071	06	06
072	61	GTD
073	00	00
074	14	14
075	73	RC*
076	00	00
077	69	DP
078	19	19
079	87	IFF
080	07	07
081	03	03
082	38	38
083	44	SUM
084	06	06
085	44	SUM
086	07	07
087	33	X ²
088	44	SUM
089	08	08
090	69	DP
091	33	33
092	69	DP
093	20	20

LOC	CODE	KEY
094	69	DP
095	35	35
096	61	GTD
097	00	00
098	18	18
099	73	RC*
100	04	04
101	33	X ²
102	44	SUM
103	05	05
104	69	DP
105	24	24
106	01	1
107	22	INV
108	44	SUM
109	11	11
110	43	RCL
111	11	11
112	67	EQ
113	01	01
114	18	18
115	61	GTD
116	00	00
117	99	99
118	43	RCL
119	01	01
120	65	X
121	43	RCL
122	02	02
123	95	=
124	42	STD
125	03	03
126	43	RCL
127	07	07
128	33	X ²
129	55	+
130	43	RCL
131	03	03
132	95	=
133	42	STD
134	06	06
135	43	RCL
136	08	08
137	75	-
138	43	RCL
139	06	06
140	95	=

LOC	CODE	KEY
141	42	STD
142	07	07
143	43	RCL
144	10	10
145	55	+
146	43	RCL
147	01	01
148	75	-
149	43	RCL
150	06	06
151	95	=
152	42	STD
153	08	08
154	43	RCL
155	07	07
156	75	-
157	43	RCL
158	08	08
159	95	=
160	42	STD
161	09	09
162	43	RCL
163	12	12
164	55	+
165	53	(
166	43	RCL
167	14	14
168	65	X
169	43	RCL
170	01	01
171	54)
172	75	-
173	43	RCL
174	06	06
175	95	=
176	42	STD
177	10	10
178	43	RCL
179	05	05
180	55	+
181	53	(
182	43	RCL
183	01	01
184	65	X
185	43	RCL
186	13	13
187	54)

LOC	CODE	KEY
188	75	-
189	43	RCL
190	06	06
191	95	=
192	42	STD
193	11	11
194	43	RCL
195	08	08
196	75	-
197	43	RCL
198	10	10
199	75	-
200	43	RCL
201	11	11
202	95	=
203	42	STD
204	12	12
205	25	CLR
206	92	RTN
207	76	LBL
208	12	B
209	43	RCL
210	02	02
211	75	-
212	01	1
213	95	=
214	42	STD
215	15	15
216	91	R/S
217	43	RCL
218	13	13
219	75	-
220	01	1
221	95	=
222	42	STD
223	16	16
224	91	R/S
225	43	RCL
226	14	14
227	75	-
228	01	1
229	95	=
230	42	STD
231	17	17
232	91	R/S
233	43	RCL
234	16	16
235	65	X
236	43	RCL

LOC	CODE	KEY
237	17	17
238	95	=
239	42	STD
240	18	18
241	91	R/S
242	43	RCL
243	02	02
244	65	X
245	53	(
246	43	RCL
247	01	01
248	75	-
249	01	1
250	54)
251	95	=
252	42	STD
253	20	20
254	91	R/S
255	43	RCL
256	03	03
257	75	-
258	01	1
259	95	=
260	42	STD
261	19	19
262	91	R/S
263	43	RCL
264	08	08
265	91	R/S
266	43	RCL
267	10	10
268	91	R/S
269	43	RCL
270	11	11
271	91	R/S
272	43	RCL
273	12	12
274	91	R/S
275	43	RCL
276	09	09
277	91	R/S
278	43	RCL
279	07	07
280	91	R/S
281	43	RCL
282	10	10
283	55	+
284	43	RCL
285	16	16

LOC	CODE	KEY
286	95	=
287	42	STD
288	21	21
289	91	R/S
290	43	RCL
291	11	11
292	55	+
293	43	RCL
294	17	17
295	95	=
296	42	STD
297	22	22
298	91	R/S
299	43	RCL
300	12	12
301	55	+
302	43	RCL
303	18	18
304	95	=
305	42	STD
306	23	23
307	91	R/S
308	43	RCL
309	09	09
310	55	+
311	43	RCL
312	20	20
313	95	=
314	42	STD
315	24	24
316	91	R/S
317	43	RCL
318	21	21
319	55	+
320	43	RCL
321	24	24
322	95	=
323	91	R/S
324	43	RCL
325	22	22
326	55	+
327	43	RCL
328	24	24
329	95	=
330	91	R/S
331	43	RCL
332	23	23
333	55	+
334	43	RCL

LOC	CODE	KEY
335	24	24
336	95	=
337	92	RTN
338	01	1
339	06	6
340	01	1
341	03	3
342	03	3
343	07	7
344	01	1
345	03	3
346	69	DP
347	01	01
348	69	DP
349	05	05
350	69	DP
351	00	00
352	03	3
353	91	R/S
354	29	CP
355	22	INV
356	86	STF
357	07	07
358	03	3
359	00	0
360	42	STD
361	00	00
362	43	RCL
363	05	05
364	67	EQ
365	00	00
366	14	14
367	61	GTO
368	00	00
369	18	18
370	76	LBL
371	13	C
372	42	STD
373	13	13
374	91	R/S
375	76	LBL
376	14	D
377	42	STD
378	14	14
379	92	RTN

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	00	0
044	00	0
045	69	DP
046	02	02
047	03	3
048	07	7

LOC	CODE	KEY
049	03	3
050	05	5
051	03	3
052	07	7
053	04	4
054	00	0
055	00	0
056	00	0
057	69	DP
058	01	01
059	69	DP
060	05	05
061	43	RCL
062	02	02
063	75	-
064	01	1
065	95	=
066	99	PRT
067	91	R/S
068	98	ADV
069	01	1
070	03	3
071	00	0
072	00	0
073	00	0
074	00	0
075	69	DP
076	01	01
077	69	DP
078	05	05
079	43	RCL
080	13	13
081	75	-
082	01	1
083	95	=
084	42	STD
085	16	16
086	99	PRT
087	91	R/S
088	98	ADV
089	01	1
090	04	4
091	00	0
092	00	0
093	00	0
094	00	0
095	69	DP
096	01	01
097	69	DP

LOC	CODE	KEY
098	05	05
099	43	RCL
100	14	14
101	75	-
102	01	1
103	95	=
104	42	STD
105	17	17
106	99	PRT
107	91	R/S
108	98	ADV
109	01	1
110	03	3
111	01	1
112	04	4
113	00	0
114	00	0
115	69	DP
116	01	01
117	69	DP
118	05	05
119	43	RCL
120	16	16
121	65	X
122	43	RCL
123	17	17
124	95	=
125	42	STD
126	18	18
127	99	PRT
128	91	R/S
129	98	ADV
130	03	3
131	05	5
132	01	1
133	07	7
134	03	3
135	06	6
136	04	4
137	00	0
138	00	0
139	00	0
140	69	DP
141	01	01
142	69	DP
143	05	05
144	43	RCL
145	02	02
146	65	X

LOC	CODE	KEY
147	53	(
148	43	RCL
149	01	01
150	75	-
151	01	1
152	54)
153	95	=
154	42	STD
155	20	20
156	99	PRT
157	91	R/S
158	98	ADV
159	03	3
160	07	7
161	03	3
162	02	2
163	03	3
164	07	7
165	04	4
166	00	0
167	00	0
168	00	0
169	69	DP
170	01	01
171	69	DP
172	05	05
173	43	RCL
174	03	03
175	75	-
176	01	1
177	95	=
178	42	STD
179	19	19
180	99	PRT
181	91	R/S
182	98	ADV
183	03	3
184	06	6
185	04	4
186	00	0
187	03	3
188	06	6
189	04	4
190	00	0
191	00	0
192	00	0
193	69	DP
194	02	02
195	03	3

LOC	CODE	KEY
196	07	7
197	03	3
198	05	5
199	03	3
200	07	7
201	04	4
202	00	0
203	00	0
204	00	0
205	69	DP
206	01	01
207	69	DP
208	05	05
209	43	RCL
210	08	08
211	99	PRT
212	91	R/S
213	98	ADV
214	01	1
215	03	3
216	00	0
217	00	0
218	00	0
219	00	0
220	69	DP
221	01	01
222	69	DP
223	05	05
224	43	RCL
225	10	10
226	99	PRT
227	91	R/S
228	98	ADV
229	01	1
230	04	4
231	00	0
232	00	0
233	00	0
234	00	0
235	69	DP
236	01	01
237	69	DP
238	05	05
239	43	RCL
240	11	11
241	99	PRT
242	91	R/S
243	98	ADV
244	01	1

LOC	CODE	KEY
245	03	3
246	01	1
247	04	4
248	00	0
249	00	0
250	69	DP
251	01	01
252	69	DP
253	05	05
254	43	RCL
255	12	12
256	99	PRT
257	91	R/S
258	98	ADV
259	03	3
260	05	5
261	01	1
262	07	7
263	03	3
264	06	6
265	04	4
266	00	0
267	00	0
268	00	0
269	69	DP
270	01	01
271	69	DP
272	05	05
273	43	RCL
274	09	09
275	99	PRT
276	91	R/S
277	98	ADV
278	03	3
279	07	7
280	03	3
281	02	2
282	03	3
283	07	7
284	04	4
285	00	0
286	00	0
287	00	0
288	69	DP
289	01	01
290	69	DP
291	05	05
292	43	RCL
293	07	07

LOC	CODE	KEY
294	99	PRT
295	91	R/S
296	98	ADV
297	03	3
298	00	0
299	04	4
300	00	0
301	03	3
302	06	6
303	04	4
304	00	0
305	00	0
306	00	0
307	69	DP
308	02	02
309	01	1
310	03	3
311	00	0
312	00	0
313	00	0
314	00	0
315	69	DP
316	01	01
317	69	DP
318	05	05
319	43	RCL
320	10	10
321	55	+
322	43	RCL
323	16	16
324	95	=
325	42	STO
326	21	21
327	99	PRT
328	91	R/S
329	98	ADV
330	01	1
331	04	4
332	00	0
333	00	0
334	00	0
335	00	0
336	69	DP
337	01	01
338	69	DP
339	05	05
340	43	RCL
341	11	11
342	55	+

LOC	CODE	KEY
343	43	RCL
344	17	17
345	95	=
346	42	STO
347	22	22
348	99	PRT
349	91	R/S
350	98	ADV
351	01	1
352	03	3
353	01	1
354	04	4
355	00	0
356	00	0
357	69	DP
358	01	01
359	69	DP
360	05	05
361	43	RCL
362	12	12
363	55	+
364	43	RCL
365	18	18
366	95	=
367	42	STO
368	23	23
369	99	PRT
370	91	R/S
371	98	ADV
372	03	3
373	05	5
374	01	1
375	07	7
376	03	3
377	06	6
378	04	4
379	00	0
380	00	0
381	00	0
382	69	DP
383	01	01
384	69	DP
385	05	05
386	43	RCL
387	09	09
388	55	+
389	43	RCL
390	20	20
391	95	=

LOC	CODE	KEY
392	42	STD
393	24	24
394	99	PRT
395	91	R/S
396	98	ADV
397	02	2
398	01	1
399	02	2
400	00	0
401	03	3
402	05	5
403	01	1
404	03	3
405	03	3
406	07	7
407	69	DP
408	01	01
409	02	2
410	04	4
411	03	3
412	02	2
413	00	0
414	00	0
415	01	1
416	03	3
417	00	0
418	00	0
419	69	DP
420	02	02
421	69	DP
422	05	05
423	43	RCL
424	21	21
425	55	+
426	43	RCL
427	24	24
428	95	=
429	99	PRT
430	91	R/S
431	98	ADV
432	02	2
433	04	4
434	03	3
435	02	2
436	00	0
437	00	0
438	01	1
439	04	4
440	00	0

LOC	CODE	KEY
441	00	0
442	69	DP
443	02	02
444	69	DP
445	05	05
446	43	RCL
447	22	22
448	55	+
449	43	RCL
450	24	24
451	95	=
452	99	PRT
453	91	R/S
454	98	ADV
455	02	2
456	04	4
457	03	3
458	02	2
459	00	0
460	00	0
461	01	1
462	03	3
463	01	1
464	04	4
465	69	DP
466	02	02
467	69	DP
468	05	05
469	43	RCL
470	23	23
471	55	+
472	43	RCL
473	24	24
474	95	=
475	99	PRT
476	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
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APPENDIX M

PROGRAM FOR TWO-FACTOR FACTORIAL IN A
RANDOMIZED COMPLETE BLOCK DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Two Factor Factorial in a Randomized Complete Block Design

OBJECTIVES: This program performs an analysis of variance for two treatment factors arranged factorially in a randomized complete block design.

LIMITS FOR:

- a) **TREATMENTS** : any number of treatments combinations
- b) **FACTORS** : 2
- c) **LEVELS** : First factor - any number
Second factor - 14
- d) **REPLICATIONS** : 14

DATA INPUT TYPE: univariate

OUTPUT ^(*): Block degrees of freedom
Main effect A degrees of freedom
Main effect B degrees of freedom
First-order interaction AB degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Block sum of squares
Main effect A sum of squares
Main effect B sum of squares
First-order interaction AB sum of squares
Residual sum of squares
Total sum of squares
Main effect A mean square
Main effect B mean square
First-order interaction AB mean square

^(*) Printed and displayed when **PRINTER UNIT** is used

Residual mean square

F-ratios for main effects A and B and first-
order interaction AB

PROGRAM CARD DESCRIPTION

Two Factor Factorial in RCB				
Proc.	Resul.	# A-B		

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter # of levels of A	# A	C	# A
6	Enter # of levels of B	# B	R/S	# B
7	Process data card		A	
7a	If number of observations is less than 30			0
7b	If number of observations is greater than 30			'3' *
8a	If step 7a is true go to step 13			
8b	If step 7b is true load side 1 of data card ₂			3
9	Process data card		R/S	
10a	If all observations have been processed go to step 11			3 **
10b	If step 10a is not true			'3' *
10c	Load next data card and go to step 9			3
11	Load side 2 of data card ₁			3
12	Process data card		R/S	
12a	If all observations have been processed go to step 13			0
12b	If step 12a is not true			'3' *
12c	Load next data card and go to step 12			
13	For a printed output go to step 14; otherwise to to 16			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for two treatment factors, each at three levels, arranged factorially in a randomized complete block design. Data from Snedecor and Cochran (1967), page 352.

		<u>BLOCKS</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
A ₁	B ₁	56	45	43	46
	B ₂	60	50	45	48
	B ₃	66	57	50	50
A ₂	B ₁	65	61	60	63
	B ₂	60	58	56	60
	B ₃	53	53	48	55
A ₃	B ₁	60	61	50	53
	B ₂	62	68	67	60
	B ₃	73	77	77	65

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
3	C	3	# of levels of A
3	R/S	3	# of levels of B
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂		display will show # 3	card upright

ENTER	PRESS	OUTPUT	COMMENTS
Data card ₁	R/S	# 3 will be in the display and DATA will be printed if printer is attached	data card ₁ must be re-entered card inverted
Data card ₂	R/S	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing card upright
Prog. card ₂	R/S	display will show # 3	process finished
Prog. card ₂	R/S	0 will be in the display	card upright
Prog. card ₂	R/S	display will show # 1	card upright
Prog. card ₂	R/S	display will show # 2 (You do not have to read this card unless you want a printed output)	card inverted
	B	3	Block D.F.
	R/S	2	Factor A D.F.
	R/S	2	Factor B D.F.
	R/S	4	Inter. AB D.F.
	R/S	24	Residual D.F.
	R/S	35	Total D.F.
	R/S	255.6388889	Block S.S.
	R/S	1027.388889	Factor A S.S.
	R/S	155.0555555	Factor B S.S.
	R/S	765.4444445	Inter. AB S.S.
	R/S	424.1111111	Residual S.S.
	R/S	2627.638889	Total S.S.
	R/S	513.6944445	Factor A M.S.
	R/S	77.52777775	Factor B M.S.
	R/S	191.3611111	Inter. AB M.S.
	R/S	17.6712963	Residual M.S.

<i>ENTER</i>	<i>PRESS</i>	<i>OUTPUT</i>	<i>COMMENTS</i>
	R/S	29.06942625	F-Ratio for A
	R/S	4.387215089	F-Ratio for B
	R/S	10.82892324	F-Ratio for AB

PRINTED OUTPUT

```

      9.
      4.

      56.
      45.
      43.
      46.
      60.
      50.
      45.
      48.
      66.
      57.
      50.
      50.
      65.
      61.
      60.
      63.
      60.
      58.
      56.
      60.
      53.
      53.
      48.
      55.
      60.
      61.
      50.
      53.
      60.
      68.
RECORD DATA
      67.
      60.
      73.
      77.
      77.
      65.

DATA
DATA
DATA
      ANOVA TABLE

BLC. D.F.
      0.

```

```

      A D.F.
      2.

      B D.F.
      2.

      AB D.F.
      4.

RES. D.F.
      24.

TOT. D.F.
      35.

BLC. S.S.
      255.6388889

      A S.S.
      1027.388889

      B S.S.
      155.0555555

      AB S.S.
      765.4444445

RES. S.S.
      424.1111111

TOT. S.S.
      2627.6388889

      A M.S.
      513.6944445

      B M.S.
      77.52777775

      AB M.S.
      191.3611111

```

RES. M.S.
17.6712963

F-RATIO A
29.06942625

F-RATIO B
4.387215089

F-RATIO AB
10.82892324

Two-Factor Factorial in RCB

PROGRAM LISTING

LOC	CODE	KEY
000	76	LBL
001	11	R
002	03	3
003	00	0
004	42	STO
005	00	00
006	01	1
007	05	5
008	42	STO
009	04	04
010	43	RCL
011	14	14
012	42	STO
013	06	06
014	43	RCL
015	01	01
016	42	STO
017	05	05
018	29	OP
019	43	RCL
020	05	05
021	22	INV
022	67	EQ
023	00	00
024	73	73
025	43	RCL
026	10	10
027	74	SM*
028	04	04
029	44	SUM
030	07	07
031	33	X ²
032	44	SUM
033	09	09
034	69	OP
035	24	24
036	69	OP
037	36	36
038	43	RCL
039	06	06
040	67	EQ
041	00	00
042	46	46
043	61	GTO
044	00	00
045	67	67
046	01	1

LOC	CODE	KEY
047	05	5
048	42	STO
049	04	04
050	43	RCL
051	07	07
052	33	X ²
053	44	SUM
054	08	08
055	00	0
056	42	STO
057	07	07
058	43	RCL
059	14	14
060	42	STO
061	06	06
062	43	RCL
063	03	03
064	67	EQ
065	00	00
066	97	97
067	00	0
068	42	STO
069	10	10
070	61	GTO
071	00	00
072	14	14
073	73	RC*
074	00	00
075	69	OP
076	19	19
077	87	IFF
078	07	07
079	04	04
080	20	20
081	44	SUM
082	10	10
083	44	SUM
084	11	11
085	33	X ²
086	44	SUM
087	12	12
088	69	OP
089	20	20
090	69	OP
091	33	33
092	69	OP
093	35	35

LOC	CODE	KEY
094	61	GTO
095	00	00
096	18	18
097	73	RC*
098	04	04
099	33	X ²
100	44	SUM
101	07	07
102	00	0
103	72	ST*
104	04	04
105	69	OP
106	24	24
107	69	OP
108	36	36
109	43	RCL
110	06	06
111	67	EQ
112	01	01
113	17	17
114	61	GTO
115	00	00
116	97	97
117	43	RCL
118	01	01
119	65	*
120	43	RCL
121	02	02
122	95	=
123	42	STO
124	03	03
125	03	3
126	00	0
127	42	STO
128	00	00
129	87	IFF
130	01	01
131	04	04
132	23	23
133	01	1
134	05	5
135	42	STO
136	04	04
137	43	RCL
138	01	01
139	42	STO
140	06	06

LOC	CODE	KEY
141	43	RCL
142	03	03
143	67	EQ
144	01	01
145	72	72
146	73	RC*
147	00	00
148	69	OP
149	19	19
150	87	IFF
151	07	07
152	04	04
153	21	21
154	74	SM*
155	04	04
156	69	OP
157	20	20
158	69	OP
159	24	24
160	69	OP
161	33	33
162	69	OP
163	36	36
164	43	RCL
165	06	06
166	67	EQ
167	01	01
168	33	33
169	61	GTO
170	01	01
171	46	46
172	73	RC*
173	04	04
174	33	X ²
175	44	SUM
176	05	05
177	69	OP
178	24	24
179	69	OP
180	36	36
181	43	RCL
182	06	06
183	67	EQ
184	01	01
185	89	89
186	61	GTO
187	01	01

LOC	CODE	KEY
188	72	72
189	43	RCL
190	01	01
191	65	X
192	43	RCL
193	02	02
194	95	=
195	42	STD
196	03	03
197	43	RCL
198	11	11
199	33	X ²
200	55	+
201	43	RCL
202	03	03
203	95	=
204	42	STD
205	10	10
206	43	RCL
207	12	12
208	75	-
209	43	RCL
210	10	10
211	95	=
212	42	STD
213	11	11
214	43	RCL
215	09	09
216	55	+
217	43	RCL
218	01	01
219	75	-
220	43	RCL
221	10	10
222	95	=
223	42	STD
224	09	09
225	43	RCL
226	05	05
227	55	+
228	43	RCL
229	02	02
230	75	-
231	43	RCL
232	10	10
233	95	=
234	42	STD
235	12	12
236	43	RCL

LOC	CODE	KEY
237	11	11
238	75	-
239	43	RCL
240	09	09
241	75	-
242	43	RCL
243	12	12
244	95	=
245	42	STD
246	06	06
247	43	RCL
248	08	08
249	55	+
250	53	(
251	43	RCL
252	14	14
253	65	X
254	43	RCL
255	01	01
256	54)
257	75	-
258	43	RCL
259	10	10
260	95	=
261	42	STD
262	08	08
263	43	RCL
264	07	07
265	55	+
266	53	(
267	43	RCL
268	13	13
269	65	X
270	43	RCL
271	01	01
272	54)
273	75	-
274	43	RCL
275	10	10
276	95	=
277	42	STD
278	07	07
279	43	RCL
280	09	09
281	75	-
282	43	RCL
283	08	08
284	75	-
285	43	RCL

LOC	CODE	KEY
286	07	07
287	95	=
288	42	STD
289	04	04
290	25	CLR
291	92	RTN
292	76	LBL
293	12	B
294	43	RCL
295	01	01
296	75	-
297	01	1
298	95	=
299	42	STD
300	15	15
301	91	R/S
302	43	RCL
303	13	13
304	75	-
305	01	1
306	95	=
307	42	STD
308	16	16
309	91	R/S
310	43	RCL
311	14	14
312	75	-
313	01	1
314	95	=
315	42	STD
316	17	17
317	91	R/S
318	43	RCL
319	16	16
320	65	X
321	43	RCL
322	17	17
323	95	=
324	42	STD
325	18	18
326	91	R/S
327	43	RCL
328	02	02
329	75	-
330	01	1
331	95	=
332	65	X
333	43	RCL
334	15	15

LOC	CODE	KEY
335	95	=
336	42	STD
337	19	19
338	91	R/S
339	43	RCL
340	03	03
341	75	-
342	01	1
343	95	=
344	91	R/S
345	43	RCL
346	12	12
347	91	R/S
348	43	RCL
349	08	08
350	91	R/S
351	43	RCL
352	07	07
353	91	R/S
354	43	RCL
355	04	04
356	91	R/S
357	43	RCL
358	06	06
359	91	R/S
360	43	RCL
361	11	11
362	91	R/S
363	43	RCL
364	08	08
365	55	+
366	43	RCL
367	16	16
368	95	=
369	42	STD
370	20	20
371	91	R/S
372	43	RCL
373	07	07
374	55	+
375	43	RCL
376	17	17
377	95	=
378	42	STD
379	21	21
380	91	R/S
381	43	RCL
382	04	04
383	55	+

LOC	CODE	KEY
384	43	RCL
385	18	18
386	95	=
387	42	STD
388	22	22
389	91	R/S
390	43	RCL
391	06	06
392	55	+
393	43	RCL
394	19	19
395	95	=
396	42	STD
397	23	23
398	91	R/S
399	43	RCL
400	20	20
401	55	+
402	43	RCL
403	23	23
404	95	=
405	91	R/S
406	43	RCL
407	21	21
408	55	+
409	43	RCL
410	23	23
411	95	=
412	91	R/S
413	43	RCL
414	22	22
415	55	+
416	43	RCL
417	23	23
418	95	=
419	92	RTN
420	22	INV
421	86	STF
422	01	01
423	01	1
424	06	E
425	01	1
426	03	3
427	03	3
428	07	7
429	01	1
430	03	3
431	69	DP
432	01	01

LOC	CODE	KEY
433	69	DP
434	05	05
435	69	DP
436	00	00
437	03	3
438	91	R/S
439	22	INV
440	86	STF
441	07	07
442	03	3
443	00	0
444	42	STD
445	00	00
446	87	IFF
447	01	01
448	04	04
449	68	68
450	86	STF
451	01	01
452	43	RCL
453	05	05
454	67	EQ
455	00	00
456	14	14
457	61	GTD
458	00	00
459	18	18
460	76	LBL
461	13	C
462	42	STD
463	13	13
464	91	R/S
465	42	STD
466	14	14
467	92	RTN
468	22	INV
469	86	STF
470	01	01
471	43	RCL
472	06	06
473	67	EQ
474	01	01
475	33	33
476	61	GTD
477	01	01
478	41	41

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADM
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	00	0
044	00	0
045	69	DP
046	02	02
047	01	1
048	04	4

LOC	CODE	KEY
049	02	2
050	07	7
051	01	1
052	05	5
053	04	4
054	00	0
055	00	0
056	00	0
057	69	DP
058	01	01
059	69	DP
060	05	05
061	43	RCL
062	01	01
063	75	-
064	01	1
065	95	=
066	42	STD
067	15	15
068	99	PRT
069	91	R/S
070	98	ADM
071	01	1
072	03	3
073	00	0
074	00	0
075	00	0
076	00	0
077	69	DP
078	01	01
079	69	DP
080	05	05
081	43	RCL
082	13	13
083	75	-
084	01	1
085	95	=
086	42	STD
087	16	16
088	99	PRT
089	91	R/S
090	98	ADM
091	01	1
092	04	4
093	00	0
094	00	0
095	00	0
096	00	0
097	69	DP

LOC	CODE	KEY
098	01	01
099	69	DP
100	05	05
101	43	RCL
102	14	14
103	75	-
104	01	1
105	95	=
106	42	STO
107	17	17
108	99	PRT
109	91	R/S
110	98	ADV
111	01	1
112	03	3
113	01	1
114	04	4
115	00	0
116	00	0
117	69	DP
118	01	01
119	69	DP
120	05	05
121	43	RCL
122	16	16
123	65	*
124	43	RCL
125	17	17
126	95	=
127	42	STO
128	18	18
129	99	PRT
130	91	R/S
131	98	ADV
132	03	3
133	05	5
134	01	1
135	07	7
136	03	3
137	06	6
138	04	4
139	00	0
140	00	0
141	00	0
142	69	DP
143	01	01
144	69	DP
145	05	05
146	43	RCL

LOC	CODE	KEY
147	02	02
148	75	-
149	01	1
150	95	=
151	65	*
152	43	RCL
153	15	15
154	95	=
155	42	STO
156	19	19
157	99	PRT
158	91	R/S
159	98	ADV
160	03	3
161	07	7
162	03	3
163	02	2
164	03	3
165	07	7
166	04	4
167	00	0
168	00	0
169	00	0
170	69	DP
171	01	01
172	69	DP
173	05	05
174	43	RCL
175	03	03
176	75	-
177	01	1
178	95	=
179	99	PRT
180	91	R/S
181	98	ADV
182	03	3
183	06	6
184	04	4
185	00	0
186	03	3
187	06	6
188	04	4
189	00	0
190	00	0
191	00	0
192	69	DP
193	02	02
194	01	1
195	04	4

LOC	CODE	KEY
196	02	2
197	07	7
198	01	1
199	05	5
200	04	4
201	00	0
202	00	0
203	00	0
204	69	DP
205	01	01
206	69	DP
207	05	05
208	43	RCL
209	12	12
210	99	PRT
211	91	R/S
212	98	ADV
213	01	1
214	03	3
215	00	0
216	00	0
217	00	0
218	00	0
219	69	DP
220	01	01
221	69	DP
222	05	05
223	43	RCL
224	08	08
225	99	PRT
226	91	R/S
227	98	ADV
228	01	1
229	04	4
230	00	0
231	00	0
232	00	0
233	00	0
234	69	DP
235	01	01
236	69	DP
237	05	05
238	43	RCL
239	07	07
240	99	PRT
241	91	R/S
242	98	ADV
243	01	1
244	03	3

LOC	CODE	KEY
245	01	1
246	04	4
247	00	0
248	00	0
249	69	DP
250	01	01
251	69	DP
252	05	05
253	43	RCL
254	04	04
255	99	PRT
256	91	R/S
257	98	ADV
258	03	3
259	05	5
260	01	1
261	07	7
262	03	3
263	06	6
264	04	4
265	00	0
266	00	0
267	00	0
268	69	DP
269	01	01
270	69	DP
271	05	05
272	43	RCL
273	06	06
274	99	PRT
275	91	R/S
276	98	ADV
277	03	3
278	07	7
279	03	3
280	02	2
281	03	3
282	07	7
283	04	4
284	00	0
285	00	0
286	00	0
287	69	DP
288	01	01
289	69	DP
290	05	05
291	43	RCL
292	11	11
293	99	PRT

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
294	91	R/S	343	17	17	392	23	23	441	69	DP
295	98	ADV	344	95	=	393	99	PRT	442	02	02
296	03	3	345	42	STD	394	91	R/S	443	69	DP
297	00	0	346	21	21	395	98	ADV	444	05	05
298	04	4	347	99	PRT	396	02	2	445	43	RCL
299	00	0	348	91	R/S	397	01	1	446	21	21
300	03	3	349	98	ADV	398	02	2	447	55	+
301	06	6	350	01	1	399	00	0	448	43	RCL
302	04	4	351	03	3	400	03	3	449	23	23
303	00	0	352	01	1	401	05	5	450	95	=
304	00	0	353	04	4	402	01	1	451	99	PRT
305	00	0	354	00	0	403	03	3	452	91	R/S
306	69	DP	355	00	0	404	03	3	453	98	ADV
307	02	02	356	69	DP	405	07	7	454	02	2
308	01	1	357	01	01	406	69	DP	455	04	4
309	03	3	358	69	DP	407	01	01	456	03	3
310	00	0	359	05	05	408	02	2	457	02	2
311	00	0	360	43	RCL	409	04	4	458	00	0
312	00	0	361	04	04	410	03	3	459	00	0
313	00	0	362	55	+	411	02	2	460	01	1
314	69	DP	363	43	RCL	412	00	0	461	03	3
315	01	01	364	18	18	413	00	0	462	01	1
316	69	DP	365	95	=	414	01	1	463	04	4
317	05	05	366	42	STD	415	03	3	464	69	DP
318	43	RCL	367	22	22	416	00	0	465	02	02
319	08	08	368	99	PRT	417	00	0	466	69	DP
320	55	+	369	91	R/S	418	69	DP	467	05	05
321	43	RCL	370	98	ADV	419	02	02	468	43	RCL
322	16	16	371	03	3	420	69	DP	469	22	22
323	95	=	372	05	5	421	05	05	470	55	+
324	42	STD	373	01	1	422	43	RCL	471	43	RCL
325	20	20	374	07	7	423	20	20	472	23	23
326	99	PRT	375	03	3	424	55	+	473	95	=
327	91	R/S	376	06	6	425	43	RCL	474	99	PRT
328	98	ADV	377	04	4	426	23	23	475	92	RTN
329	01	1	378	00	0	427	95	=			
330	04	4	379	00	0	428	99	PRT			
331	00	0	380	00	0	429	91	R/S			
332	00	0	381	69	DP	430	98	ADV			
333	00	0	382	01	01	431	02	2			
334	00	0	383	69	DP	432	04	4			
335	69	DP	384	05	05	433	03	3			
336	01	01	385	43	RCL	434	02	2			
337	69	DP	386	06	06	435	00	0			
338	05	05	387	55	+	436	00	0			
339	43	RCL	388	43	RCL	437	01	1			
340	07	07	389	19	19	438	04	4			
341	55	+	390	95	=	439	00	0			
342	43	RCL	391	42	STD	440	00	0			

APPENDIX N

**PROGRAM FOR THREE-FACTOR FACTORIAL IN A
COMPLETELY RANDOMIZED DESIGN**

PROGRAM DESCRIPTION

PROGRAM TITLE: Three Factor Factorial in a Completely Randomized Design

OBJECTIVES: This program performs an analysis of variance for three treatment factors arranged factorially in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number of treatment combinations
- b) **FACTORS** : 3
- c) **LEVELS** : any number for any factor
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: univariate

OUTPUT^(*): Main effects A, B, and C degrees of freedom
First-order interactions AB, AC, and BC degrees of freedom
Second-order interaction ABC degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Main effects A, B, and C sum of squares
First-order interactions AB, AC, and BC sum of squares
Second-order interaction ABC sum of squares
Residual sum of squares
Total sum of squares
Main effects A, B, and C mean squares
First-order interactions AB, AC, and BC mean squares

() printed and displayed when PRINTER UNIT is used*

Second-order interaction ABC mean square
Residual mean square
F-ratios for main effects A, B, and C
F-ratios for first-order interactions AB, AC,
and BC
F-ratio for second-order interaction ABC

PROGRAM CARD DESCRIPTION

Three Factor Factorial in CRD				
Proc.	#A,B,C			
Proc.	Resul.	Fac.A	Fac.B	Fac.C

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter # of levels of A	# Levels A	2nd B	# A
6	Enter # of levels of B	# Levels B	R/S	# B
7	Enter # of levels of C	# Levels C	R/S	# C
8	Process data card		A	
8a	If number of observations is less than 30			0
8b	If number of observations is greater than 30			'3' *
9a	If step 8a is true go to step 11			
9b	If step 8b is true load side 1 of data card ₂			3
10	Process data card		R/S	
10a	If all observations have been processed go to step 11			0
10b	If step 10a is not true			'3' *
10c	Load next data card and go to step 10			3
11	Initialize factor A totals		C	0
11a	Enter cell AB _{i,j} totals from two-way table AB for i=1,..,a and j=1,..,b	Cell AB _{i,j}	R/S	n
12	Initialize factor C totals		D	0
12a	Enter cell AC _{i,j} totals from two-way table AC for i=1,..,c and j=1,..,a	Cell AC _{i,j}	R/S	n

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
13	Initialize factor B totals		E	0
13a	Enter cell $BC_{i,j}$ totals from two-way table BC for $i=1,..,b$ and $j=1,..,c$	Cell $BC_{i,j}$	R/S	n
14	Process totals		2nd A	2 **
15	Set new partition	3	2nd OP	
			17	719.29
16	Load side 1 of program card ₂			1
17	Load side 2 of program card ₂			2
18	Load side 1 of program card ₃			3
19	Obtain results		B	A D.F.
			R/S	B D.F.
			R/S	C D.F.
			R/S	AB D.F.
			R/S	AC D.F.
			R/S	BC D.F.
			R/S	ABC D.F.
			R/S	Res. D.F.
			R/S	Tot. F.F.
			R/S	A S.S.
			R/S	B S.S.
			R/S	C S.S.
			R/S	AB S.S.
			R/S	AC S.S.
			R/S	BC S.S.
			R/S	ABC S.S.
			R/S	Res. S.S.
			R/S	Tot. S.S.
			R/S	A M.S.
			R/S	B M.S.
			R/S	C M.S.
			R/S	AB M.S.
			R/S	AC M.S.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	BC M.S.
			R/S	ABC M.S.
			R/S	Res. M.S.
			R/S	F-Ratio A
			R/S	F-Ratio B
			R/S	F-Ratio C
			R/S	F-Ratio
				AB
			R/S	F-Ratio
				AC
			R/S	F-Ratio
				BC
			R/S	F-Ratio
				ABC
	<p>* DATA will be printed if printer is attached</p> <p>** PROG. CARD(2) will be printed if printer is attached</p>			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for three treatment factors, the first at 2 levels, the second at 3 levels and the third at 2 levels, arranged factorially in a completely randomized design.

Simulated Data

B ₁		$\frac{A_1}{B_2}$		B ₃		B ₁		$\frac{A_2}{B_2}$		B ₃	
C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂
8	5	9	15	10	12	7	6	10	8	9	8
4	7	6	8	13	8	5	9	7	4	5	7

TWO-WAY TABLES

	A ₁	A ₂		A ₁	A ₂		C ₁	C ₂
B ₁	24	27	C ₁	50	43	B ₁	24	27
B ₂	38	29	C ₂	55	42	B ₂	32	35
B ₃	43	29				B ₃	37	35

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
2	2nd B	2	# of levels of A
3	R/S	3	# of levels of B
2	R/S	2	# of levels of C
	A	0 will show in the display	observations processed
	C	0	initialize factor A

ENTER	PRESS	OUTPUT	COMMENTS
24	R/S	1	$A_1 B_1$ total
38	R/S	2	$A_1 B_2$ total
43	R/S	3	$A_1 B_3$ total
27	R/S	4	$A_2 B_1$ total
29	R/S	5	$A_2 B_2$ total
29	R/S	6	$A_2 B_3$ total
	D	0	initialize factor C totals
50	R/S	1	$A_1 C_1$ total
43	R/S	2	$A_2 C_1$ total
55	R/S	3	$A_1 C_2$ total
42	R/S	4	$A_2 C_2$ total
	E	0	initialize factor B totals
24	R/S	1	$B_1 C_1$ total
27	R/S	2	$B_1 C_2$ total
32	R/S	3	$B_2 C_1$ total
35	R/S	4	$B_2 C_2$ total
37	R/S	5	$B_3 C_1$ total
35	R/S	6	$B_3 C_2$ total
	2nd A	2 and PROG. CARD(2)	process finished
		will be printed if printer is attached	
3	2nd OP 17	719.29	new partition
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
Prog. card ₃		Display will show # 3	card upright
	B	1	A D.F.
	R/S	2	B D.F.
	R/S	1	C D.F.
	R/S	2	AB D.F.
	R/S	1	AC D.F.
	R/S	2	BC D.F.

ENTER	PRESS	OUTPUT	COMMENTS
	R/S	2	ABC D.F.
	R/S	12	Res. D.F.
	R/S	23	Tot. D.F.
	R/S	16.66666667	A S.S.
	R/S	30.08333333	B S.S.
	R/S	0.666666667	C S.S.
	R/S	19.08333333	AB S.S.
	R/S	1.5	AC S.S.
	R/S	2.083333333	BC S.S.
	R/S	22.75	ABC S.S.
	R/S	79.0	Res. S.S.
	R/S	171.8333333	Tot. S.S.
	R/S	16.66666667	A M.S.
	R/S	15.04166667	B M.S.
	R/S	0.666666667	C M.S.
	R/S	9.54166667	AB M.S.
	R/S	1.5	AC M.S.
	R/S	1.041666667	BC M.S.
	R/S	11.375	ABC M.S.
	R/S	6.583333333	Res. M.S.
	R/S	2.53164557	F-Ratio for A
	R/S	2.284810127	F-Ratio for B
	R/S	0.1012658228	F-Ratio for C
	R/S	1.449367089	F-Ratio for AB
	R/S	0.2278481013	F-Ratio for AC
	R/S	0.1582278481	F-Ratio for BC
	R/S	1.727848101	F-Ratio for ABC

PRINTED OUTPUT

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```

PROG. CARD(2)
ANOVA TABLE

A D. F. 1.

B D. F. 2.

C D. F. 1.

AB D. F. 2.

AC D. F. 1.

```

BC D. F. 2.

```

ABC D. F. 2.

RES. D. F. 12.

TOT. D. F. 23.

A S. S. 16.66666667

B S. S. 30.08333333

C S. S. 0.666666667

AB S. S. 19.08333333

AC S. S. 1.5

BC S. S. 2.083333333

ABC S. S. 22.75

RES. S. S. 79.

TOT. S. S. 171.8333333

A M. S. 16.66666667

B M. S.
15.041666667

C M. S.
0.666666667

AB M. S.
9.541666667

AC M. S.
1.5

BC M. S.
1.041666667

ABC M. S.
11.375

RES. M. S.
6.583333333

F-RATIO A
2.53164557

F-RATIO B
2.284810127

F-RATIO C
.1012658228

F-RATIO AB
1.449367089

F-RATIO AC
.2278481013

F-RATIO BC
.1582278481

F-RATIO ABC
1.727848101

Three-Factor Factorial in CRD **PROGRAM LISTING**

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	08	08	094	67	EQ	141	43	RCL
001	11	A	048	33	X ²	095	01	01	142	08	08
002	03	3	049	44	SUM	096	02	02	143	61	GTD
003	00	0	050	05	05	097	43	RCL	144	01	01
004	42	STD	051	69	DP	098	08	08	145	26	26
005	00	00	052	20	20	099	61	GTD	146	43	RCL
006	43	RCL	053	69	DP	100	00	00	147	17	17
007	01	01	054	29	29	101	81	81	148	33	X ²
008	42	STD	055	69	DP	102	43	RCL	149	44	SUM
009	04	04	056	34	34	103	15	15	150	15	15
010	29	CP	057	61	GTD	104	33	X ²	151	00	0
011	43	RCL	058	00	00	105	44	SUM	152	42	STD
012	04	04	059	10	10	106	13	13	153	17	17
013	22	INV	060	25	CLR	107	00	0	154	43	RCL
014	67	EQ	061	91	R/S	108	42	STD	155	08	08
015	00	00	062	76	LBL	109	15	15	156	61	GTD
016	36	36	063	17	B*	110	43	RCL	157	01	01
017	43	RCL	064	42	STD	111	08	08	158	20	20
018	08	08	065	10	10	112	61	GTD	159	76	LBL
019	33	X ²	066	91	R/S	113	00	00	160	15	E
020	44	SUM	067	42	STD	114	75	75	161	00	0
021	06	06	068	11	11	115	76	LBL	162	42	STD
022	00	0	069	91	R/S	116	14	D	163	08	08
023	42	STD	070	42	STD	117	00	0	164	43	RCL
024	08	08	071	12	12	118	42	STD	165	12	12
025	43	RCL	072	91	R/S	119	08	08	166	42	STD
026	03	03	073	76	LBL	120	43	RCL	167	04	04
027	32	XIT	074	13	C	121	10	10	168	43	RCL
028	43	RCL	075	43	RCL	122	42	STD	169	08	08
029	09	09	076	11	11	123	04	04	170	91	R/S
030	67	EQ	077	42	STD	124	43	RCL	171	44	SUM
031	00	00	078	04	04	125	08	08	172	19	19
032	60	60	079	43	RCL	126	91	R/S	173	33	X ²
033	61	GTD	080	08	08	127	44	SUM	174	44	SUM
034	00	00	081	91	R/S	128	17	17	175	18	18
035	06	06	082	44	SUM	129	33	X ²	176	69	DP
036	73	RC*	083	15	15	130	44	SUM	177	28	28
037	00	00	084	33	X ²	131	16	16	178	69	DP
038	69	DP	085	44	SUM	132	69	DP	179	34	34
039	19	19	086	14	14	133	28	28	180	43	RCL
040	87	IFF	087	69	DP	134	69	DP	181	04	04
041	07	07	088	28	28	135	34	34	182	67	EQ
042	03	03	089	69	DP	136	43	RCL	183	01	01
043	87	87	090	34	34	137	04	04	184	90	90
044	44	SUM	091	29	CP	138	67	EQ	185	43	RCL
045	07	07	092	43	RCL	139	01	01	186	08	08
046	44	SUM	093	04	04	140	46	46	187	61	GTD

LOC	CODE	KEY
188	01	01
189	70	70
190	43	RCL
191	19	19
192	33	X ²
193	44	SUM
194	17	17
195	00	0
196	42	STD
197	19	19
198	43	RCL
199	08	08
200	61	GTO
201	01	01
202	64	64
203	76	LBL
204	16	R*
205	43	RCL
206	07	07
207	33	X ²
208	55	+
209	43	RCL
210	03	03
211	95	=
212	42	STD
213	04	04
214	43	RCL
215	05	05
216	75	-
217	43	RCL
218	04	04
219	95	=
220	42	STD
221	05	05
222	43	RCL
223	06	06
224	55	+
225	43	RCL
226	01	01
227	75	-
228	43	RCL
229	04	04
230	95	=
231	42	STD
232	06	06
233	43	RCL
234	05	05
235	75	-
236	43	RCL

LOC	CODE	KEY
237	06	06
238	95	=
239	42	STD
240	07	07
241	43	RCL
242	13	13
243	55	+
244	53	(
245	43	RCL
246	11	11
247	65	*
248	43	RCL
249	12	12
250	65	*
251	43	RCL
252	01	01
253	54)
254	75	-
255	43	RCL
256	04	04
257	95	=
258	42	STD
259	08	08
260	42	STD
261	00	00
262	43	RCL
263	15	15
264	55	+
265	53	(
266	43	RCL
267	10	10
268	65	*
269	43	RCL
270	11	11
271	65	*
272	43	RCL
273	01	01
274	54)
275	75	-
276	43	RCL
277	04	04
278	95	=
279	42	STD
280	13	13
281	44	SUM
282	00	00
283	43	RCL
284	17	17
285	55	+

LOC	CODE	KEY
286	53	(
287	43	RCL
288	10	10
289	65	*
290	43	RCL
291	12	12
292	65	*
293	43	RCL
294	01	01
295	54)
296	75	-
297	43	RCL
298	04	04
299	95	=
300	42	STD
301	15	15
302	44	SUM
303	00	00
304	43	RCL
305	14	14
306	55	+
307	53	(
308	43	RCL
309	12	12
310	65	*
311	43	RCL
312	01	01
313	54)
314	75	-
315	43	RCL
316	04	04
317	75	-
318	43	RCL
319	08	08
320	75	-
321	43	RCL
322	15	15
323	95	=
324	42	STD
325	09	09
326	44	SUM
327	00	00
328	43	RCL
329	16	16
330	55	+
331	53	(
332	43	RCL
333	11	11
334	65	*

LOC	CODE	KEY
335	43	RCL
336	01	01
337	54)
338	75	-
339	43	RCL
340	04	04
341	75	-
342	43	RCL
343	08	08
344	75	-
345	43	RCL
346	13	13
347	95	=
348	42	STD
349	14	14
350	44	SUM
351	00	00
352	43	RCL
353	18	18
354	55	+
355	53	(
356	43	RCL
357	10	10
358	65	*
359	43	RCL
360	01	01
361	54)
362	75	-
363	43	RCL
364	04	04
365	75	-
366	43	RCL
367	13	13
368	75	-
369	43	RCL
370	15	15
371	95	=
372	42	STD
373	16	16
374	44	SUM
375	00	00
376	43	RCL
377	06	06
378	75	-
379	43	RCL
380	00	00
381	95	=
382	42	STD
383	17	17

LOC	CODE	KEY
384	61	GTO
385	04	04
386	18	18
387	01	1
388	06	6
389	01	1
390	03	3
391	03	3
392	07	7
393	01	1
394	03	3
395	69	DP
396	01	01
397	69	DP
398	05	05
399	69	DP
400	00	00
401	03	3
402	91	R/S
403	22	INV
404	86	STF
405	07	07
406	03	3
407	00	0
408	42	STO
409	00	00
410	43	RCL
411	04	04
412	67	EQ
413	00	00
414	06	06
415	61	GTO
416	00	00
417	11	11
418	03	3
419	03	3
420	03	3
421	05	5
422	03	3
423	02	2
424	02	2
425	02	2
426	04	4
427	00	0
428	69	DP
429	01	01
430	01	1
431	05	5
432	01	1

LOC	CODE	KEY
433	03	3
434	03	3
435	05	5
436	01	1
437	06	6
438	69	DP
439	02	02
440	05	5
441	05	5
442	00	0
443	03	3
444	05	5
445	06	6
446	00	0
447	00	0
448	00	0
449	00	0
450	69	DP
451	03	03
452	69	DP
453	05	05
454	69	DP
455	00	00
456	02	2
457	92	RTN

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	69	DP
044	02	02
045	01	1
046	03	3
047	69	DP
048	01	01

LOC	CODE	KEY
049	69	DP
050	05	05
051	43	RCL
052	10	10
053	75	-
054	01	1
055	95	=
056	42	STO
057	18	18
058	99	PRT
059	91	R/S
060	98	ADV
061	01	1
062	04	4
063	69	DP
064	01	01
065	69	DP
066	05	05
067	43	RCL
068	11	11
069	75	-
070	01	1
071	95	=
072	42	STO
073	19	19
074	99	PRT
075	91	R/S
076	98	ADV
077	01	1
078	05	5
079	69	DP
080	01	01
081	69	DP
082	05	05
083	43	RCL
084	12	12
085	75	-
086	01	1
087	95	=
088	42	STO
089	20	20
090	99	PRT
091	91	R/S
092	98	ADV
093	01	1
094	03	3
095	01	1
096	04	4
097	69	DP

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
098	01	01	147	99	PRT	196	25	25	245	69	DP
099	69	DP	148	91	R/S	197	99	PRT	246	05	05
100	05	05	149	98	ADV	198	91	R/S	247	43	RCL
101	43	RCL	150	01	1	199	98	ADV	248	15	15
102	18	18	151	03	3	200	03	3	249	99	PRT
103	65	*	152	01	1	201	07	7	250	91	R/S
104	43	RCL	153	04	4	202	03	3	251	98	ADV
105	19	19	154	01	1	203	02	2	252	01	1
106	95	=	155	05	5	204	03	3	253	05	5
107	42	STD	156	69	DP	205	07	7	254	69	DP
108	21	21	157	01	01	206	04	4	255	01	01
109	99	PRT	158	69	DP	207	00	0	256	69	DP
110	91	R/S	159	05	05	208	69	DP	257	05	05
111	98	ADV	160	43	RCL	209	01	01	258	43	RCL
112	01	1	161	18	18	210	69	DP	259	13	13
113	03	3	162	65	*	211	05	05	260	99	PRT
114	01	1	163	43	RCL	212	43	RCL	261	91	R/S
115	05	5	164	19	19	213	03	03	262	98	ADV
116	69	DP	165	65	*	214	75	-	263	01	1
117	01	01	166	43	RCL	215	01	1	264	03	3
118	69	DP	167	20	20	216	95	=	265	01	1
119	05	05	168	95	=	217	99	PRT	266	04	4
120	43	RCL	169	42	STD	218	91	R/S	267	69	DP
121	18	18	170	24	24	219	03	3	268	01	01
122	65	*	171	99	PRT	220	06	6	269	69	DP
123	43	RCL	172	91	R/S	221	04	4	270	05	05
124	20	20	173	98	ADV	222	00	0	271	43	RCL
125	95	=	174	03	3	223	03	3	272	09	09
126	42	STD	175	05	5	224	06	6	273	99	PRT
127	22	22	176	01	1	225	04	4	274	91	R/S
128	99	PRT	177	07	7	226	00	0	275	98	ADV
129	91	R/S	178	03	3	227	69	DP	276	01	1
130	98	ADV	179	06	6	228	02	02	277	03	3
131	01	1	180	04	4	229	98	ADV	278	01	1
132	04	4	181	00	0	230	01	1	279	05	5
133	01	1	182	69	DP	231	03	3	280	69	DP
134	05	5	183	01	01	232	69	DP	281	01	01
135	69	DP	184	69	DP	233	01	01	282	69	DP
136	01	01	185	05	05	234	69	DP	283	05	05
137	69	DP	186	43	RCL	235	05	05	284	43	RCL
138	05	05	187	01	01	236	43	RCL	285	14	14
139	43	RCL	188	75	-	237	08	08	286	99	PRT
140	19	19	189	01	1	238	99	PRT	287	91	R/S
141	65	*	190	95	=	239	91	R/S	288	98	ADV
142	43	RCL	191	65	*	240	98	ADV	289	01	1
143	20	20	192	43	RCL	241	01	1	290	04	4
144	95	=	193	02	02	242	04	4	291	01	1
145	42	STD	194	95	=	243	69	DP	292	05	5
146	23	23	195	42	STD	244	01	01	293	69	DP

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
294	01	01	343	01	01	392	99	PRT	441	55	+
295	69	DP	344	69	DP	393	91	R/S	442	43	RCL
296	05	05	345	05	05	394	98	ADV	443	22	22
297	43	RCL	346	43	RCL	395	01	1	444	95	=
298	16	16	347	05	05	396	05	5	445	42	STD
299	99	PRT	348	99	PRT	397	69	DP	446	22	22
300	91	R/S	349	91	R/S	398	01	01	447	99	PRT
301	98	ADV	350	98	ADV	399	69	DP	448	91	R/S
302	01	1	351	03	3	400	05	05	449	98	ADV
303	03	3	352	00	0	401	43	RCL	450	01	1
304	01	1	353	04	4	402	13	13	451	04	4
305	04	4	354	00	0	403	55	+	452	01	1
306	01	1	355	03	3	404	43	RCL	453	05	5
307	05	5	356	06	6	405	20	20	454	69	DP
308	69	DP	357	04	4	406	95	=	455	01	01
309	01	01	358	00	0	407	42	STD	456	69	DP
310	69	DP	359	69	DP	408	20	20	457	05	05
311	05	05	360	02	02	409	99	PRT	458	43	RCL
312	43	RCL	361	01	1	410	91	R/S	459	16	16
313	17	17	362	03	3	411	98	ADV	460	55	+
314	99	PRT	363	69	DP	412	01	1	461	43	RCL
315	91	R/S	364	01	01	413	03	3	462	23	23
316	98	ADV	365	69	DP	414	01	1	463	95	=
317	03	3	366	05	05	415	04	4	464	42	STD
318	05	5	367	43	RCL	416	69	DP	465	23	23
319	01	1	368	08	08	417	01	01	466	99	PRT
320	07	7	369	55	+	418	69	DP	467	91	R/S
321	03	3	370	43	RCL	419	05	05	468	98	ADV
322	06	6	371	18	18	420	43	RCL	469	01	1
323	04	4	372	95	=	421	09	09	470	03	3
324	00	0	373	42	STD	422	55	+	471	01	1
325	69	DP	374	18	18	423	43	RCL	472	04	4
326	01	01	375	99	PRT	424	21	21	473	01	1
327	69	DP	376	91	R/S	425	95	=	474	05	5
328	05	05	377	98	ADV	426	42	STD	475	69	DP
329	43	RCL	378	01	1	427	21	21	476	01	01
330	07	07	379	04	4	428	99	PRT	477	69	DP
331	99	PRT	380	69	DP	429	91	R/S	478	05	05
332	91	R/S	381	01	01	430	98	ADV	479	43	RCL
333	98	ADV	382	69	DP	431	01	1	480	17	17
334	03	3	383	05	05	432	03	3	481	55	+
335	07	7	384	43	RCL	433	01	1	482	43	RCL
336	03	3	385	15	15	434	05	5	483	24	24
337	02	2	386	55	+	435	69	DP	484	95	=
338	03	3	387	43	RCL	436	01	01	485	42	STD
339	07	7	388	19	19	437	69	DP	486	24	24
340	04	4	389	95	=	438	05	05	487	99	PRT
341	00	0	390	42	STD	439	43	RCL	488	91	R/S
342	69	DP	391	19	19	440	14	14	489	98	ADV

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
490	03	3	539	43	RCL	588	43	RCL	637	99	PRT
491	05	5	540	18	18	589	25	25	638	91	R/S
492	01	1	541	55	+	590	95	=	639	98	ADV
493	07	7	542	43	RCL	591	99	PRT	640	02	2
494	03	3	543	25	25	592	91	R/S	641	04	4
495	06	6	544	95	=	593	98	ADV	642	03	3
496	04	4	545	99	PRT	594	02	2	643	02	2
497	00	0	546	91	R/S	595	04	4	644	00	0
498	69	DP	547	98	ADV	596	03	3	645	00	0
499	01	01	548	02	2	597	02	2	646	01	1
500	69	DP	549	04	4	598	00	0	647	04	4
501	05	05	550	03	3	599	00	0	648	01	1
502	43	RCL	551	02	2	600	01	1	649	05	5
503	07	07	552	00	0	601	03	3	650	69	DP
504	55	+	553	00	0	602	01	1	651	02	02
505	43	RCL	554	01	1	603	04	4	652	69	DP
506	25	25	555	04	4	604	69	DP	653	05	05
507	95	=	556	00	0	605	02	02	654	43	RCL
508	42	STD	557	00	0	606	69	DP	655	23	23
509	25	25	558	69	DP	607	05	05	656	55	+
510	99	PRT	559	02	02	608	43	RCL	657	43	RCL
511	91	R/S	560	69	DP	609	21	21	658	25	25
512	98	ADV	561	05	05	610	55	+	659	95	=
513	02	2	562	43	RCL	611	43	RCL	660	99	PRT
514	01	1	563	19	19	612	25	25	661	91	R/S
515	02	2	564	55	+	613	95	=	662	98	ADV
516	00	0	565	43	RCL	614	99	PRT	663	02	2
517	03	3	566	25	25	615	91	R/S	664	04	4
518	05	5	567	95	=	616	98	ADV	665	03	3
519	01	1	568	99	PRT	617	02	2	666	02	2
520	03	3	569	91	R/S	618	04	4	667	00	0
521	03	3	570	98	ADV	619	03	3	668	00	0
522	07	7	571	02	2	620	02	2	669	01	1
523	69	DP	572	04	4	621	00	0	670	03	3
524	01	01	573	03	3	622	00	0	671	01	1
525	02	2	574	02	2	623	01	1	672	04	4
526	04	4	575	00	0	624	03	3	673	69	DP
527	03	3	576	00	0	625	01	1	674	02	02
528	02	2	577	01	1	626	05	5	675	01	1
529	00	0	578	05	5	627	69	DP	676	05	5
530	00	0	579	00	0	628	02	02	677	00	0
531	01	1	580	00	0	629	69	DP	678	00	0
532	03	3	581	69	DP	630	05	05	679	00	0
533	00	0	582	02	02	631	43	RCL	680	00	0
534	00	0	583	69	DP	632	22	22	681	00	0
535	69	DP	584	05	05	633	55	+	682	00	0
536	02	02	585	43	RCL	634	43	RCL	683	00	0
537	69	DP	586	20	20	635	25	25	684	00	0
538	05	05	587	55	+	636	95	=	685	69	DP

LOC	CODE	KEY
686	03	03
687	69	DP
688	05	05
689	43	RCL
690	24	24
691	55	=
692	43	RCL
693	25	25
694	95	=
695	99	PRT
696	92	RTN

LOC	CODE	KEY
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LOC	CODE	KEY
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LOC	CODE	KEY
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APPENDIX O

PROGRAM FOR THREE-FACTOR FACTORIAL IN A
RANDOMIZED COMPLETE BLOCK DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Three Factor Factorial in a Randomized Complete Block Design

OBJECTIVES: This program performs an analysis of variance for three treatment factors arranged factorially in a randomized complete block design.

LIMITS FOR:

- a) **TREATMENTS** : any number of treatment combinations
- b) **FACTORS** : 3
- c) **LEVELS** : any number for any factor
- d) **REPLICATIONS** : 15

DATA INPUT TYPE: univariate

OUTPUT^(*): Block degrees of freedom
Main effects A, B, and C degrees of freedom
First-order interactions AB, AC, and BC degrees of freedom
Second-order interaction ABC degrees of freedom
Residual degrees of freedom
Total degrees of freedom
Block sum of squares
Main effects A, B, and C sum of squares
First-order interactions AB, AC, and BC sum of squares
Second-order interaction ABC sum of squares
Residual sum of squares
Total sum of squares
Main effects A, B, and C mean squares

^(*) printed and displayed when **PRINTER UNIT** is used

First-order interactions AB, AC, and BC mean squares

Second-order interaction ABC mean square

F-ratios for main effects A, B, and C

F-ratios for first-order interactions AB, AC, and BC

F-ratio for second-order interaction ABC

PROGRAM CARD DESCRIPTION

Three Factor Factorial in RCB				
Proc.	#A,B,C			
Proc.	Resul.	Fac.A	Fac.B	Fac.C

USERS INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter # of levels of A	# Levels A	2nd A	# A
6	Enter # of levels of B	# Levels B	R/S	# B
7	Enter # of levels of C	# Levels C	R/S	# C
8	Process data card		A	
8a	If number of observations is less than 30			0
8b	If number of observations is greater than 30			'3' *
9a	If step 8a is true go to step 11			
9b	If step 8b is true load side 1 of data card ₂			3
10	Process data card		R/S	
10a	If all observations have been processed go to step 11			0
10b	If step 10a is not true			'3' *
10c	Load next data card and go to step 10			3
11	Initialize factor A totals		C	0
11a	Enter cell AB _{i,j} totals from two-way table AB for i=1,...,a and j=1,...,b	Cell AB _{i,j}	R/S	n
12	Initialize factor C totals		D	0
12a	Enter cell AC _{i,j} totals from two-way table AC for i=1,...,c and j=1,...,a	Cell AC _{i,j}	R/S	n

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
13	Initialize factor B totals		E	0
13a	Enter cell $BC_{i,j}$ totals from two-way table BC for $i=1,..,b$ and $j=1,..,c$	Cell $BC_{i,j}$	R/S	n
14	Process totals		2nd A	2 **
15	Set new partition	3	2nd OP	
			17	719.29
16	Load side 1 of program card ₂			1
17	Load side 2 of program card ₂			2
18	Load side 1 of program card ₃			3
19	Obtain results		B	Blc. D.F.
			R/S	A D.F.
			R/S	B D.F.
			R/S	C D.F.
			R/S	AB D.F.
			R/S	AC D.F.
			R/S	BC D.F.
			R/S	ABC D.F.
			R/S	Res. D.F.
			R/S	Tot. D.F.
			R/S	Blc. S.S.
			R/S	A S.S.
			R/S	B S.S.
			R/S	C S.S.
			R/S	AB S.S.
			R/S	AC S.S.
			R/S	BC S.S.
			R/S	ABC S.S.
			R/S	Res. S.S.
			R/S	Tot. S.S.
			R/S	A M.S.
			R/S	B M.S.
			R/S	C M.S.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	AB M.S.
			R/S	AC M.S.
			R/S	ABC M.S.
			R/S	Res. M.S.
			R/S	F-Ratio A
			R/S	F-Ratio B
			R/S	F-Ratio C
			R/S	F-Ratio
				AB
			R/S	F-Ratio
				AC
			R/S	F-Ratio
				BC
			R/S	F-Ratio
				ABC
	<p>* DATA will be printed if printer is attached</p> <p>** PROG. CARD(2) will be printed if printer is attached</p>			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for three treatment factors, the first at 4 levels, the second at 3 levels, and the third at 2 levels and arranged factorially in a randomized complete block design. Data from Snedecor and Cochran (1967), page 362.

A_1	B_1	|	C_1	1.11	0.97	A_1	B_1	|	C_1	1.22	1.13
		|	C_2	1.52	1.45			|	C_2	1.38	1.08
	B_2	|	C_1	1.09	0.99		B_2	|	C_1	1.34	1.41
		|	C_2	1.27	1.22			|	C_2	1.40	1.21
	B_3	|	C_1	0.85	1.21		B_3	|	C_1	1.34	1.19
		|	C_2	1.67	1.24			|	C_2	1.46	1.39
A_2	B_1	|	C_1	1.30	1.00	A_2	B_1	|	C_1	1.19	1.03
		|	C_2	1.55	1.53			|	C_2	0.80	1.29
	B_2	|	C_1	1.03	1.21		B_2	|	C_1	1.36	1.16
		|	C_2	1.24	1.34			|	C_2	1.42	1.39
	B_3	|	C_1	1.12	0.96		B_3	|	C_1	1.46	1.03
		|	C_2	1.76	1.27			|	C_2	1.62	1.27

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
4	2nd B	4	# levels of A
3	R/S	3	# levels of B
2	R/S	2	# levels of C
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂		display will show # 3	card upright

TWO-WAY TABLES

	A ₁	A ₂	A ₃	A ₄
B ₁	5.05	5.38	4.81	4.31
B ₂	4.57	4.82	5.36	5.33
B ₃	5.97	5.11	5.38	5.38

	A ₁	A ₂	A ₃	A ₄
C ₁	6.22	6.62	7.63	7.23
C ₂	8.37	8.69	7.92	7.79

	C ₁	C ₂
B ₁	8.95	10.60
B ₂	9.59	10.49
B ₃	9.16	11.68

ENTER	PRESS	OUTPUT	COMMENTS
	R/S	0 will show in the display	
	C	0	initialize factor A totals
5.05	R/S	1	A ₁ B ₁ total
4.57	R/S	2	A ₁ B ₂ total
4.97	R/S	3	A ₁ B ₃ total
5.38	R/S	4	A ₂ B ₁ total
4.82	R/S	5	A ₂ B ₂ total
5.11	R/S	6	A ₂ B ₃ total
4.81	R/S	7	A ₃ B ₁ total
5.36	R/S	8	A ₃ B ₂ total
5.38	R/S	9	A ₃ B ₃ total
4.31	R/S	10	A ₄ B ₁ total
5.33	R/S	11	A ₄ B ₂ total
5.38	R/S	12	A ₄ B ₃ total
	D	0	initialize factor C totals
6.22	R/S	1	A ₁ C ₁ total
6.62	R/S	2	A ₂ C ₁ total
7.63	R/S	3	A ₃ C ₁ total
7.23	R/S	4	A ₄ C ₁ total
8.37	R/S	5	A ₁ C ₂ total
8.69	R/S	6	A ₂ C ₂ total
7.92	R/S	7	A ₃ C ₂ total
7.79	R/S	8	A ₄ C ₂ total
	E	0	initialize factor B totals
8.95	R/S	1	B ₁ C ₁ total
10.60	R/S	2	B ₁ C ₂ total
9.59	R/S	3	B ₂ C ₁ total
10.49	R/S	4	B ₂ C ₂ total
9.16	R/S	5	B ₃ C ₁ total
11.68	R/S	6	B ₃ C ₂ total

ENTER	PRESS	OUTPUT	COMMENTS
3 Prog. card ₂ Prog. card ₂ Prog. card ₃	2nd A	2 and PROG. CARD(2) will be printed if printer is attached	process finished
	2nd OP 17	719.29	new partition
		display will show # 1	card upright
		display will show # 2	card inverted
		display will show # 3	card upright
	B	1	Blc. D.F.
	R/S	3	A D.F.
	R/S	2	B D.F.
	R/S	1	C D.F.
	R/S	6	AB D.F.
	R/S	3	AC D.F.
	R/S	2	BC D.F.
	R/S	6	ABC D.F.
	R/S	23	Res. D.F.
	R/S	47	Tot. S.S.
	R/S	0.1333520833	Blc. S.S.
	R/S	0.042656225	A S.S.
	R/S	0.0525541667	B S.S.
	R/S	0.53551875	C S.S.
	R/S	0.2543625	AB S.S.
	R/S	0.23990625	AC S.S.
	R/S	0.0821625	BC S.S.
	R/S	0.0684875	ABC S.S.
	R/S	0.6318979167	Res. S.S.
	R/S	2.040897937	Tot. M.S.
	R/S	0.01421875	A M.S.
	R/S	0.0262770833	B M.S.
	R/S	0.53551875	C M.S.
R/S	0.04239375	AB M.S.	
R/S	0.07996875	AC M.S.	

<i>ENTER</i>	<i>PRESS</i>	<i>OUTPUT</i>	<i>COMMENTS</i>
	R/S	0.04108125	BC M.S.
	R/S	0.011445833	ABC M.S.
	R/S	0.0274738225	Res. M.S.
	R/S	0.5175381045	F-Ratio for A
	R/S	0.956440749	F-Ratio for B
	R/S	19.49196369	F-Ratio for C
	R/S	1.543059764	F-Ratio for AB
	R/S	2.910725295	F-Ratio for AC
	R/S	1.495287016	F-Ratio for BC
	R/S	0.415471249	F-Ratio for ABC

PRINTED OUTPUT

```

24.
 2.
.
1.11
0.97
1.52
1.45
1.09
0.99
1.27
1.22
0.85
1.21
1.67
1.24
 1.3
  1.
1.55
1.53
1.03
1.21
1.24
1.34
1.12
0.96
1.76
1.27
1.22
1.13
1.38
1.08
1.34
1.41
RECORD DATA
 1.4
 1.21
 1.34
 1.19
 1.46
 1.39
 1.19
 1.03
  0.8
 1.29
 1.36
 1.16
 1.42
 1.39

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1.46
1.03
1.62
1.27
DATA
PROG. CARD(2)
ANOVA TABLE

BLC D. F.
      1.

  A D. F.
      3.

  B D. F.
      2.

  C D. F.
      1.

 AB D. F.
      6.

 AC D. F.
      3.

 BC D. F.
      2.

 ABC D. F.
      6.

 RES D. F.
      23.

TOT D. F.
      47.

BLC S. S.
.1333520833

  A S. S.
0.04265625

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B S. S.
.0525541667

C S. S.
0.53551875

AB S. S.
0.2543625

AC S. S.
0.23990625

BC S. S.
0.0821625

ABC S. S.
0.0684875

RES S. S.
.6318979167

TDT S. S.
2.040897917

A M. S.
0.01421875

B M. S.
.0262770833

C M. S.
0.53551875

AB M. S.
0.04239375

AC M. S.
0.07996875

BC M. S.
0.04108125

ABC M. S.
.0114145833

RES M. S.
.0274738225

F-A
.5175381045

F-B
0.956440749

F-C
19.49196369

F-AB
1.543059764

F-AC
2.910725295

F-BC
1.495287016

F-ABC
0.415471249

Three-Factor Factorial in RCB

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	19	19	094	98	98	141	16	16
001	11	A	048	87	IFF	095	61	GTD	142	33	X ²
002	03	3	049	07	07	096	00	00	143	44	SUM
003	00	0	050	04	04	097	75	75	144	14	14
004	42	STD	051	08	08	098	25	CLR	145	00	0
005	00	00	052	44	SUM	099	91	R/S	146	42	STD
006	01	1	053	08	08	100	76	LBL	147	16	16
007	05	5	054	44	SUM	101	17	B ¹	148	43	RCL
008	42	STD	055	10	10	102	42	STD	149	04	04
009	05	05	056	74	SM*	103	11	11	150	61	GTD
010	43	RCL	057	05	05	104	91	R/S	151	01	01
011	01	01	058	33	X ²	105	42	STD	152	13	13
012	42	STD	059	44	SUM	106	12	12	153	76	LBL
013	04	04	060	06	06	107	91	R/S	154	14	D
014	29	CP	061	69	DP	108	42	STD	155	00	0
015	43	RCL	062	20	20	109	13	13	156	42	STD
016	04	04	063	69	DP	110	91	R/S	157	04	04
017	22	INV	064	25	25	111	76	LBL	158	43	RCL
018	67	EQ	065	69	DP	112	13	C	159	11	11
019	00	00	066	29	29	113	43	RCL	160	42	STD
020	44	44	067	69	DP	114	12	12	161	05	05
021	43	RCL	068	34	34	115	42	STD	162	43	RCL
022	10	10	069	61	GTD	116	05	05	163	04	04
023	33	X ²	070	00	00	117	43	RCL	164	91	R/S
024	44	SUM	071	14	14	118	04	04	165	44	SUM
025	07	07	072	00	0	119	91	R/S	166	18	18
026	00	0	073	42	STD	120	44	SUM	167	33	X ²
027	42	STD	074	09	09	121	16	16	168	44	SUM
028	10	10	075	73	RC*	122	33	X ²	169	17	17
029	01	1	076	05	05	123	44	SUM	170	69	DP
030	05	5	077	33	X ²	124	15	15	171	24	24
031	42	STD	078	44	SUM	125	69	DP	172	69	DP
032	05	05	079	10	10	126	24	24	173	35	35
033	43	RCL	080	00	0	127	69	DP	174	43	RCL
034	09	09	081	72	ST*	128	35	35	175	05	05
035	32	X ¹ T	082	05	05	129	29	CP	176	67	EQ
036	43	RCL	083	69	DP	130	43	RCL	177	01	01
037	03	03	084	25	25	131	05	05	178	84	84
038	67	EQ	085	69	DP	132	67	EQ	179	43	RCL
039	00	00	086	29	29	133	01	01	180	04	04
040	72	72	087	43	RCL	134	40	40	181	61	GTD
041	61	GTD	088	01	01	135	43	RCL	182	01	01
042	00	00	089	32	X ¹ T	136	04	04	183	64	64
043	10	10	090	43	RCL	137	61	GTD	184	43	RCL
044	73	RC*	091	09	09	138	01	01	185	18	18
045	00	00	092	67	EQ	139	19	19	186	33	X ²
046	69	DP	093	00	00	140	43	RCL	187	44	SUM

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
188	16	16	237	04	04	286	43	RCL	335	00	00
189	00	0	238	61	GTD	287	12	12	336	95	=
190	42	STD	239	02	02	288	65	x	337	42	STD
191	18	18	240	02	02	289	43	RCL	338	10	10
192	43	RCL	241	76	LBL	290	13	13	339	43	RCL
193	04	04	242	16	A'	291	65	x	340	15	15
194	61	GTD	243	43	RCL	292	43	RCL	341	55	÷
195	01	01	244	08	08	293	01	01	342	53	(
196	58	58	245	33	X²	294	54	)	343	43	RCL
197	76	LBL	246	55	÷	295	75	-	344	13	13
198	15	E	247	43	RCL	296	43	RCL	345	65	x
199	00	0	248	03	03	297	00	00	346	43	RCL
200	42	STD	249	95	=	298	95	=	347	01	01
201	04	04	250	42	STD	299	42	STD	348	54)
202	43	RCL	251	00	00	300	08	08	349	75	-
203	13	13	252	43	RCL	301	43	RCL	350	43	RCL
204	42	STD	253	06	06	302	16	16	351	00	00
205	05	05	254	75	-	303	55	÷	352	75	-
206	43	RCL	255	43	RCL	304	53	(	353	43	RCL
207	04	04	256	00	00	305	43	RCL	354	08	08
208	91	R/S	257	95	=	306	11	11	355	75	-
209	44	SUM	258	42	STD	307	65	x	356	43	RCL
210	20	20	259	04	04	308	43	RCL	357	10	10
211	33	X²	260	43	RCL	309	12	12	358	95	=
212	44	SUM	261	07	07	310	65	x	359	42	STD
213	19	19	262	55	÷	311	43	RCL	360	14	14
214	69	DF	263	43	RCL	312	01	01	361	43	RCL
215	24	24	264	01	01	313	54	)	362	17	17
216	69	DF	265	75	-	314	75	-	363	55	÷
217	35	35	266	43	RCL	315	43	RCL	364	53	(
218	43	RCL	267	00	00	316	00	00	365	43	RCL
219	05	05	268	95	=	317	95	=	366	12	12
220	67	EQ	269	42	STD	318	42	STD	367	65	x
221	02	02	270	05	05	319	09	09	368	43	RCL
222	28	28	271	43	RCL	320	43	RCL	369	01	01
223	43	RCL	272	10	10	321	18	18	370	54)
224	04	04	273	55	÷	322	55	÷	371	75	-
225	61	GTD	274	43	RCL	323	53	(	372	43	RCL
226	02	02	275	02	02	324	43	RCL	373	00	00
227	08	08	276	75	-	325	11	11	374	75	-
228	43	RCL	277	43	RCL	326	65	x	375	43	RCL
229	20	20	278	00	00	327	43	RCL	376	08	08
230	33	X²	279	95	=	328	13	13	377	75	-
231	44	SUM	280	42	STD	329	65	x	378	43	RCL
232	18	18	281	06	06	330	43	RCL	379	09	09
233	00	0	282	43	RCL	331	01	01	380	95	=
234	42	STD	283	14	14	332	54	)	381	42	STD
235	20	20	284	55	÷	333	75	-	382	15	15
236	43	RCL	285	53	(	334	43	RCL	383	43	RCL

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
384	19	19	433	67	EQ	000	76	LBL	049	00	0
385	55	+	434	00	00	001	12	B	050	02	2
386	53	(	435	10	10	002	43	RCL	051	01	1
387	43	RCL	436	61	GTO	003	04	04	052	04	4
388	11	11	437	00	00	004	75	-	053	00	0
389	65	*	438	14	14	005	43	RCL	054	69	DP
390	43	RCL	439	03	3	006	05	05	055	02	02
391	01	01	440	03	3	007	75	-	056	01	1
392	54	)	441	03	3	008	43	RCL	057	04	4
393	75	-	442	05	5	009	06	06	058	02	2
394	43	RCL	443	03	3	010	95	=	059	07	7
395	00	00	444	02	2	011	42	STO	060	01	1
396	75	-	445	02	2	012	07	07	061	05	5
397	43	RCL	446	02	2	013	01	1	062	69	DP
398	09	09	447	04	4	014	03	3	063	01	01
399	75	-	448	00	0	015	69	DP	064	69	DP
400	43	RCL	449	69	DP	016	01	01	065	05	05
401	10	10	450	01	01	017	03	3	066	43	RCL
402	95	=	451	01	1	018	01	1	067	01	01
403	42	STO	452	05	5	019	03	3	068	75	-
404	16	16	453	01	1	020	02	2	069	01	1
405	61	GTO	454	03	3	021	04	4	070	95	=
406	04	04	455	03	3	022	02	2	071	42	STO
407	39	39	456	05	5	023	01	1	072	00	00
408	01	1	457	01	1	024	03	3	073	99	PRT
409	06	6	458	06	6	025	00	0	074	91	R/S
410	01	1	459	69	DP	026	00	0	075	98	ADV
411	03	3	460	02	02	027	69	DP	076	01	1
412	03	3	461	05	5	028	02	02	077	03	3
413	07	7	462	05	5	029	03	3	078	69	DP
414	01	1	463	00	0	030	07	7	079	01	01
415	03	3	464	03	3	031	01	1	080	69	DP
416	69	DP	465	05	5	032	03	3	081	05	05
417	01	01	466	06	6	033	01	1	082	43	RCL
418	69	DP	467	00	0	034	04	4	083	11	11
419	05	05	468	00	0	035	02	2	084	75	-
420	69	DP	469	00	0	036	07	7	085	01	1
421	00	00	470	00	0	037	01	1	086	95	=
422	03	3	471	69	DP	038	07	7	087	42	STO
423	91	R/S	472	03	03	039	69	DP	088	17	17
424	22	INV	473	69	DP	040	03	03	089	99	PRT
425	86	STF	474	05	05	041	69	DP	090	91	R/S
426	07	07	475	69	DP	042	05	05	091	98	ADV
427	03	3	476	00	00	043	69	DP	092	01	1
428	00	0	477	02	2	044	00	00	093	04	4
429	42	STO	478	92	RTN	045	98	ADV	094	69	DP
430	00	00				046	01	1	095	01	01
431	43	RCL				047	06	6	096	69	DP
432	04	04				048	04	4	097	05	05

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
098	43	RCL	147	69	DP	196	65	*	245	99	PRT
099	12	12	148	01	01	197	43	RCL	246	91	R/S
100	75	-	149	69	DP	198	19	19	247	03	3
101	01	1	150	05	05	199	95	=	248	06	6
102	95	=	151	43	RCL	200	42	STO	249	04	4
103	42	STO	152	17	17	201	23	23	250	00	0
104	18	18	153	65	*	202	99	PRT	251	03	3
105	99	PRT	154	43	RCL	203	91	R/S	252	06	6
106	91	R/S	155	19	19	204	98	ADV	253	04	4
107	98	ADV	156	95	=	205	03	3	254	00	0
108	01	1	157	42	STO	206	05	5	255	69	DP
109	05	5	158	21	21	207	01	1	256	02	02
110	69	DP	159	99	PRT	208	07	7	257	98	ADV
111	01	01	160	91	R/S	209	03	3	258	01	1
112	69	DP	161	98	ADV	210	06	6	259	04	4
113	05	05	162	01	1	211	69	DP	260	02	2
114	43	RCL	163	04	4	212	01	01	261	07	7
115	13	13	164	01	1	213	69	DP	262	01	1
116	75	-	165	05	5	214	05	05	263	05	5
117	01	1	166	69	DP	215	43	RCL	264	69	DP
118	95	=	167	01	01	216	00	00	265	01	01
119	42	STO	168	69	DP	217	65	*	266	69	DP
120	19	19	169	05	05	218	53	(	267	05	05
121	99	PRT	170	43	RCL	219	43	RCL	268	43	RCL
122	91	R/S	171	18	18	220	02	02	269	06	06
123	98	ADV	172	65	*	221	75	-	270	99	PRT
124	01	1	173	43	RCL	222	01	1	271	91	R/S
125	03	3	174	19	19	223	54	)	272	98	ADV
126	01	1	175	95	=	224	95	=	273	01	1
127	04	4	176	42	STO	225	42	STO	274	03	3
128	69	DP	177	22	22	226	24	24	275	69	DP
129	01	01	178	99	PRT	227	99	PRT	276	01	01
130	69	DP	179	91	R/S	228	91	R/S	277	69	DP
131	05	05	180	98	ADV	229	98	ADV	278	05	05
132	43	RCL	181	01	1	230	03	3	279	43	RCL
133	17	17	182	03	3	231	07	7	280	08	08
134	65	*	183	01	1	232	03	3	281	42	STO
135	43	RCL	184	04	4	233	02	2	282	25	25
136	18	18	185	01	1	234	03	3	283	99	PRT
137	95	=	186	05	5	235	07	7	284	91	R/S
138	42	STO	187	69	DP	236	69	DP	285	98	ADV
139	20	20	188	01	01	237	01	01	286	01	1
140	99	PRT	189	69	DP	238	69	DP	287	04	4
141	91	R/S	190	05	05	239	05	05	288	69	DP
142	98	ADV	191	43	RCL	240	43	RCL	289	01	01
143	01	1	192	17	17	241	03	03	290	69	DP
144	03	3	193	65	*	242	75	-	291	05	05
145	01	1	194	43	RCL	243	01	1	292	43	RCL
146	05	5	195	18	18	244	95	=	293	10	10

LOC	CODE	KEY
294	44	SUM
295	25	25
296	99	PRT
297	91	R/S
298	98	ADV
299	01	1
300	05	5
301	69	DP
302	01	01
303	69	DP
304	05	05
305	43	RCL
306	09	09
307	44	SUM
308	25	25
309	99	PRT
310	91	R/S
311	98	ADV
312	01	1
313	03	3
314	01	1
315	04	4
316	69	DP
317	01	01
318	69	DP
319	05	05
320	43	RCL
321	14	14
322	44	SUM
323	25	25
324	99	PRT
325	91	R/S
326	98	ADV
327	01	1
328	03	3
329	01	1
330	05	5
331	69	DP
332	01	01
333	69	DP
334	05	05
335	43	RCL
336	15	15
337	44	SUM
338	25	25
339	99	PRT
340	91	R/S
341	98	ADV
342	01	1

LOC	CODE	KEY
343	04	4
344	01	1
345	05	5
346	69	DP
347	01	01
348	69	DP
349	05	05
350	43	RCL
351	16	16
352	44	SUM
353	25	25
354	99	PRT
355	91	R/S
356	98	ADV
357	01	1
358	03	3
359	01	1
360	04	4
361	01	1
362	05	5
363	69	DP
364	01	01
365	69	DP
366	05	05
367	43	RCL
368	05	05
369	75	-
370	43	RCL
371	25	25
372	95	=
373	42	STD
374	25	25
375	99	PRT
376	91	R/S
377	98	ADV
378	03	3
379	05	5
380	01	1
381	07	7
382	03	3
383	06	6
384	69	DP
385	01	01
386	69	DP
387	05	05
388	43	RCL
389	07	07
390	99	PRT
391	91	R/S

LOC	CODE	KEY
392	98	ADV
393	03	3
394	07	7
395	03	3
396	02	2
397	03	3
398	07	7
399	69	DP
400	01	01
401	69	DP
402	05	05
403	43	RCL
404	04	04
405	99	PRT
406	91	R/S
407	98	ADV
408	03	3
409	00	0
410	04	4
411	00	0
412	03	3
413	06	6
414	04	4
415	00	0
416	69	DP
417	02	02
418	01	1
419	03	3
420	69	DP
421	01	01
422	69	DP
423	05	05
424	43	RCL
425	08	08
426	55	+
427	43	RCL
428	17	17
429	95	=
430	42	STD
431	17	17
432	99	PRT
433	91	R/S
434	98	ADV
435	01	1
436	04	4
437	69	DP
438	01	01
439	69	DP
440	05	05

LOC	CODE	KEY
441	43	RCL
442	10	10
443	55	+
444	43	RCL
445	18	18
446	95	=
447	42	STD
448	18	18
449	99	PRT
450	91	R/S
451	98	ADV
452	01	1
453	05	5
454	69	DP
455	01	01
456	69	DP
457	05	05
458	43	RCL
459	09	09
460	55	+
461	43	RCL
462	19	19
463	95	=
464	42	STD
465	19	19
466	99	PRT
467	91	R/S
468	98	ADV
469	01	1
470	03	3
471	01	1
472	04	4
473	69	DP
474	01	01
475	69	DP
476	05	05
477	43	RCL
478	14	14
479	55	+
480	43	RCL
481	20	20
482	95	=
483	42	STD
484	20	20
485	99	PRT
486	91	R/S
487	98	ADV
488	01	1
489	03	3

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
490	01	1	539	43	RCL	588	98	ADV	637	69	DP
491	05	5	540	23	23	589	02	2	638	05	05
492	69	DP	541	95	=	590	01	1	639	43	RCL
493	01	01	542	42	STD	591	02	2	640	20	20
494	69	DP	543	23	23	592	00	0	641	55	+
495	05	05	544	99	PRT	593	01	1	642	43	RCL
496	43	RCL	545	91	R/S	594	04	4	643	24	24
497	15	15	546	98	ADV	595	69	DP	644	95	=
498	55	+	547	03	3	596	01	01	645	99	PRT
499	43	RCL	548	05	5	597	69	DP	646	91	R/S
500	21	21	549	01	1	598	05	05	647	98	ADV
501	95	=	550	07	7	599	43	RCL	648	02	2
502	42	STD	551	03	3	600	18	18	649	01	1
503	21	21	552	06	6	601	55	+	650	02	2
504	99	PRT	553	69	DP	602	43	RCL	651	00	0
505	91	R/S	554	01	01	603	24	24	652	01	1
506	98	ADV	555	69	DP	604	95	=	653	03	3
507	01	1	556	05	05	605	99	PRT	654	01	1
508	04	4	557	43	RCL	606	91	R/S	655	05	5
509	01	1	558	07	07	607	98	ADV	656	69	DP
510	05	5	559	55	+	608	02	2	657	01	01
511	69	DP	560	43	RCL	609	01	1	658	69	DP
512	01	01	561	24	24	610	02	2	659	05	05
513	69	DP	562	95	=	611	00	0	660	43	RCL
514	05	05	563	42	STD	612	01	1	661	21	21
515	43	RCL	564	24	24	613	05	5	662	55	+
516	16	16	565	99	PRT	614	69	DP	663	43	RCL
517	55	+	566	91	R/S	615	01	01	664	24	24
518	43	RCL	567	98	ADV	616	69	DP	665	95	=
519	22	22	568	69	DP	617	05	05	666	99	PRT
520	95	=	569	00	00	618	43	RCL	667	91	R/S
521	42	STD	570	02	2	619	19	19	668	98	ADV
522	22	22	571	01	1	620	55	+	669	02	2
523	99	PRT	572	02	2	621	43	RCL	670	01	1
524	91	R/S	573	00	0	622	24	24	671	02	2
525	98	ADV	574	01	1	623	95	=	672	00	0
526	01	1	575	03	3	624	99	PRT	673	01	1
527	03	3	576	69	DP	625	91	R/S	674	04	4
528	01	1	577	01	01	626	98	ADV	675	01	1
529	04	4	578	69	DP	627	02	2	676	05	5
530	01	1	579	05	05	628	01	1	677	69	DP
531	05	5	580	43	RCL	629	02	2	678	01	01
532	69	DP	581	17	17	630	00	0	679	69	DP
533	01	01	582	55	+	631	01	1	680	05	05
534	69	DP	583	43	RCL	632	03	3	681	43	RCL
535	05	05	584	24	24	633	01	1	682	22	22
536	43	RCL	585	95	=	634	04	4	683	55	+
537	25	25	586	99	PRT	635	69	DP	684	43	RCL
538	55	+	587	91	R/S	636	01	01	685	24	24

LOC	CODE	KEY
686	95	=
687	99	PRT
688	91	R/S
689	98	RDV
690	02	2
691	01	1
692	02	2
693	00	0
694	01	1
695	03	3
696	01	1
697	04	4
698	01	1
699	05	5
700	69	DP
701	01	01
702	69	DP
703	05	05
704	43	RCL
705	23	23
706	55	+
707	43	RCL
708	24	24
709	95	=
710	99	PRT
711	92	RTN

LOC	CODE	KEY
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LOC	CODE	KEY
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LOC	CODE	KEY
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APPENDIX P

PROGRAM FOR TWO-LEVEL NESTED DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Two-Level Nested Design

OBJECTIVES: This program performs an analysis of variance for three factors (A, B, and C), where C is nested in B and B is nested in A, arranged in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number of nested combinations
- b) **FACTORS** : 3
- c) **LEVELS** : any number for any factor
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: univariate

OUTPUT^(*): Treatment (factor A) degrees of freedom
Subgroup (factor B) within treatments degrees of freedom
Determination (factor C) within subgroup degrees of freedom
Total degrees of freedom
Treatment (factor A) sum of squares
Subgroup (factor B) with treatments sum of squares
Determination (factor C) within subgroup sum of squares
Total sum of squares
Treatment (factor A) mean square
Subgroup (factor B) within treatments mean square

^(*) Printed and displayed when **PRINTER UNIT** is used

Determination (factor C) within subgroups mean
square

F-ratio for treatments (factor A)

F-ratio for subgroup (factor B) within
treatments

PROGRAM CARD DESCRIPTION

Two Level Nesting in CRD				
Proc.	Resul.	Levels		

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter number of treatments	# Trt.	C	# Trt.
6	Enter number of subgroups	# Subg.	R/S	# Subg.
7	Process data card		A	
7a	If number of observations is less than 30			0
7b	If number of observations is greater than 30			'3' *
8a	If step 7a is true go to step 10			
8b	If step 7b is true load side 1 of data card ₂			3
9	Process data card		R/S	
9a	If all observations have been processed go to step 10			0
9b	If step 9a is not true			'3' *
9c	Load next data card and go to step 9			3
10	For a printed output go to step 11; otherwise go to step 13			
11	Load side 1 of program card ₂			1
12	Load side 2 of program card ₂			2
13	Obtain results		B	A D.F.
			R/S	BWA D.F.
			R/S	Det. D.F.
			R/S	Tot. D.F.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	<p>* DATA will be printed if printer is attached</p>		<p>R/S R/S R/S R/S R/S R/S R/S R/S R/S</p>	<p>A S.S. B W A S.S. Det. S.S. Tot. S.S. A M.S. B W A S.S. Det. M.S. F-ratio A F-ratio B W A</p>

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for three treatments, each divided in four groups with two determinations per group. Data from Sokal and Rohlf (1969), page 260.

A_1	B_1	58.5	59.5
	B_2	77.8	80.9
	B_3	84.0	83.6
	B_4	70.1	68.3
A_2	B_1	69.8	69.8
	B_2	56.0	54.5
	B_3	50.7	49.3
	B_4	63.8	65.8
A_3	B_1	56.6	57.5
	B_2	77.8	79.2
	B_3	69.9	69.2
	B_4	62.1	64.5

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card		display will show # 4	card upright
Data card		display will show # 3	card inverted
3	C	3	# of treatments
4	R/S	4	# of subgroups
	A	0 will show in the display	process finished
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted

ENTER	PRESS	OUTPUT	COMMENTS
		(You do not have to read this card unless you want a printed output)	
	B	2	A D.F.
	R/S	9	B W A D.F.
	R/S	12	Deter. D.F.
	R/S	23	Total D.F.
	R/S	665.6758334	A D.F.
	R/S	1720.6775	B W A S.S.
	R/S	15.62	Deter. S.S.
	R/S	2401.973333	Total S.S.
	R/S	332.8379167	A M.S.
	R/S	191.1863889	B W A M.S.
	R/S	1.301666667	Deter. M.S.
	R/S	1.74090815	F-Ratio for A
	R/S	146.8781477	F-Ratio for B W A

PRINTED OUTPUT

```

      12.
      2.

      58.5
      59.5
      77.8
      80.9
      84.
      83.6
      70.1
      68.3
      69.8
      69.8
      58.
      54.5
      50.7
      49.3
      63.8
      65.8
      56.6
      57.3
      77.8
      79.2
      69.9
      69.2
      62.1
      64.5
ANOVA TABLE

      A      D.F.
              2.

      B W A D.F.
              9.

      DET. D.F.
              12.

      TOT. D.F.
              23.

      A      S.S.
      665.6758334

      B W A S.S.
      1720.6775

```

```

      DET. S.S.
              15.62

      TOT. S.S.
      2401.973333

      A      M.S.
      332.8379167

      B W A M.S.
      191.1863889

      DET. M.S.
      1.301666667

      F-RATIO A
      1.740908015

      F-RATIO B W A
      146.8781477

```


Two-Level Nested Design

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	00	0	094	10	10	141	10	10
001	11	R	048	42	STD	095	75	-	142	25	CLR
002	03	3	049	11	11	096	43	RCL	143	91	R/S
003	00	0	050	69	DP	097	04	04	144	76	LBL
004	42	STD	051	34	34	098	95	=	145	13	C
005	00	00	052	43	RCL	099	42	STD	146	42	STD
006	43	RCL	053	04	04	100	05	05	147	07	07
007	07	07	054	67	EQ	101	43	RCL	148	91	R/S
008	42	STD	055	00	00	102	14	14	149	42	STD
009	04	04	056	84	84	103	55	+	150	08	08
010	43	RCL	057	61	GTD	104	53	(	151	92	RTN
011	08	08	058	00	00	105	43	RCL	152	01	1
012	42	STD	059	10	10	106	01	01	153	06	6
013	05	05	060	73	RC*	107	65	*	154	01	1
014	43	RCL	061	00	00	108	43	RCL	155	03	3
015	01	01	062	69	DP	109	08	08	156	03	3
016	42	STD	063	19	19	110	54	)	157	07	7
017	06	06	064	87	IFF	111	95	=	158	01	1
018	43	RCL	065	07	07	112	42	STD	159	03	3
019	06	06	066	01	01	113	15	15	160	69	DP
020	22	INV	067	52	52	114	75	-	161	01	01
021	67	EQ	068	44	SUM	115	43	RCL	162	69	DP
022	00	00	069	09	09	116	04	04	163	05	05
023	60	60	070	44	SUM	117	95	=	164	69	DP
024	43	RCL	071	11	11	118	42	STD	165	00	00
025	12	12	072	44	SUM	119	06	06	166	03	3
026	33	X ²	073	12	12	120	43	RCL	167	91	R/S
027	44	SUM	074	33	X ²	121	13	13	168	22	INV
028	13	13	075	44	SUM	122	55	+	169	86	STF
029	00	0	076	10	10	123	43	RCL	170	07	07
030	42	STD	077	69	DP	124	01	01	171	03	3
031	12	12	078	20	20	125	95	=	172	00	0
032	69	DP	079	69	DP	126	42	STD	173	42	STD
033	35	35	080	36	36	127	16	16	174	00	00
034	43	RCL	081	61	GTD	128	75	-	175	43	RCL
035	05	05	082	00	00	129	43	RCL	176	06	06
036	67	EQ	083	18	18	130	15	15	177	67	EQ
037	00	00	084	43	RCL	131	95	=	178	00	00
038	42	42	085	09	09	132	42	STD	179	14	14
039	61	GTD	086	33	X ²	133	09	09	180	61	GTD
040	00	00	087	55	+	134	43	RCL	181	00	00
041	14	14	088	43	RCL	135	10	10	182	18	18
042	43	RCL	089	03	03	136	75	-	183	76	LBL
043	11	11	090	95	=	137	43	RCL	184	12	B
044	33	X ²	091	42	STD	138	16	16	185	43	RCL
045	44	SUM	092	04	04	139	95	=	186	07	07
046	14	14	093	43	RCL	140	42	STD	187	75	-

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
188	01	1	237	06	06	000	76	LBL	049	00	0
189	95	=	238	55	+	001	12	B	050	00	0
190	42	STD	239	43	RCL	002	01	1	051	69	DP
191	11	11	240	11	11	003	03	3	052	01	01
192	91	R/S	241	95	=	004	69	DP	053	69	DP
193	43	RCL	242	42	STD	005	01	01	054	05	05
194	08	08	243	14	14	006	03	3	055	43	RCL
195	75	-	244	91	R/S	007	01	1	056	07	07
196	01	1	245	43	RCL	008	03	3	057	75	-
197	95	=	246	09	09	009	02	2	058	01	1
198	65	x	247	55	+	010	04	4	059	95	=
199	43	RCL	248	43	RCL	011	02	2	060	42	STD
200	07	07	249	12	12	012	01	1	061	11	11
201	95	=	250	95	=	013	03	3	062	99	PRT
202	42	STD	251	42	STD	014	00	0	063	91	R/S
203	12	12	252	15	15	015	00	0	064	98	ADV
204	91	R/S	253	91	R/S	016	69	DP	065	01	1
205	43	RCL	254	43	RCL	017	02	02	066	04	4
206	02	02	255	10	10	018	03	3	067	00	0
207	65	x	256	55	+	019	07	7	068	00	0
208	53	(	257	43	RCL	020	01	1	069	04	4
209	43	RCL	258	13	13	021	03	3	070	03	3
210	01	01	259	95	=	022	01	1	071	00	0
211	75	-	260	42	STD	023	04	4	072	00	0
212	01	1	261	16	16	024	02	2	073	01	1
213	54	)	262	91	R/S	025	07	7	074	03	3
214	95	=	263	43	RCL	026	01	1	075	69	DP
215	42	STD	264	14	14	027	07	7	076	01	01
216	13	13	265	55	+	028	69	DP	077	69	DP
217	91	R/S	266	43	RCL	029	03	03	078	05	05
218	43	RCL	267	15	15	030	69	DP	079	43	RCL
219	03	03	268	95	=	031	05	05	080	08	08
220	75	-	269	91	R/S	032	69	DP	081	75	-
221	01	1	270	43	RCL	033	00	00	082	01	1
222	95	=	271	15	15	034	98	ADV	083	95	=
223	91	R/S	272	55	+	035	01	1	084	65	x
224	43	RCL	273	43	RCL	036	06	6	085	43	RCL
225	06	06	274	16	16	037	04	4	086	07	07
226	91	R/S	275	95	=	038	00	0	087	95	=
227	43	RCL	276	92	RTN	039	02	2	088	42	STD
228	09	09				040	01	1	089	12	12
229	91	R/S				041	04	4	090	99	PRT
230	43	RCL				042	00	0	091	91	R/S
231	10	10				043	69	DP	092	98	ADV
232	91	R/S				044	02	02	093	01	1
233	43	RCL				045	01	1	094	06	6
234	05	05				046	03	3	095	01	1
235	91	R/S				047	00	0	096	07	7
236	43	RCL				048	00	0	097	03	3

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
098	07	7	147	00	0	196	43	RCL	245	14	14
099	04	4	148	69	DP	197	10	10	246	99	PRT
100	00	0	149	02	02	198	99	PRT	247	91	R/S
101	69	DP	150	01	1	199	91	R/S	248	98	ADV
102	01	01	151	03	3	200	98	ADV	249	01	1
103	69	DP	152	00	0	201	03	3	250	04	4
104	05	05	153	00	0	202	07	7	251	00	0
105	43	RCL	154	00	0	203	03	3	252	00	0
106	02	02	155	00	0	204	02	2	253	04	4
107	65	*	156	69	DP	205	03	3	254	03	3
108	53	(	157	01	01	206	07	7	255	00	0
109	43	RCL	158	69	DP	207	04	4	256	00	0
110	01	01	159	05	05	208	00	0	257	01	1
111	75	-	160	43	RCL	209	69	DP	258	03	3
112	01	1	161	06	06	210	01	01	259	69	DP
113	54	)	162	99	PRT	211	69	DP	260	01	01
114	95	=	163	91	R/S	212	05	05	261	69	DP
115	42	STD	164	98	ADV	213	43	RCL	262	05	05
116	13	13	165	01	1	214	05	05	263	43	RCL
117	99	PRT	166	04	4	215	99	PRT	264	09	09
118	91	R/S	167	00	0	216	91	R/S	265	55	+
119	98	ADV	168	00	0	217	98	ADV	266	43	RCL
120	03	3	169	04	4	218	03	3	267	12	12
121	07	7	170	03	3	219	00	0	268	95	=
122	03	3	171	00	0	220	04	4	269	42	STD
123	02	2	172	00	0	221	00	0	270	15	15
124	03	3	173	01	1	222	03	3	271	99	PRT
125	07	7	174	03	3	223	06	6	272	91	R/S
126	04	4	175	69	DP	224	04	4	273	98	ADV
127	00	0	176	01	01	225	00	0	274	01	1
128	69	DP	177	69	DP	226	69	DP	275	06	6
129	01	01	178	05	05	227	02	02	276	01	1
130	69	DP	179	43	RCL	228	01	1	277	07	7
131	05	05	180	09	09	229	03	3	278	03	3
132	43	RCL	181	99	PRT	230	00	0	279	07	7
133	03	03	182	91	R/S	231	00	0	280	04	4
134	75	-	183	98	ADV	232	00	0	281	00	0
135	01	1	184	01	1	233	00	0	282	69	DP
136	95	=	185	06	6	234	69	DP	283	01	01
137	99	PRT	186	01	1	235	01	01	284	69	DP
138	91	R/S	187	07	7	236	69	DP	285	05	05
139	98	ADV	188	03	3	237	05	05	286	43	RCL
140	03	3	189	07	7	238	43	RCL	287	10	10
141	06	6	190	04	4	239	06	06	288	55	+
142	04	4	191	00	0	240	55	+	289	43	RCL
143	00	0	192	69	DP	241	43	RCL	290	13	13
144	03	3	193	01	01	242	11	11	291	95	=
145	06	6	194	69	DP	243	95	=	292	42	STD
146	04	4	195	05	05	244	42	STD	293	16	16

LOC	CODE	KEY
294	99	PRT
295	91	R/S
296	98	ADV
297	02	2
298	01	1
299	02	2
300	00	0
301	03	3
302	05	5
303	01	1
304	03	3
305	03	3
306	07	7
307	69	DP
308	01	01
309	02	2
310	04	4
311	03	3
312	02	2
313	00	0
314	00	0
315	01	1
316	03	3
317	00	0
318	00	0
319	69	DP
320	02	02
321	69	DP
322	05	05
323	43	RCL
324	14	14
325	55	+
326	43	RCL
327	15	15
328	95	=
329	99	PRT
330	91	R/S
331	98	ADV
332	02	2
333	04	4
334	03	3
335	02	2
336	00	0
337	00	0
338	01	1
339	04	4
340	00	0
341	00	0
342	69	DP

LOC	CODE	KEY
343	02	02
344	04	4
345	03	3
346	00	0
347	00	0
348	01	1
349	03	3
350	00	0
351	00	0
352	00	0
353	00	0
354	69	DP
355	03	03
356	69	DP
357	05	05
358	43	RCL
359	15	15
360	55	+
361	43	RCL
362	16	16
363	95	=
364	99	PRT
365	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX Q

PROGRAM FOR THREE-LEVEL NESTED DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE: Three-Level Nested Design

OBJECTIVES: This program performs an analysis of variance for four treatment factors (A, B, C, and D), where D is nested in C, C is nested in B, and B is nested in A, arranged in a completely randomized design.

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : 4
- c) **LEVELS** : any number for any factor
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: univariate

OUTPUT^(*): Treatment (factor A) degrees of freedom
Subgroups (factor B) within treatments degrees of freedom
Sub-subgroups (factor C) within subgroups degrees of freedom
Determination (factor D) within sub-subgroups degrees of freedom
Total degrees of freedom
Treatment (factor A) sum of squares
Subgroups (factor B) within treatments sum of squares
Sub-subgroups (factor C) within subgroups sum of squares
Determination (factor D) within sub-subgroups sum of squares

() Printed and displayed when PRINTER UNIT is used*

Total sum of squares
Treatment (factor A) mean square
Subgroups (factor B) within treatments mean
square
Sub-subgroups (factor C) within subgroups
mean square
Determination (factor D) within sub-subgroups
mean square
F-ratio for treatments (factor A)
F-ratio for subgroups (factor B) within
treatments
F-ratio for sub-subgroups (factor C) within
subgroups

PROGRAM CARD DESCRIPTION

Three Level Nesting in CRD				
Proc.	Resul.	Levels		

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter number of treatments	# Trt.	C	# Trt.
6	Enter number of subgroups	# Subgr.	R/S	# Subgr.
7	Enter number of sub-sub-groups	# Sub-subr.	R/S	# Sub-subr.
8	Process data card		A	
8a	If number of observations is less than 30			0
8b	If number of observations is greater than 30			'3' *
9a	If step 8a is true go to step 11			
9b	If step 8b is true load side 1 of data card ₂			3
10	Process data card		R/S	
10a	If all observations have been processed go to step 11			0
10b	If step 10a is not true			'3' *
10c	Load next data card and go to step 10			3
11	For a printed output go to step 12; otherwise go to step 14			
12	Load side 1 of program card ₂			1
13	Load side 2 of program card ₂			2
14	Obtain results		B R/S R/S	A D.F. B W A D.F. C W B D.F.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
			R/S	Det. D.F.
			R/S	Tot. D.F.
			R/S	A S.S.
			R/S	B W A D.F.
			R/S	C W B S.S.
			R/S	Det. S.S.
			R/S	Tot. S.S.
			R/S	A M.S.
			R/S	B W A M.S.
			R/S	C W B M.S.
			R/S	Det. M.S.
			R/S	F-ratio A
			R/S	F-ratio
				B W A
			R/S	F-ratio
				C W B
	* DATA will be printed if printer is attached			

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for three treatments, each treatment divided in two subgroups and each subgroup divided in three sub-subgroups with two determinations per sub-subgroup. Data from Sokal and Rohlf (1969), page 270.

A_1	B ₁	C ₁	131	130	A_3	B ₁	C ₁	134	125
		C ₂	131	125			C ₂	138	138
		C ₃	136	142			C ₃	135	136
	B ₂	C ₁	150	148		B ₂	C ₁	138	140
		C ₂	140	143			C ₂	139	138
		C ₃	160	150			C ₃	134	127
A_2	B ₁	C ₁	157	145	A_2	B ₂	C ₁	151	155
		C ₂	154	142			C ₂	147	147
		C ₃	147	153			C ₃	162	152
	B ₂	C ₁	151	155		B ₂	C ₁	151	155
		C ₂	147	147			C ₂	147	147
		C ₃	162	152			C ₃	162	152

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
3	C	3	# of treatments
2	R/S	2	# of subgroups
3	R/S	3	# of sub-subgroups
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂		display will show # 3	card upright

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₂ Prog. card ₂	R/S	0 will show in the display display will show # 1 display will show # 2 (You do not have to read this card unless you want a printed output)	process finished card upright card inverted
	B	2	A D.F.
	R/S	3	B W A D.F.
	R/S	12	C W B D.F.
	R/S	18	Deter. D.F.
	R/S	35	Total D.F.
	R/S	1557.555556	A S.S.
	R/S	797.6666667	B W A S.S.
	R/S	594.0	C W B S.S.
	R/S	381.0	Deter. S.S.
	R/S	3330.222222	Total S.S.
	R/S	778.7777778	A M.S.
	R/S	265.8888889	B W A M.S.
	R/S	49.5	C W B M.S.
	R/S	21.16666667	Deter. M.S.
	R/S	2.928959465	F-Ratio for A
	R/S	5.371492705	F-Ratio for B W A
	R/S	2.338582677	F-Ratio for C W A

PRINTED OUTPUT

18.
2.
131.
130.
131.
125.
136.
142.
150.
148.
140.
143.
160.
150.
157.
145.
154.
142.
147.
153.
151.
155.
147.
147.
162.
152.
136.
125.
138.
138.
135.
136.
RECORD DATA
138.
140.
139.
138.
134.
127.
DATA

ANOVA TABLE	
A	D. F.
	2.
B W A	D. F.
	3.
C W B	D. F.
	12.
DET.	D. F.
	18.
TOT.	D. F.
	35.
A	S. S.
	1557.555556
B W A	S. S.
	797.6666667
C W B	S. S.
	594.
DET.	S. S.
	381.
TOT.	S. S.
	3330.222222
A	M. S.
	778.7777778
B W A	M. S.
	265.8888889
C W B	M. S.
	49.5
DET.	M. S.
	21.16666667

F-R
2.928959465

F-B M R
5.371492705

F-C M B
2.338582677

Three-Level Nested Design

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	14	14	094	44	SUM	141	75	-
001	11	R	048	33	X ²	095	14	14	142	43	RCL
002	03	3	049	44	SUM	096	44	SUM	143	04	04
003	00	0	050	17	17	097	15	15	144	95	=
004	42	STD	051	00	0	098	33	X ²	145	42	STD
005	00	00	052	42	STD	099	44	SUM	146	06	06
006	43	RCL	053	14	14	100	12	12	147	43	RCL
007	08	08	054	69	DP	101	69	DP	148	17	17
008	42	STD	055	35	35	102	20	20	149	55	+
009	04	04	056	43	RCL	103	69	DP	150	53	(
010	43	RCL	057	05	05	104	37	37	151	43	RCL
011	09	09	058	67	EQ	105	61	GTD	152	10	10
012	42	STD	059	00	00	106	00	00	153	65	*
013	05	05	060	64	64	107	22	22	154	43	RCL
014	43	RCL	061	61	GTD	108	43	RCL	155	01	01
015	10	10	062	00	00	109	11	11	156	54)
016	42	STD	063	14	14	110	33	X ²	157	95	=
017	06	06	064	43	RCL	111	55	+	158	42	STD
018	43	RCL	065	13	13	112	43	RCL	159	20	20
019	01	01	066	33	X ²	113	03	03	160	75	-
020	42	STD	067	44	SUM	114	95	=	161	43	RCL
021	07	07	068	18	18	115	42	STD	162	19	19
022	43	RCL	069	00	0	116	04	04	163	95	=
023	07	07	070	42	STD	117	43	RCL	164	42	STD
024	22	INV	071	13	13	118	12	12	165	07	07
025	67	EQ	072	69	DP	119	75	-	166	43	RCL
026	00	00	073	34	34	120	43	RCL	167	16	16
027	82	82	074	43	RCL	121	04	04	168	55	+
028	43	RCL	075	04	04	122	95	=	169	43	RCL
029	15	15	076	67	EQ	123	42	STD	170	01	01
030	33	X ²	077	01	01	124	05	05	171	95	=
031	44	SUM	078	08	08	125	43	RCL	172	42	STD
032	16	16	079	61	GTD	126	18	18	173	21	21
033	00	0	080	00	00	127	55	+	174	75	-
034	42	STD	081	10	10	128	53	(	175	43	RCL
035	15	15	082	73	RC#	129	43	RCL	176	20	20
036	69	DP	083	00	00	130	01	01	177	95	=
037	36	36	084	69	DP	131	65	*	178	42	STD
038	43	RCL	085	19	19	132	43	RCL	179	11	11
039	06	06	086	87	IFF	133	09	09	180	43	RCL
040	67	EQ	087	07	07	134	65	*	181	12	12
041	00	00	088	01	01	135	43	RCL	182	75	-
042	46	46	089	90	90	136	10	10	183	43	RCL
043	61	GTD	090	44	SUM	137	54	)	184	21	21
044	00	00	091	11	11	138	95	=	185	95	=
045	18	18	092	44	SUM	139	42	STD	186	42	STD
046	43	RCL	093	13	13	140	19	19	187	12	12

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
188	25	CLR	237	01	1	286	91	R/S	335	42	STD
189	92	RTN	238	95	=	287	43	RCL	336	20	20
190	01	1	239	42	STD	288	06	06	337	91	R/S
191	06	6	240	13	13	289	91	R/S	338	43	RCL
192	01	1	241	91	R/S	290	43	RCL	339	17	17
193	03	3	242	43	RCL	291	07	07	340	55	+
194	03	3	243	09	09	292	91	R/S	341	43	RCL
195	07	7	244	75	-	293	43	RCL	342	18	18
196	01	1	245	01	1	294	11	11	343	95	=
197	03	3	246	95	=	295	91	R/S	344	91	R/S
198	69	DP	247	65	x	296	43	RCL	345	43	RCL
199	01	01	248	43	RCL	297	12	12	346	18	18
200	69	DP	249	08	08	298	91	R/S	347	55	+
201	05	05	250	95	=	299	43	RCL	348	43	RCL
202	69	DP	251	42	STD	300	05	05	349	19	19
203	00	00	252	14	14	301	91	R/S	350	95	=
204	03	3	253	91	R/S	302	43	RCL	351	91	R/S
205	91	R/S	254	43	RCL	303	06	06	352	43	RCL
206	22	INV	255	10	10	304	55	+	353	19	19
207	86	STF	256	75	-	305	43	RCL	354	55	+
208	07	07	257	01	1	306	13	13	355	43	RCL
209	03	3	258	95	=	307	95	=	356	20	20
210	00	0	259	65	x	308	42	STD	357	95	=
211	42	STD	260	43	RCL	309	17	17	358	92	RTN
212	00	00	261	09	09	310	91	R/S			
213	43	RCL	262	65	x	311	43	RCL			
214	07	07	263	43	RCL	312	07	07			
215	67	EQ	264	08	08	313	55	+			
216	00	00	265	95	=	314	43	RCL			
217	18	18	266	42	STD	315	14	14			
218	61	GTD	267	15	15	316	95	=			
219	00	00	268	91	R/S	317	42	STD			
220	22	22	269	43	RCL	318	18	18			
221	76	LBL	270	01	01	319	91	R/S			
222	13	C	271	75	-	320	43	RCL			
223	42	STD	272	01	1	321	11	11			
224	08	08	273	95	=	322	55	+			
225	91	R/S	274	65	x	323	43	RCL			
226	42	STD	275	43	RCL	324	15	15			
227	09	09	276	02	02	325	95	=			
228	91	R/S	277	95	=	326	42	STD			
229	42	STD	278	42	STD	327	19	19			
230	10	10	279	16	16	328	91	R/S			
231	92	RTN	280	91	R/S	329	43	RCL			
232	76	LBL	281	43	RCL	330	12	12			
233	12	B	282	03	03	331	55	+			
234	43	RCL	283	75	-	332	43	RCL			
235	08	08	284	01	1	333	16	16			
236	75	-	285	95	=	334	95	=			

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	69	DP
044	02	02
045	01	1
046	03	3
047	00	0
048	00	0

LOC	CODE	KEY
049	00	0
050	00	0
051	69	DP
052	01	01
053	69	DP
054	05	05
055	43	RCL
056	08	08
057	75	-
058	01	1
059	95	=
060	42	STO
061	13	13
062	99	PRT
063	91	R/S
064	98	ADV
065	01	1
066	04	4
067	00	0
068	00	0
069	04	4
070	03	3
071	00	0
072	00	0
073	01	1
074	03	3
075	69	DP
076	01	01
077	69	DP
078	05	05
079	43	RCL
080	09	09
081	75	-
082	01	1
083	95	=
084	65	x
085	43	RCL
086	08	08
087	95	=
088	42	STO
089	14	14
090	99	PRT
091	91	R/S
092	98	ADV
093	01	1
094	05	5
095	00	0
096	00	0
097	04	4

LOC	CODE	KEY
098	03	3
099	00	0
100	00	0
101	01	1
102	04	4
103	69	DP
104	01	01
105	69	DP
106	05	05
107	43	RCL
108	10	10
109	75	-
110	01	1
111	95	=
112	65	x
113	43	RCL
114	09	09
115	65	x
116	43	RCL
117	08	08
118	95	=
119	42	STO
120	15	15
121	99	PRT
122	91	R/S
123	98	ADV
124	01	1
125	06	6
126	01	1
127	07	7
128	03	3
129	07	7
130	04	4
131	00	0
132	00	0
133	00	0
134	69	DP
135	01	01
136	69	DP
137	05	05
138	43	RCL
139	01	01
140	75	-
141	01	1
142	95	=
143	65	x
144	43	RCL
145	02	02
146	95	=

LOC	CODE	KEY
147	42	STO
148	16	16
149	99	PRT
150	91	R/S
151	98	ADV
152	03	3
153	07	7
154	03	3
155	02	2
156	03	3
157	07	7
158	04	4
159	00	0
160	00	0
161	00	0
162	69	DP
163	01	01
164	69	DP
165	05	05
166	43	RCL
167	03	03
168	75	-
169	01	1
170	95	=
171	99	PRT
172	91	R/S
173	98	ADV
174	03	3
175	06	6
176	04	4
177	00	0
178	03	3
179	06	6
180	04	4
181	00	0
182	69	DP
183	02	02
184	01	1
185	03	3
186	00	0
187	00	0
188	00	0
189	00	0
190	69	DP
191	01	01
192	69	DP
193	05	05
194	43	RCL
195	06	06

LOC	CODE	KEY
196	99	PRT
197	91	R/S
198	98	ADV
199	01	1
200	04	4
201	00	0
202	00	0
203	04	4
204	03	3
205	00	0
206	00	0
207	01	1
208	03	3
209	69	DP
210	01	01
211	69	DP
212	05	05
213	43	RCL
214	07	07
215	99	PRT
216	91	R/S
217	98	ADV
218	01	1
219	05	5
220	00	0
221	00	0
222	04	4
223	03	3
224	00	0
225	00	0
226	01	1
227	04	4
228	69	DP
229	01	01
230	69	DP
231	05	05
232	43	RCL
233	11	11
234	99	PRT
235	91	R/S
236	98	ADV
237	01	1
238	06	6
239	01	1
240	07	7
241	03	3
242	07	7
243	04	4
244	00	0

LOC	CODE	KEY
245	00	0
246	00	0
247	69	DP
248	01	01
249	69	DP
250	05	05
251	43	RCL
252	12	12
253	99	PRT
254	91	R/S
255	98	ADV
256	03	3
257	07	7
258	03	3
259	02	2
260	03	3
261	07	7
262	04	4
263	00	0
264	00	0
265	00	0
266	69	DP
267	01	01
268	69	DP
269	05	05
270	43	RCL
271	05	05
272	99	PRT
273	91	R/S
274	98	ADV
275	03	3
276	00	0
277	04	4
278	00	0
279	03	3
280	06	6
281	04	4
282	00	0
283	69	DP
284	02	02
285	01	1
286	03	3
287	00	0
288	00	0
289	00	0
290	00	0
291	69	DP
292	01	01
293	69	DP

LOC	CODE	KEY
294	05	05
295	43	RCL
296	06	06
297	55	+
298	43	RCL
299	13	13
300	95	=
301	42	STD
302	17	17
303	99	PRT
304	91	R/S
305	98	ADV
306	01	1
307	04	4
308	00	0
309	00	0
310	04	4
311	03	3
312	00	0
313	00	0
314	01	1
315	03	3
316	69	DP
317	01	01
318	69	DP
319	05	05
320	43	RCL
321	07	07
322	55	+
323	43	RCL
324	14	14
325	95	=
326	42	STD
327	18	18
328	99	PRT
329	91	R/S
330	98	ADV
331	01	1
332	05	5
333	00	0
334	00	0
335	04	4
336	03	3
337	00	0
338	00	0
339	01	1
340	04	4
341	69	DP
342	01	01

LOC	CODE	KEY
343	69	DP
344	05	05
345	43	RCL
346	11	11
347	55	+
348	43	RCL
349	15	15
350	95	=
351	42	STD
352	19	19
353	99	PRT
354	91	R/S
355	98	ADV
356	01	1
357	06	6
358	01	1
359	07	7
360	03	3
361	07	7
362	04	4
363	00	0
364	69	DP
365	01	01
366	69	DP
367	05	05
368	43	RCL
369	12	12
370	55	+
371	43	RCL
372	16	16
373	95	=
374	42	STD
375	20	20
376	99	PRT
377	91	R/S
378	98	ADV
379	69	DP
380	00	00
381	02	2
382	01	1
383	02	2
384	00	0
385	01	1
386	03	3
387	00	0
388	00	0
389	00	0
390	00	0
391	69	DP

LOC	CODE	KEY
392	01	01
393	69	DP
394	05	05
395	43	RCL
396	17	17
397	55	+
398	43	RCL
399	18	18
400	95	=
401	99	PRT
402	91	R/S
403	98	ADM
404	02	2
405	01	1
406	02	2
407	00	0
408	01	1
409	04	4
410	00	0
411	00	0
412	04	4
413	03	3
414	69	DP
415	01	01
416	01	1
417	03	3
418	00	0
419	00	0
420	00	0
421	00	0
422	00	0
423	00	0
424	69	DP
425	02	02
426	69	DP
427	05	05
428	43	RCL
429	18	18
430	55	+
431	43	RCL
432	19	19
433	95	=
434	99	PRT
435	91	R/S
436	98	ADM
437	02	2
438	01	1
439	02	2
440	00	0

LOC	CODE	KEY
441	01	1
442	05	5
443	00	0
444	00	0
445	04	4
446	03	3
447	69	DP
448	01	01
449	01	1
450	04	4
451	00	0
452	00	0
453	00	0
454	00	0
455	00	0
456	00	0
457	69	DP
458	02	02
459	69	DP
460	05	05
461	43	RCL
462	19	19
463	55	+
464	43	RCL
465	20	20
466	95	=
467	99	PRT
468	92	RTN

LOC	CODE	KEY
-----	------	-----

LOC	CODE	KEY
-----	------	-----

APPENDIX R

**PROGRAM FOR SPLIT-PLOT IN A COMPLETELY
RANDOMIZED DESIGN**

PROGRAM DESCRIPTION

PROGRAM TITLE: Split-Plot in a Completely Randomized Design

OBJECTIVES: This program performs the analysis of variance for two treatment factors, where the whole-plot factor is arranged in a completely randomized design and the sub-plot factor is a subdivision of the whole-plot factor.

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : 2
- c) **LEVELS** : Whole-plot--any number
Sub-plot--15
- d) **REPLICATIONS** : any number

DATA INPUT TYPE: univariate

OUTPUT ^(*): Whole-plot factor degrees of freedom
Whole-plot error degrees of freedom
Sub-plot factor degrees of freedom
Whole-plot/sub-plot interaction degrees of freedom
Sub-plot error degrees of freedom
Total degrees of freedom
Whole-plot factor sum of squares
Whole-plot error sum of squares
Sub-plot factor sum of squares
Whole-plot/sub-plot interaction sum of squares
Total sum of squares
Whole-plot factor mean square
Whole-plot error mean square
Sub-plot factor mean square

^(*) Printed and displayed when **PRINTER UNIT** is used

Whole-plot/sub-plot interaction mean square

Sub-plot error mean square

F-ratio for whole-plot factor

F-ratio for sub-plot factor

F-ratio for whole-plot/sub-plot interaction

PROGRAM CARD DESCRIPTION

Split-Plot in CRD				
Proc.	Resul.	# A	# B	

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter number of levels of A	# A	C	# A
6	Enter number of levels of B	# B	D	# B
7	Process data card		A	
7a	If number of observations is less than 30			3 *
7b	If number of observations is greater than 30			'3' **
8a	If step 7a is true go to step 10			
8b	If step 7b is true load side 1 of data card ₂			3
9	Process data card		R/S	
9a	If all observations have been processed go to step 10			3 *
9b	If step 9a is not true			'3' **
9c	Load next data card and go to step 9			3
10	Load side 2 of data card ₁			3
11	Process data card		R/S	
11a	If all observations have been processed go to step 12			2 ***
11b	If step 11a is not true			'3' **
11c	Load next data card and go to step 11			3
12	Load side 1 of program card ₂			1
13	Load side 2 of program card ₂			2

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for a split-plot design with two treatment factors. The whole-plot factor has 4 levels and the sub-plot factor has 3 levels. The whole-plot factor is arranged in a completely randomized design. Simulated data.

<u>A₁</u>			<u>A₂</u>			<u>A₃</u>			<u>A₄</u>		
<u>B₁</u>	<u>B₂</u>	<u>B₃</u>	<u>B₁</u>	<u>B₂</u>	<u>B₃</u>	<u>B₁</u>	<u>B₂</u>	<u>B₃</u>	<u>B₁</u>	<u>B₂</u>	<u>B₃</u>
217	233	175	158	138	152	229	186	155	223	227	156
188	201	195	126	130	147	160	170	161	201	181	172
162	170	213	122	185	180	167	181	182	182	201	199

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
4	C	4	# of levels of A
3	D	3	# of levels of B
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂	R/S	display will show # 3 display will show # 3 and DATA will be printed	card upright

ENTER	PRESS	OUTPUT	COMMENTS
Data card ₁	R/S	if printer is attached display will show # 3 # 3 will flash in the display and DATA will be printed if printer is attached	card inverted press CLR to stop flashing
Data card ₂	R/S	display will show # 3 # 2 will be in the display and PROG. CARD (2) will be printed if printer is attached	process finished
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
	B	3	A D.F.
	R/S	8	Error(a) D.F.
	R/S	2	B D.F.
	R/S	6	AB D.F.
	R/S	16	Error(b) D.F.
	R/S	35	Total D.F.
	R/S	12494.30556	A D.F.
	R/S	3736.666667	Error(a) S.S.
	R/S	566.222223	B S.S.
	R/S	2600.444444	AB S.S.
	R/S	9933.333333	Error(b) S.S.
	R/S	29330.97222	Total S.S.
	R/S	4164.768519	A M.S
	R/S	467.083334	Error(a) M.S.
	R/S	283.111115	B M.S.
	R/S	433.4074073	AB M.S.
	R/S	620.8333333	Error(b) M.S.
	R/S	8.916542796	F-Ratio for A
	R/S	0.450178977	F-Ratio for B
	R/S	0.698105891	F-Ratio for AB

PRINTED OUTPUT

```

      12.
      3.

217.
188.
162.
233.
201.
170.
175.
195.
213.
158.
126.
122.
138.
130.
185.
152.
147.
180.
229.
160.
167.
186.
170.
181.
155.
161.
182.
223.
201.
182.
RECORD DATA
      227.
      181.
      201.
      156.
      172.
      199.

DATA
DATA
DATA
PROG. CARD (2)
      ANOVA TABLE

```

```

      A      D. F.      3.

ER (A) D. F.      8.

      B      D. F.      2.

      AB     D. F.      6.

ER (B) D. F.     16.

      TOT.  D. F.     35.

      A      S. S.
12494.30556

ER (A) S. S.
 3736.666667

      B      S. S.
 566.222223

      AB     S. S.
2600.444444

ER (B) S. S.
9933.333333

      TOT.  S. S.
29330.97222

      A      M. S.
 4164.768519

ER (A) M. S.
 467.0833334

```

B M. S.
283.1111115

AB M. S.
433.4074073

ER(B) M. S.
620.8333333

F-A
8.916542769

F-B
.4560178977

F-AB
0.698105891

Split-Plot in CRD

PROGRAM LISTING

LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY	LOC	CODE	KEY
000	76	LBL	047	69	69	094	69	DP	141	05	5
001	11	A	048	01	1	095	35	35	142	42	STD
002	03	3	049	05	5	096	61	GTD	143	04	04
003	00	0	050	42	STD	097	00	00	144	87	IFF
004	42	STD	051	04	04	098	18	18	145	01	01
005	00	00	052	43	RCL	099	73	RC*	146	03	03
006	01	1	053	09	09	100	04	04	147	45	45
007	05	5	054	33	X ²	101	33	X ²	148	43	RCL
008	42	STD	055	44	SUM	102	44	SUM	149	01	01
009	04	04	056	12	12	103	09	09	150	42	STD
010	43	RCL	057	00	0	104	00	0	151	05	05
011	14	14	058	42	STD	105	72	ST*	152	29	CP
012	42	STD	059	09	09	106	04	04	153	43	RCL
013	11	11	060	43	RCL	107	69	DP	154	05	05
014	43	RCL	061	14	14	108	24	24	155	22	INV
015	01	01	062	42	STD	109	01	1	156	67	EQ
016	42	STD	063	11	11	110	22	INV	157	02	02
017	05	05	064	43	RCL	111	44	SUM	158	07	07
018	29	CP	065	03	03	112	11	11	159	01	1
019	43	RCL	066	67	EQ	113	43	RCL	160	22	INV
020	05	05	067	00	00	114	11	11	161	44	SUM
021	22	INV	068	99	99	115	67	EQ	162	11	11
022	67	EQ	069	00	0	116	01	01	163	43	RCL
023	00	00	070	42	STD	117	21	21	164	11	11
024	75	75	071	06	06	118	61	GTD	165	67	EQ
025	43	RCL	072	61	GTD	119	00	00	166	01	01
026	06	06	073	00	00	120	99	99	167	71	71
027	74	SM*	074	14	14	121	00	0	168	61	GTD
028	04	04	075	73	RC*	122	42	STD	169	01	01
029	44	SUM	076	00	00	123	06	06	170	40	40
030	09	09	077	69	DP	124	43	RCL	171	01	1
031	33	X ²	078	19	19	125	01	01	172	05	5
032	44	SUM	079	87	IFF	126	65	X	173	42	STD
033	10	10	080	07	07	127	43	RCL	174	04	04
034	01	1	081	03	03	128	02	02	175	43	RCL
035	22	INV	082	42	42	129	95	=	176	01	01
036	44	SUM	083	44	SUM	130	42	STD	177	42	STD
037	11	11	084	06	06	131	03	03	178	05	05
038	69	DP	085	44	SUM	132	03	3	179	73	RC*
039	24	24	086	07	07	133	00	0	180	04	04
040	43	RCL	087	33	X ²	134	42	STD	181	33	X ²
041	11	11	088	44	SUM	135	00	00	182	44	SUM
042	67	EQ	089	08	08	136	43	RCL	183	06	06
043	00	00	090	69	DP	137	14	14	184	00	0
044	48	48	091	33	33	138	42	STD	185	72	ST*
045	61	GTD	092	69	DP	139	11	11	186	04	04
046	00	00	093	20	20	140	01	1	187	69	DP

LOC	CODE	KEY
188	24	24
189	69	DP
190	35	35
191	43	RCL
192	05	05
193	67	EQ
194	01	01
195	99	99
196	61	GTD
197	01	01
198	79	79
199	43	RCL
200	03	03
201	67	EQ
202	02	02
203	28	28
204	61	GTD
205	01	01
206	36	36
207	73	RC*
208	00	00
209	69	DP
210	19	19
211	87	IFF
212	07	07
213	03	03
214	43	43
215	74	SM*
216	04	04
217	69	DP
218	20	20
219	69	DP
220	24	24
221	69	DP
222	33	33
223	69	DP
224	35	35
225	61	GTD
226	01	01
227	52	52
228	43	RCL
229	01	01
230	65	*
231	43	RCL
232	02	02
233	95	=
234	42	STD
235	03	03
236	43	RCL

LOC	CODE	KEY
237	07	07
238	33	X²
239	55	+
240	43	RCL
241	03	03
242	95	=
243	42	STD
244	07	07
245	43	RCL
246	08	08
247	75	-
248	43	RCL
249	07	07
250	95	=
251	42	STD
252	08	08
253	43	RCL
254	10	10
255	55	+
256	43	RCL
257	01	01
258	75	-
259	43	RCL
260	07	07
261	95	=
262	42	STD
263	10	10
264	43	RCL
265	12	12
266	55	+
267	53	(
268	43	RCL
269	01	01
270	65	*
271	43	RCL
272	14	14
273	54)
274	75	-
275	43	RCL
276	07	07
277	95	=
278	42	STD
279	12	12
280	43	RCL
281	06	06
282	55	+
283	43	RCL
284	14	14
285	75	-

LOC	CODE	KEY
286	43	RCL
287	07	07
288	95	=
289	42	STD
290	11	11
291	43	RCL
292	11	11
293	75	-
294	43	RCL
295	12	12
296	95	=
297	42	STD
298	00	00
299	43	RCL
300	09	09
301	55	+
302	53	(
303	43	RCL
304	01	01
305	65	*
306	43	RCL
307	13	13
308	54)
309	75	-
310	43	RCL
311	07	07
312	95	=
313	42	STD
314	04	04
315	43	RCL
316	10	10
317	75	-
318	43	RCL
319	12	12
320	75	-
321	43	RCL
322	04	04
323	95	=
324	42	STD
325	05	05
326	43	RCL
327	08	08
328	75	-
329	43	RCL
330	04	04
331	75	-
332	43	RCL
333	05	05
334	75	-

LOC	CODE	KEY
335	43	RCL
336	11	11
337	95	=
338	42	STD
339	15	15
340	61	GTD
341	15	E
342	22	INV
343	86	STF
344	01	01
345	01	1
346	06	6
347	01	1
348	03	3
349	03	3
350	07	7
351	01	1
352	03	3
353	69	DP
354	01	01
355	69	DP
356	05	05
357	69	DP
358	00	00
359	03	3
360	91	R/S
361	22	INV
362	86	STF
363	07	07
364	03	3
365	00	0
366	42	STD
367	00	00
368	87	IFF
369	01	01
370	49	PRD
371	86	STF
372	01	01
373	43	RCL
374	05	05
375	67	EQ
376	00	00
377	14	14
378	61	GTD
379	00	00
380	18	18
381	76	LBL
382	49	PRD
383	22	INV

LOC	CODE	KEY
384	86	STF
385	01	01
386	43	RCL
387	05	05
388	67	EQ
389	01	01
390	48	48
391	61	GTO
392	01	01
393	52	52
394	92	RTN
395	76	LBL
396	13	C
397	42	STO
398	13	13
399	91	R/S
400	76	LBL
401	14	D
402	42	STO
403	14	14
404	91	R/S
405	76	LBL
406	15	E
407	03	3
408	03	3
409	03	3
410	05	5
411	03	3
412	02	2
413	02	2
414	02	2
415	04	4
416	00	0
417	69	DP
418	01	01
419	01	1
420	05	5
421	01	1
422	03	3
423	03	3
424	05	5
425	01	1
426	06	6
427	69	DP
428	02	02
429	05	5
430	05	5
431	00	0
432	03	3

LOC	CODE	KEY
433	05	5
434	06	6
435	00	0
436	00	0
437	00	0
438	00	0
439	69	DP
440	03	03
441	69	DP
442	05	05
443	69	DP
444	00	00
445	02	2
446	92	RTN

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	69	DP
044	02	02
045	01	1
046	03	3
047	00	0
048	00	0

LOC	CODE	KEY
049	00	0
050	00	0
051	69	DP
052	01	01
053	69	DP
054	05	05
055	43	RCL
056	13	13
057	75	-
058	01	1
059	95	=
060	42	STO
061	16	16
062	99	PRT
063	91	R/S
064	98	ADV
065	01	1
066	07	7
067	03	3
068	05	5
069	05	5
070	05	5
071	01	1
072	03	3
073	05	5
074	06	6
075	69	DP
076	01	01
077	69	DP
078	05	05
079	43	RCL
080	13	13
081	65	*
082	53	(
083	43	RCL
084	01	01
085	75	-
086	01	1
087	54)
088	95	=
089	42	STO
090	17	17
091	99	PRT
092	91	R/S
093	98	ADV
094	01	1
095	04	4
096	00	0
097	00	0

LOC	CODE	KEY
098	00	0
099	00	0
100	69	DP
101	01	01
102	69	DP
103	05	05
104	43	RCL
105	14	14
106	75	-
107	01	1
108	95	=
109	42	STD
110	18	18
111	99	PRT
112	91	R/S
113	98	ADV
114	01	1
115	03	3
116	01	1
117	04	4
118	00	0
119	00	0
120	69	DP
121	01	01
122	69	DP
123	05	05
124	43	RCL
125	16	16
126	65	*
127	43	RCL
128	18	18
129	95	=
130	42	STD
131	19	19
132	99	PRT
133	91	R/S
134	98	ADV
135	01	1
136	07	7
137	03	3
138	05	5
139	05	5
140	05	5
141	01	1
142	04	4
143	05	5
144	06	6
145	69	DP
146	01	01

LOC	CODE	KEY
147	69	DP
148	05	05
149	43	RCL
150	13	13
151	65	*
152	43	RCL
153	18	18
154	65	*
155	53	(
156	43	RCL
157	01	01
158	75	-
159	01	1
160	54)
161	95	=
162	42	STD
163	20	20
164	99	PRT
165	91	R/S
166	98	ADV
167	03	3
168	07	7
169	03	3
170	02	2
171	03	3
172	07	7
173	04	4
174	00	0
175	69	DP
176	01	01
177	69	DP
178	05	05
179	43	RCL
180	03	03
181	75	-
182	01	1
183	95	=
184	99	PRT
185	91	R/S
186	98	ADV
187	03	3
188	06	6
189	04	4
190	00	0
191	03	3
192	06	6
193	04	4
194	00	0
195	69	DP

LOC	CODE	KEY
196	02	02
197	01	1
198	03	3
199	00	0
200	00	0
201	00	0
202	00	0
203	69	DP
204	01	01
205	69	DP
206	05	05
207	43	RCL
208	12	12
209	99	PRT
210	91	R/S
211	98	ADV
212	01	1
213	07	7
214	03	3
215	05	5
216	05	5
217	05	5
218	01	1
219	03	3
220	05	5
221	06	6
222	69	DP
223	01	01
224	69	DP
225	05	05
226	43	RCL
227	00	00
228	99	PRT
229	91	R/S
230	98	ADV
231	01	1
232	04	4
233	00	0
234	00	0
235	00	0
236	00	0
237	69	DP
238	01	01
239	69	DP
240	05	05
241	43	RCL
242	04	04
243	99	PRT
244	91	R/S

LOC	CODE	KEY
245	98	ADV
246	01	1
247	03	3
248	01	1
249	04	4
250	00	0
251	00	0
252	69	DP
253	01	01
254	69	DP
255	05	05
256	43	RCL
257	05	05
258	99	PRT
259	91	R/S
260	98	ADV
261	01	1
262	07	7
263	03	3
264	05	5
265	05	5
266	05	5
267	01	1
268	04	4
269	05	5
270	06	6
271	69	DP
272	01	01
273	69	DP
274	05	05
275	43	RCL
276	15	15
277	99	PRT
278	91	R/S
279	98	ADV
280	03	3
281	07	7
282	03	3
283	02	2
284	03	3
285	07	7
286	04	4
287	00	0
288	69	DP
289	01	01
290	69	DP
291	05	05
292	43	RCL
293	08	08

LOC	CODE	KEY
294	99	PRT
295	91	R/S
296	98	ADV
297	03	3
298	00	0
299	04	4
300	00	0
301	03	3
302	06	6
303	04	4
304	00	0
305	69	DP
306	02	02
307	01	1
308	03	3
309	00	0
310	00	0
311	00	0
312	00	0
313	69	DP
314	01	01
315	69	DP
316	05	05
317	43	RCL
318	12	12
319	55	+
320	43	RCL
321	16	16
322	95	=
323	42	STD
324	21	21
325	99	PRT
326	91	R/S
327	98	ADV
328	01	1
329	07	7
330	03	3
331	05	5
332	05	5
333	05	5
334	01	1
335	03	3
336	05	5
337	06	6
338	69	DP
339	01	01
340	69	DP
341	05	05
342	43	RCL

LOC	CODE	KEY
343	00	00
344	55	+
345	43	RCL
346	17	17
347	95	=
348	42	STD
349	22	22
350	99	PRT
351	91	R/S
352	98	ADV
353	01	1
354	04	4
355	00	0
356	00	0
357	00	0
358	00	0
359	69	DP
360	01	01
361	69	DP
362	05	05
363	43	RCL
364	04	04
365	55	+
366	43	RCL
367	18	18
368	95	=
369	42	STD
370	23	23
371	99	PRT
372	91	R/S
373	98	ADV
374	01	1
375	03	3
376	01	1
377	04	4
378	00	0
379	00	0
380	69	DP
381	01	01
382	69	DP
383	05	05
384	43	RCL
385	05	05
386	55	+
387	43	RCL
388	19	19
389	95	=
390	42	STD
391	24	24

LOC	CODE	KEY
392	99	PRT
393	91	R/S
394	98	ADV
395	01	1
396	07	7
397	03	3
398	05	5
399	05	5
400	05	5
401	01	1
402	04	4
403	05	5
404	06	6
405	69	DP
406	01	01
407	69	DP
408	05	05
409	69	DP
410	00	00
411	43	RCL
412	15	15
413	55	+
414	43	RCL
415	20	20
416	95	=
417	42	STD
418	25	25
419	99	PRT
420	91	R/S
421	98	ADV
422	02	2
423	01	1
424	02	2
425	00	0
426	01	1
427	03	3
428	69	DP
429	01	01
430	69	DP
431	05	05
432	43	RCL
433	21	21
434	55	+
435	43	RCL
436	22	22
437	95	=
438	99	PRT
439	91	R/S
440	98	ADV

LOC	CODE	KEY
441	02	2
442	01	1
443	02	2
444	00	0
445	01	1
446	04	4
447	69	DP
448	01	01
449	69	DP
450	05	05
451	43	RCL
452	23	23
453	55	+
454	43	RCL
455	25	25
456	95	=
457	99	PRT
458	91	R/S
459	98	ADV
460	02	2
461	01	1
462	02	2
463	00	0
464	01	1
465	03	3
466	01	1
467	04	4
468	69	DP
469	01	01
470	69	DP
471	05	05
472	43	RCL
473	24	24
474	55	+
475	43	RCL
476	25	25
477	95	=
478	99	PRT
479	92	RTN

APPENDIX S

PROGRAM FOR SPLIT-PLOT IN A RANDOMIZED
COMPLETE BLOCK DESIGN

PROGRAM DESCRIPTION

PROGRAM TITLE : Split-Plot in a Randomized Complete Block Design

OBJECTIVES: This program performs an analysis of variance for two treatment factors, where the whole-plot factor is arranged in a randomized complete block design and the sub-plot factor is a sub-division of the whole-plot factor.

LIMITS FOR:

- a) **TREATMENTS** : any number
- b) **FACTORS** : 2
- c) **LEVELS** : Whole-plot factor - any number
Sub-plot factor - 14
- d) **REPLICATIONS** : 14

DATA INPUT TYPE: univariate

OUTPUT^(*): Block degrees of freedom
Whole-plot factor degrees of freedom
Whole-plot error degrees of freedom
Sub-plot factor degrees of freedom
Whole-plot/sub-plot interaction degrees of freedom
Sub-plot error degrees of freedom
Total degrees of freedom
Block sum of squares
Whole-plot factor sum of squares
Whole-plot error sum of squares
Sub-plot factor sum of squares
Whole-plot/sub-plot interaction sum of squares
Sub-plot error sum of squares
Total sum of squares
Whole-plot factor mean square

() printed and displayed when PRINTER UNIT is used*

Whole-plot error mean square
Sub-plot factor mean square
Whole-plot/sub-plot interaction mean square
Sub-plot error mean square
F-ratio for whole-plot factor
F-ratio for sub-plot factor
F-ratio for whole-plot/sub-plot interaction

PROGRAM CARD DESCRIPTION

Split-Plot in RCB				
Proc.	Resul.	#A,B		Proc.

USER'S INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Load side 1 of program card ₁			1
2	Load side 2 of program card ₁			2
3	Load side 1 of data card ₁			4
4	Load side 2 of data card ₁			3
5	Enter number of levels of A	# A	C	# A
6	Enter number of levels of B	# B	R/S	# B
7	Process data card		A	
7a	If number of observations is less than 30			3 *
7b	If number of observations is greater than 30			'3' **
8a	If step 7a is true go to step 10			
8b	If step 7b is true load side 1 of data card ₂			3
9	Process data card		R/S	
9a	If all observations have been processed go to step 10			3 *
9b	If step 9a is not true			'3' **
9c	Load next data card and go to step 9			3
10	Load side 2 of data card ₁			3
11	Process data card		R/S	
11a	If all observations have been processed go to step 12			3 *
11b	If step 11a is not true			'3' **
11c	Load next data card and go to step 11			3
12	Load side 2 of data card ₁			3
13	Process data card		E	

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
13a	If all observations have been processed go to step 14			2 ***
13b	If step 13 a is not true			'3' **
13c	Load next data card and go to step 13			3
14	Set new partition	3	2nd OP 17	719.29
15	Load side 1 of program card ₂			1
16	Load side 2 of program card ₂			2
17	Load side 1 of program card ₃			3
18	Obtain the results		B	Blc. D.F.
			R/S	A D.F.
			R/S	ER(a) D.F.
			R/S	B D.F.
			R/S	AB D.F.
			R/S	Er(b) D.F.
			R/S	Tot. D.F.
			R/S	Blc. S.S.
			R/S	A S.S.
			R/S	Er(a) S.S.
			R/S	B S.S.
			R/S	AB S.S.
			R/S	Er(b) S.S.
			R/S	Tot. S.S.
			R/S	A M.S.
			R/S	Er(a) M.S.
			R/S	B M.S.
			R/S	AB M.S.
			R/S	Er(b) M.S.
			R/S	F-Ratio A
			R/S	F-Ratio B
			R/S	F-Ratio
				AB

* Number 3 in the display indicates that side 2 of data card₁ must be read; DATA will be printed if printer is attached

** Number 3 will flash in the display and DATA will be printed if printer is attached

*** PROG. CARD(2) will be printed if printer is attached

SAMPLE PROBLEM

EXAMPLE: Analysis of variance for a split-plot design with two treatment factors. Both factors, the whole-plot factor and the sub-plot factor, have 4 levels each. The whole-plot factor is arranged in a randomized complete block design. Data from Steel and Torrie (1960), page 237. (Data is presented on the following page)

ENTER	PRESS	OUTPUT	COMMENTS
Prog. card ₁		display will show # 1	card upright
Prog. card ₁		display will show # 2	card inverted
Data card ₁		display will show # 4	card upright
Data card ₁		display will show # 3	card inverted
4	C	4	# of levels of A
4	R/S	4	# of levels of B
	A	# 3 will flash in the display and DATA will be printed if printer is attached	press CLR to stop flashing
Data card ₂		display will show # 3	card upright
	R/S	# 3 will flash in the	

		<u>BLOCKS</u>			
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
A ₁	B ₁	42.9	41.6	28.9	30.8
	B ₂	53.8	58.5	43.9	46.3
	B ₃	49.5	53.8	40.7	39.4
	B ₄	44.4	41.8	28.3	34.7
A ₂	B ₁	53.3	69.6	45.4	35.1
	B ₂	57.6	69.6	42.4	51.9
	B ₃	59.8	65.8	41.4	45.4
	B ₄	64.1	57.4	44.1	51.6
A ₃	B ₁	62.3	58.5	44.6	50.3
	B ₂	63.4	50.4	45.0	46.7
	B ₃	64.5	46.1	62.6	50.3
	B ₄	63.6	56.1	52.7	51.8
A ₄	B ₁	75.4	65.6	54.0	52.7
	B ₂	70.3	67.3	57.6	58.5
	B ₃	68.8	65.3	45.6	51.0
	B ₄	71.6	69.4	56.6	47.4

ENTER	PRESS	OUTPUT	COMMENTS
Data card ₂	R/S	display and DATA will be printed if printer is attached display will show # 3 # 3 will show in the display and DATA will be printed if printer is attached	press CLR to stop flashing card inverted
Data card ₁	R/S	display will show # 3 # 3 will flash in the display and DATA will be printed if printer is attached	card inverted press CLR to stop flashing
Data card ₂	R/S	display will show # 3 # 3 will flash in the display and DATA will be printed if printer is attached	card upright press CLR to stop flashing
Data card ₂	R/S	display will show # 3 #3 will be in the display and DATA will be printed if printer is attached	card inverted press CLR to stop flashing
Data card ₁	E	display will show # 3 # 3 will flash in the display and DATA will be printed if printer is attached	card inverted press CLR to stop flashing
Data card ₂	E	display will show # 3 # 3 will flash in the display and DATA will be printed if printer is attached	card upright press CLR to stop flashing

ENTER	PRESS	OUTPUT	COMMENTS
Data card ₂	E	display will show # 3 # 2 will be in the display and PROG. CARD (2) will be printed if printer is attached	card inverted process finished
3	2nd OP 17	719.29	new partition
Prog. card ₂		display will show # 1	card upright
Prog. card ₂		display will show # 2	card inverted
Prog. card ₃		display will show # 3	card upright
	B	3	Block D.F.
	R/S	3	A D.F.
	R/S	9	Error(a) D.F.
	R/S	3	B D.F.
	R/S	9	AB D.F.
	R/S	36	Error(b) D.F.
	R/S	63	Total D.F.
	R/S	2842.873125	Block S.S.
	R/S	2848.021875	A S.S.
	R/S	618.294375	Error(a) S.S.
	R/S	170.536875	B S.S.
	R/S	586.465625	AB S.S.
	R/S	731.2025	Error(b) S.S.
	R/S	7797.394375	Total S.S.
	R/S	949.340625	A M.S.
	R/S	68.699375	Error(a) M.S.
	R/S	56.845625	B M.S.
	R/S	65.16284722	AB M.S.
	R/S	20.31118056	Error(b) M.S.
	R/S	13.81876655	F-Ratio for A
	R/S	2.798735644	F-Ratio for B
	R/S	3.208225492	F-Ratio for AB

ER(B) D.F.
36.

TOT. D.F.
63.

BLC. S.S.
2842.873125

A S.S.
2848.021875

ER(A) S.S.
618.294375

B S.S.
170.536875

AB S.S.
586.465625

ER(B) S.S.
731.2025

TOT. S.S.
7797.394375

A M.S.
949.340625

ER(A) M.S.
68.699375

B M.S.
56.845625

AB M.S.
65.16284722

ER(B) M.S.
20.31118056

F-RATIO A
13.81876655

F-RATIO B
2.798735644

F-RATIO AB
3.208225492

Split-Plot in RCB

LOC	CODE	KEY
000	76	LBL
001	11	R
002	03	3
003	00	0
004	42	STD
005	00	00
006	01	1
007	05	5
008	42	STD
009	04	04
010	43	RCL
011	14	14
012	42	STD
013	06	06
014	43	RCL
015	01	01
016	42	STD
017	05	05
018	29	CP
019	43	RCL
020	05	05
021	22	INV
022	67	EQ
023	00	00
024	73	73
025	43	RCL
026	10	10
027	74	SM*
028	04	04
029	44	SUM
030	07	07
031	33	X ²
032	44	SUM
033	09	09
034	69	DP
035	24	24
036	69	DP
037	36	36
038	43	RCL
039	06	06
040	67	EQ
041	00	00
042	46	46
043	61	GTD
044	00	00
045	67	67
046	01	1

LOC	CODE	KEY
047	05	5
048	42	STD
049	04	04
050	43	RCL
051	07	07
052	33	X ²
053	44	SUM
054	08	08
055	00	0
056	42	STD
057	07	07
058	43	RCL
059	14	14
060	42	STD
061	06	06
062	43	RCL
063	03	03
064	67	EQ
065	00	00
066	97	97
067	00	0
068	42	STD
069	10	10
070	61	GTD
071	00	00
072	14	14
073	73	RC*
074	00	00
075	69	DP
076	19	19
077	87	IFF
078	07	07
079	04	04
080	05	05
081	44	SUM
082	10	10
083	44	SUM
084	11	11
085	33	X ²
086	44	SUM
087	12	12
088	69	DP
089	20	20
090	69	DP
091	33	33
092	69	DP
093	35	35

PROGRAM LISTING

LOC	CODE	KEY
094	61	GTD
095	00	00
096	18	18
097	73	RC*
098	04	04
099	33	X ²
100	44	SUM
101	07	07
102	00	0
103	72	ST*
104	04	04
105	69	DP
106	24	24
107	69	DP
108	36	36
109	43	RCL
110	06	06
111	67	EQ
112	01	01
113	17	17
114	61	GTD
115	00	00
116	97	97
117	43	RCL
118	01	01
119	65	*
120	43	RCL
121	02	02
122	95	=
123	42	STD
124	03	03
125	03	3
126	00	0
127	42	STD
128	00	00
129	87	IFF
130	01	01
131	04	04
132	08	08
133	01	1
134	05	5
135	42	STD
136	04	04
137	43	RCL
138	01	01
139	42	STD
140	06	06

LOC	CODE	KEY
141	43	RCL
142	03	03
143	67	EQ
144	01	01
145	72	72
146	73	RC*
147	00	00
148	69	DP
149	19	19
150	87	IFF
151	07	07
152	04	04
153	06	06
154	74	SM*
155	04	04
156	69	DP
157	20	20
158	69	DP
159	24	24
160	69	DP
161	33	33
162	69	DP
163	36	36
164	43	RCL
165	06	06
166	67	EQ
167	01	01
168	33	33
169	61	GTD
170	01	01
171	46	46
172	73	RC*
173	04	04
174	33	X ²
175	44	SUM
176	05	05
177	00	0
178	72	ST*
179	04	04
180	69	DP
181	24	24
182	69	DP
183	36	36
184	43	RCL
185	06	06
186	67	EQ
187	01	01

LOC	CODE	KEY
188	92	92
189	61	GTO
190	01	01
191	72	72
192	03	3
193	00	0
194	42	STO
195	00	00
196	43	RCL
197	13	13
198	42	STO
199	02	02
200	43	RCL
201	14	14
202	42	STO
203	03	03
204	87	IFF
205	01	01
206	04	04
207	08	08
208	01	1
209	06	6
210	42	STO
211	04	04
212	43	RCL
213	01	01
214	42	STO
215	06	06
216	73	RC*
217	00	00
218	69	DP
219	19	19
220	87	IFF
221	07	07
222	04	04
223	08	08
224	74	SM*
225	04	04
226	69	DP
227	20	20
228	69	DP
229	24	24
230	69	DP
231	36	36
232	43	RCL
233	06	06
234	67	EQ
235	02	02
236	40	40

LOC	CODE	KEY
237	61	GTO
238	02	02
239	16	16
240	69	DP
241	33	33
242	43	RCL
243	03	03
244	67	EQ
245	02	02
246	50	50
247	61	GTO
248	02	02
249	08	08
250	01	1
251	06	6
252	42	STO
253	04	04
254	43	RCL
255	01	01
256	42	STO
257	06	06
258	73	RC*
259	04	04
260	33	X ²
261	44	SUM
262	15	15
263	00	0
264	72	ST*
265	04	04
266	69	DP
267	24	24
268	69	DP
269	36	36
270	43	RCL
271	06	06
272	67	EQ
273	02	02
274	78	78
275	61	GTO
276	02	02
277	58	58
278	69	DP
279	32	32
280	43	RCL
281	02	02
282	67	EQ
283	02	02
284	92	92
285	43	RCL

LOC	CODE	KEY
286	14	14
287	42	STO
288	03	03
289	61	GTO
290	02	02
291	08	08
292	43	RCL
293	13	13
294	65	X
295	43	RCL
296	14	14
297	95	=
298	42	STO
299	02	02
300	43	RCL
301	01	01
302	65	X
303	43	RCL
304	02	02
305	95	=
306	42	STO
307	03	03
308	43	RCL
309	11	11
310	33	X ²
311	55	+
312	43	RCL
313	03	03
314	95	=
315	42	STO
316	10	10
317	43	RCL
318	15	15
319	55	+
320	43	RCL
321	14	14
322	75	-
323	43	RCL
324	10	10
325	95	=
326	42	STO
327	15	15
328	43	RCL
329	05	05
330	55	+
331	43	RCL
332	02	02
333	75	-
334	43	RCL

LOC	CODE	KEY
335	10	10
336	95	=
337	42	STO
338	05	05
339	43	RCL
340	08	08
341	55	+
342	53	(
343	43	RCL
344	14	14
345	65	X
346	43	RCL
347	01	01
348	54)
349	75	-
350	43	RCL
351	10	10
352	95	=
353	42	STO
354	08	08
355	43	RCL
356	15	15
357	75	-
358	43	RCL
359	08	08
360	75	-
361	43	RCL
362	05	05
363	95	=
364	42	STO
365	06	06
366	03	3
367	03	3
368	03	3
369	05	5
370	03	3
371	02	2
372	02	2
373	02	2
374	69	DP
375	01	01
376	01	1
377	05	5
378	01	1
379	03	3
380	03	3
381	05	5
382	01	1
383	06	6

LOC	CODE	KEY
384	69	DP
385	02	02
386	05	5
387	05	5
388	00	0
389	03	3
390	05	5
391	06	6
392	00	0
393	00	0
394	00	0
395	00	0
396	69	DP
397	03	03
398	69	DP
399	05	05
400	69	DP
401	00	00
402	00	0
403	02	2
404	92	RTN
405	22	INV
406	86	STF
407	01	01
408	01	1
409	06	6
410	01	1
411	03	3
412	03	3
413	07	7
414	01	1
415	03	3
416	69	DP
417	01	01
418	69	DP
419	05	05
420	69	DP
421	00	00
422	03	3
423	91	R/S
424	76	LBL
425	14	D
426	22	INV
427	86	STF
428	07	07
429	03	3
430	00	0
431	42	STD
432	00	00

LOC	CODE	KEY
433	87	IFF
434	01	01
435	04	04
436	55	55
437	86	STF
438	01	01
439	43	RCL
440	05	05
441	67	EQ
442	00	00
443	14	14
444	61	GTD
445	00	00
446	18	18
447	76	LBL
448	13	C
449	42	STD
450	13	13
451	91	R/S
452	42	STD
453	14	14
454	92	RTN
455	43	RCL
456	06	06
457	67	EQ
458	01	01
459	33	33
460	61	GTD
461	01	01
462	41	41
463	76	LBL
464	15	E
465	22	INV
466	86	STF
467	07	07
468	03	3
469	00	0
470	42	STD
471	00	00
472	43	RCL
473	06	06
474	67	EQ
475	02	02
476	08	08
477	61	GTD
478	02	02
479	16	16

LOC	CODE	KEY
000	76	LBL
001	12	B
002	01	1
003	03	3
004	69	DP
005	01	01
006	03	3
007	01	1
008	03	3
009	02	2
010	04	4
011	02	2
012	01	1
013	03	3
014	00	0
015	00	0
016	69	DP
017	02	02
018	03	3
019	07	7
020	01	1
021	03	3
022	01	1
023	04	4
024	02	2
025	07	7
026	01	1
027	07	7
028	69	DP
029	03	03
030	69	DP
031	05	05
032	69	DP
033	00	00
034	98	ADV
035	01	1
036	06	6
037	04	4
038	00	0
039	02	2
040	01	1
041	04	4
042	00	0
043	69	DP
044	02	02
045	01	1
046	04	4
047	02	2
048	07	7

LOC	CODE	KEY
049	01	1
050	05	5
051	04	4
052	00	0
053	69	DP
054	01	01
055	69	DP
056	05	05
057	43	RCL
058	01	01
059	75	-
060	01	1
061	95	=
062	42	STD
063	16	16
064	99	PRT
065	91	R/S
066	98	ADV
067	01	1
068	03	3
069	69	DP
070	01	01
071	69	DP
072	05	05
073	43	RCL
074	13	13
075	75	-
076	01	1
077	95	=
078	42	STD
079	17	17
080	99	PRT
081	91	R/S
082	98	ADV
083	01	1
084	07	7
085	03	3
086	05	5
087	05	5
088	05	5
089	01	1
090	03	3
091	05	5
092	06	6
093	69	DP
094	01	01
095	69	DP
096	05	05
097	43	RCL

LOC	CODE	KEY
098	16	16
099	65	*
100	43	RCL
101	17	17
102	95	=
103	42	STD
104	18	18
105	99	PRT
106	91	R/S
107	98	ADV
108	01	1
109	04	4
110	69	DP
111	01	01
112	69	DP
113	05	05
114	43	RCL
115	14	14
116	75	-
117	01	1
118	95	=
119	42	STD
120	19	19
121	99	PRT
122	91	R/S
123	98	ADV
124	01	1
125	03	3
126	01	1
127	04	4
128	69	DP
129	01	01
130	69	DP
131	05	05
132	43	RCL
133	17	17
134	65	*
135	43	RCL
136	19	19
137	95	=
138	42	STD
139	20	20
140	99	PRT
141	91	R/S
142	98	ADV
143	01	1
144	07	7
145	03	3
146	05	5

LOC	CODE	KEY
147	05	5
148	05	5
149	01	1
150	04	4
151	05	5
152	06	6
153	69	DP
154	01	01
155	69	DP
156	05	05
157	43	RCL
158	16	16
159	65	*
160	43	RCL
161	19	19
162	65	*
163	43	RCL
164	13	13
165	95	=
166	42	STD
167	21	21
168	99	PRT
169	91	R/S
170	98	ADV
171	03	3
172	07	7
173	03	3
174	02	2
175	03	3
176	07	7
177	04	4
178	00	0
179	69	DP
180	01	01
181	69	DP
182	05	05
183	43	RCL
184	03	03
185	75	-
186	01	1
187	95	=
188	99	PRT
189	91	R/S
190	98	ADV
191	03	3
192	06	6
193	04	4
194	00	0
195	03	3

LOC	CODE	KEY
196	06	6
197	04	4
198	00	0
199	69	DP
200	02	02
201	01	1
202	04	4
203	02	2
204	07	7
205	01	1
206	05	5
207	04	4
208	00	0
209	69	DP
210	01	01
211	69	DP
212	05	05
213	43	RCL
214	05	05
215	99	PRT
216	91	R/S
217	98	ADV
218	01	1
219	03	3
220	69	DP
221	01	01
222	69	DP
223	05	05
224	43	RCL
225	08	08
226	99	PRT
227	91	R/S
228	98	ADV
229	01	1
230	07	7
231	03	3
232	05	5
233	05	5
234	05	5
235	01	1
236	03	3
237	05	5
238	06	6
239	69	DP
240	01	01
241	69	DP
242	05	05
243	43	RCL
244	06	06

LOC	CODE	KEY
245	99	PRT
246	91	R/S
247	98	ADV
248	01	1
249	04	4
250	69	DP
251	01	01
252	69	DP
253	05	05
254	43	RCL
255	07	07
256	55	+
257	53	(
258	43	RCL
259	13	13
260	65	*
261	43	RCL
262	01	01
263	54)
264	75	-
265	43	RCL
266	10	10
267	95	=
268	42	STD
269	22	22
270	99	PRT
271	91	R/S
272	98	ADV
273	01	1
274	03	3
275	01	1
276	04	4
277	69	DP
278	01	01
279	69	DP
280	05	05
281	43	RCL
282	09	09
283	55	+
284	43	RCL
285	01	01
286	75	-
287	43	RCL
288	10	10
289	75	-
290	43	RCL
291	22	22
292	75	-
293	43	RCL

LOC	CODE	KEY
294	08	08
295	95	=
296	42	STD
297	04	04
298	99	PRT
299	91	R/S
300	98	ADV
301	01	1
302	07	7
303	03	3
304	05	5
305	05	5
306	05	5
307	01	1
308	04	4
309	05	5
310	06	6
311	69	DP
312	01	01
313	69	DP
314	05	05
315	43	RCL
316	12	12
317	75	-
318	43	RCL
319	10	10
320	95	=
321	42	STD
322	11	11
323	75	-
324	43	RCL
325	15	15
326	75	-
327	43	RCL
328	22	22
329	75	-
330	43	RCL
331	04	04
332	95	=
333	42	STD
334	23	23
335	99	PRT
336	91	R/S
337	98	ADV
338	03	3
339	07	7
340	03	3
341	02	2
342	03	3

LOC	CODE	KEY
343	07	7
344	04	4
345	00	0
346	69	DP
347	01	01
348	69	DP
349	05	05
350	43	RCL
351	11	11
352	99	PRT
353	91	R/S
354	98	ADV
355	03	3
356	00	0
357	04	4
358	00	0
359	03	3
360	06	6
361	04	4
362	00	0
363	69	DP
364	02	02
365	01	1
366	03	3
367	69	DP
368	01	01
369	69	DP
370	05	05
371	43	RCL
372	08	08
373	55	+
374	43	RCL
375	17	17
376	95	=
377	42	STD
378	24	24
379	99	PRT
380	91	R/S
381	98	ADV
382	01	1
383	07	7
384	03	3
385	05	5
386	05	5
387	05	5
388	01	1
389	03	3
390	05	5
391	06	6

LOC	CODE	KEY
392	69	DP
393	01	01
394	69	DP
395	05	05
396	43	RCL
397	06	06
398	55	+
399	43	RCL
400	18	18
401	95	=
402	42	STD
403	25	25
404	99	PRT
405	91	R/S
406	98	ADV
407	01	1
408	04	4
409	69	DP
410	01	01
411	69	DP
412	05	05
413	43	RCL
414	22	22
415	55	+
416	43	RCL
417	19	19
418	95	=
419	42	STD
420	26	26
421	99	PRT
422	91	R/S
423	98	ADV
424	01	1
425	03	3
426	01	1
427	04	4
428	69	DP
429	01	01
430	69	DP
431	05	05
432	43	RCL
433	04	04
434	55	+
435	43	RCL
436	20	20
437	95	=
438	42	STD
439	27	27
440	99	PRT

LOC	CODE	KEY
441	91	R/S
442	98	ADV
443	01	1
444	07	7
445	03	3
446	05	5
447	05	5
448	05	5
449	01	1
450	04	4
451	05	5
452	06	6
453	69	DP
454	01	01
455	69	DP
456	05	05
457	43	RCL
458	23	23
459	55	+
460	43	RCL
461	21	21
462	95	=
463	42	STD
464	28	28
465	99	PRT
466	91	R/S
467	98	ADV
468	02	2
469	01	1
470	02	2
471	00	0
472	03	3
473	05	5
474	01	1
475	03	3
476	03	3
477	07	7
478	69	DP
479	01	01
480	02	2
481	04	4
482	03	3
483	02	2
484	00	0
485	00	0
486	01	1
487	03	3
488	00	0
489	00	0

LOC	CODE	KEY
490	69	DP
491	02	02
492	69	DP
493	05	05
494	43	RCL
495	24	24
496	55	+
497	43	RCL
498	25	25
499	95	=
500	99	PRT
501	91	R/S
502	98	ADV
503	02	2
504	04	4
505	03	3
506	02	2
507	00	0
508	00	0
509	01	1
510	04	4
511	00	0
512	00	0
513	69	DP
514	02	02
515	69	DP
516	05	05
517	43	RCL
518	26	26
519	55	+
520	43	RCL
521	28	28
522	95	=
523	99	PRT
524	91	R/S
525	98	ADV
526	02	2
527	04	4
528	03	3
529	02	2
530	00	0
531	00	0
532	01	1
533	03	3
534	01	1
535	04	4
536	69	DP
537	02	02
538	69	DP

LOC	CODE	KEY
539	05	05
540	43	RCL
541	27	27
542	55	+
543	43	RCL
544	28	28
545	95	=
546	99	PRT
547	92	RTN

LOC	CODE	KEY
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LOC	CODE	KEY
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